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EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE

AND

ALLIED SCIENCE

BY VARIOUS WRITERS

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Pacchioni, Antonio.—Born at Reggio, Italy, on June 13, 1665. He went to Rome and devoted himself to the study of anatomy. In this way he gained the friendship and protection of Malpighi. He was called to Tivoli, and for a period of six years he practised medicine in that town with great success. Then he returned to Rome and attached himself more particularly to Lancisi, the distinguished physician of Pope Innocent XII. He was held in great esteem by the public generally and also by scientific men. His death occurred on Nov. 5, 1726.

In strict justice—says the Dictionnaire Historique de la Médecine—Pacchioni's name should have been allowed to pass into oblivion, for he committed several serious anatomical errors—as, for instance, in describing the dura mater as a muscular structure, and in putting forward certain untenable hypotheses with regard to the rôle which this membrane plays in the economy. He also committed the error of assuming that the granulations which are found on the meninges, are glandular structures. However, despite the latter error, his name continues even to-day to be associated with these granulations. A. H. B.

Pacchionian Bodies.—These granulations, once falsely called glands, were perhaps first mentioned by Willis (1676), then by Méry (1701), and almost simultaneously described by A. Pacchioni. They start as minute spheroidal, partially vesicular outgrowths (villi of Luschka) from the arachnoidal layer of the pia—where it bridges fissures as well as where it rests on the gyres—retaining its epithelial covering. They must not be confounded with granulations of the choroid or ependyma, with vegetations notably in the cavernous sinus (Hyrtl, 1862), nor with granular (aciniform) conditions of the meninges seen in inflammations. They are often clustered, become pedunculated, penetrate the opposed dura, and finally project into the overlying venous channels, and even excavate (in part repel) the bone. They are usually most abundant opposite the middle of the falcial sinus—more correctly opposite the largest parasinual spaces—but may occur on boths sides, along nearly the whole length of this sinus, beside the transverse and tentorial sinuses, and even beneath the latter, also in the temporal fossa opposite the trunks of the medidural vessels and the frequently present temporal sinus. They occur not rarely three centimeters, and even farther, from the long sinus along the line of large incoming veins after the latter have left the pia, and also farther out at one point near the frontal border of parietal bone, probably where a medidural artery bends to connect through the skull with temporal vessels. Hence, in general, they occur opposite intradural blood channels of some size, and especially those subject to continual variations in caliber (pulsation, ebb and flow). Their prevalent growth toward and into venous spaces has led to the view that the granulations themselves were venous structures, or opened into such (Key and Retzius, Kollmann, and others; it is not true that Trolard claimed this). From the intimate connection of the older granulations with the spaces, they become darker colored; or, on tearing the two structures apart, flecked with blood. But the younger free corpuscles are pale, whitish.

The parasinual spaces may diminish with age, while the granulations certainly increase. Up to the twentieth year the Pacchionians are rarely developed to any extent. In congenital defect of the heart, they appear early and excessive (case of Lambl, 1860; one of the writer). However, at all ages continuous or intermittent compression of the brain space, of whatever origin, is the most frequent cause of their overdevelopment. Under this head fall intracranial tumors of any kind or seat. Repeated congestion, as in chronic alcoholism, is also an accepted factor, doubtless acting mechanically. Various systemic troubles, as nephritis and diabetes, favor the enlargement of these bodies, possibly by unusual variations in the encranial pressure.

In view of all the facts—viz., that while these corpuscles regularly occur opposite intradural (extra-arachnoidal) blood channels not necessarily venous, their growth is especially favored on the one hand by venous stasis, on the other by pressure from the side of the cranial space—it is evident that they result from the oft-repeated local oscillation of the arachnoid. As the cerebrospinal fluid is sub-arachnoidal, it, especially when under pressure, forces that membrane at its weakest points into any depression, as that beside a dilated vessel—*the granulations always grow away from the cranial cavity, never toward it.* When, then, the favoring condition—be that even negative instead of positive—relaxes, the granulations, to the extent that they have formed, press against and penetrate superimposed structures, the continuous alternation of the conditions as continually favoring the process.

Pathology, Clinical History, etc.—(*a*) Like the wrinkling of the skin, the turning gray and falling out of the hair, and many other processes, the granulations themselves should be considered pathological only when they become excessive or develop prematurely. (*b*) Calcification or ossification of these bodies is not unusual. They may contain deposits of so-called brain sand and even fat globules. (*c*) Where they penetrate into blood spaces and even a sinus, they so far interfere with the return current, and also favor thrombosis. (*d*) Foveæ glandulares, sharp depressions or excavations in the inside of the skull (preceding *e* and *f*), quite analogous to that seen in aneurysm of a dural artery, are sometimes found. From their more or less intimate relations with the sinus walls. Allen advises avoidance of the middle line in all operations upon the skull cap. However, the diploë itself is never opened by these growths as a new

layer of bone always forms around the foveæ. (e) Small flat elevations of the external plate of the skull, opposite the foveæ, and hence near the superior median line, are mentioned by many. (*f*) Very rarely complete perforation of the cranium occurs: 1. Case of Weber-Ribes (1819; Pozzi); hole small, and covered by ligamentous membrane. 2. Luschka (page 116); perforation of squamous portion of temporal bone. 3. Lecat (Heincke in Pitha-Billroth); pneumatocele capitis; skull at some points perforated by granulations of the dura. 4. Demme (1862; Mastin). "On the left of the sagittal suture (posteriorly was a sharp-edged opening the size of a cherry stone, through which protruded a Pacchionian granulation." 5. The writer's observation. Man of forty; had suffered over three years from a tumor of the brain. At the favorite spot near the frontal border of the parietal, somewhat removed from the sagittal suture, there was a clean-cut, complete perforation of the skull by Pacchionian granulations. This was circular, fully 0.5 centimeter across, surrounded even in the diploic portion by smooth continuous bone, and covered by periosteal membrane. At the border there was a very trifling overprojection of the outer bone plate. It is recognized that such perforations—even when incomplete—may, from local injury, lead to the formation of epicranial blood cysts, inasmuch as the causative granulations usually traverse some blood channel. (*g*) In a few cases growths of this class have pressed on passing nerves, causing local neuralgic or paretic symptoms. Though it has been claimed that at times these growths induce headache, it is probable that they are then but co-effects of some other cause. (*h*) M. B. Schmidt calls attention to the etiological relation of the Pacchionian granulations to dural sarcoma and psammoma. (*i*) In animals generally these corpuscles are not present. Luschka found them only in the horse. Bluntschli found them in apes, but not in lower animals. Injection work indicates that the Pacchionian structures are the main efferents for the cerebrospinal fluid in man. There is an important distinction in this respect between animals and man. In the former, Quincke (1872) and Key and Retzius (1873) showed that there are channels along outgoing spinal nerves, connecting the subarachnoid space with extraspinal tissues. The writer, however, has shown that, while in animals there are such efferent spinal passages for the fluid at all times of life, in the human they exist only during fetal life. Childhood is the favorite time for the occurrence of hydrocephalus. This then finds its explanation in the closure of the spinal efferents at birth, and the imperfect development of the Pacchionian bodies until a later period.

WILLIAM BROWNING.

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Pacific Congress Springs.—Santa Clara County, California.

POST-OFFICE.—Saratoga.

LOCATION.—On direct electric line from San Jose via Saratoga; twelve miles from San Jose, and one mile from Saratoga.

These springs obtain their name from their resemblance to the well-known Congress Spring at Saratoga, N. Y. The Santa Clara Valley is celebrated for its excellent climate and dry, pure, and invigorating air. The Congress Spring Café is on the grounds. The springs are located about 800 feet above the sea-level on the mountainside. The drives about these springs are among the finest in the State. There are on the premises several springs which flow in great profusion. The waters belong to the alkaline-chalybeate class. They are valuable for table purposes. The following analysis was made by Anderson in 1888:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	115.76
Sodium carbonate	120.42
Sodium sulphate	12.95
Potassium carbonate	2.06
Magnesium carbonate	26.34
Magnesium sulphate	14.17
Calcium carbonate	16.03
Calcium sulphate	14.19
Ferrous carbonate	13.87
Alumina	4.50
Silica	3.98
Organic matter	Trace.
Total	344.27

Free carbonic acid gas 44.17 cubic inches. Temperature of water, 50° F.

This water is much less densely mineralized than is that of its New York namesake. The action of the California Congress waters is decidedly tonic, owing to the large infusion of iron. They are also mildly aperient (from the presence of Glauber's and Epsom salts), diuretic, and antacid (from the presence of alkaline carbonates). The springs have gained considerable celebrity in the treatment of anemia, dyspepsia, liver and kidney troubles, irritability of the bladder, rheumatic affections, gout, and cutaneous disorders. The waters are shipped to all parts of the coast.

EMMA E. WALKER.

Pacini, Filippo.—Born at Pistoja, Italy, on May 25, 1812. He began the study of medicine in his native city in 1830, and pursued the work with such earnestness that already in 1835, when he was only twenty-three years old, he was able to present to the Medico-physical Society of Florence an account of his discovery of the peculiar bodies which are found at the ends of the finger nerves and which bear his name ("Pacinian corpuscles"). The scientific men of that day, however, did not seem to attach any importance to the discovery; but their indifference did not discourage Pacini. He borrowed from Puccini an Amici microscope and was thus enabled to push his investigations with such a degree of success that in 1839 he demonstrated the existence of the corpuscles to the members of the Scientific Congress which was then in session at Pisa; and one year later he published a description of the structures, with illustrative drawings. In 1849 he was appointed Professor of Topographic Anatomy and Histology in Florence, and three years later (1852) he published the results of his studies of the electric organ of the Gymnotus electricus and of the corresponding organ possessed by other electric fishes. During the epidemic of Asiatic cholera that raged in 1854–1855 Pacini, assisted by Magni (subsequently Professor of Ophthalmology in the University of Bologna), made a most careful study of the alterations effected by that disease in the intestinal mucous membrane. He discovered millions of rod-shaped microbes in these parts, and he believed that they were the causative factors in this disease; but the later discovery of Koch's comma-bacillus showed that he was mistaken in this belief. He died on July 9, 1883.

Pacini was a prolific contributor to current medical literature, but lack of space will not permit us to enumerate in this place any of the titles of these writings.

A. H. B.

Pacinian Corpuscles, Pathology of.—Very few observations have been made upon the occurrence of pathological changes in the Pacinian corpuscles.

Virchow noted the possibility of the development of the so-called lamellated fibroma from Pacinian corpuscles, but regarded such origin as being of the nature of a pathological curiosity.

Osler (Proceedings of the Pathological Society of Philadelphia, 1886) reported a case of hemorrhagic pancreatitis in which the Pacinian corpuscles were enormously swollen and edematous and the neighboring tissue was infiltrated.

Przewoski (*Arch. f. path. Anat. u. Phys.*, Bd. lxiii.) described five cases of edema of the Pacinian corpuscles which occurred in mitral insufficiency, in chronic nephritis, in emphysema, and in two cases of chronic pulmonary tuberculosis. In the first two cases general edema was present, but not in the other three. He claims to have been the first to observe this condition.

Rattone (*Archivio per le scienze mediche*, Torino, vol. ix.) also describes a case of local edema of the Pacinian corpuscles. In a case of scoliosis, in which no other pathological changes of note were found, the Pacinian corpuscles about the pancreas showed an extreme grade of edema. He, as did Przewoski, at first took the cyst-like bodies to be cysticercus cysts, but microscopic examination showed them to be Pacinian corpuscles. In a case of fibroma of the mamma, occurring in a young male, he found a much compressed Pacinian body. The chief symptom of the case had been agonizing neuralgic pain, and Rattone believes that this was caused by the changes produced in the Pacinian corpuscle through pressure. There were no evidences of inflammation in or about the corpuscle.

The most extensive observations yet made upon the pathology of the Pacinian corpuscle are those reported by the writer (*Phil. Monthly Med. Jour.*, February, 1899). In nine cases pathological changes were found in Pacinian corpuscles embracing the following conditions: congestion, edema, hemorrhage, changes in vessel walls, acute and chronic inflammatory processes, mucous and colloid degeneration, hyaline deposit, calcification, and necrosis.

In one case of pulmonary gangrene great numbers of hyaline or cystic bodies, varying in size from a pinhead to a small cherry, were found in the mesentery, particularly in the neighborhood of the pancreas and semilunar ganglia. The majority were transparent, jelly-like, and fluctuating, suggesting parasitic cysts. Microscopical examination showed these to be Pacinian corpuscles in various stages of cystic change. The interstitial tissue of the lamellæ contained large cyst-like spaces in which a mucin- or pseudo-mucin-like substance was present. These changes were confined to the corpuscles, and were apparently primary. In some of the corpuscles the presence of congestion, small hemorrhages, and small-celled infiltration would appear to justify the diagnosis of a primary inflammation (pacinitis) of the Pacinian corpuscle.

In a case of chronic parenchymatous nephritis, mitral insufficiency, and general edema, a similar condition of edema and cystic change was found, which was regarded as secondary to the general edema.

In four cases hyaline change of the Pacinian corpuscles was found: in two cases in the peritoneum and mesentery, in the other two in the region of the prostatic plexus. The hyaline bodies showed transition stages to an appearance similar to the lamellated fibroma, as described in the literature. In two other cases similar hyaline bodies were found, but they were so changed that their genesis could not be determined.

In a case of femoral thrombosis chronic inflammatory changes were found in and about the Pacinian corpuscles present in the vessel sheath. The process was regarded as an extension from a chronic inflammatory process involving the sheath of the vessels and the vessels themselves.

In a case of hemorrhagic pancreatitis necrosis, edema, and hemorrhage were found in the Pacinian corpuscles in the neighborhood of the pancreas. These changes were regarded as secondary to the pancreatic disease, the marked liquefaction necrosis of the nerve structure being due to the action of pancreatic ferments. The involvement of the Pacinian corpuscles and nerve trunks may be the immediate cause of death, as suggested by Osler.

Since the report of these cases the writer has observed other cases in which pathological conditions of Pacinian corpuscles were found. Edema and cystic degeneration were observed in the corpuscles in the neighborhood of the pancreas, in a case of valvular disease of the heart with general edema, and in a case of colitis without general edema. In a scirrhous carcinoma of the mammary gland a much compressed Pacinian corpuscle was found, completely surrounded by carcinoma tissue. In contrast to the case observed by Rattone this patient had never suffered pain. In a second tumor of the mammary gland, a cystadenofibroma, a much compressed Pacinian corpuscle was found extending across a large cyst filled with serous fluid. Though surrounded on all sides by fluid, the corpuscle showed no change beyond that of compression. The tumor in this case was painful. In routine examinations of breast tumors it is common to find Pacinian corpuscles completely imbedded in carcinoma tissue. Often the capsule shows no evidence of pathologic change; at other times it appears compressed or atrophic. In a few instances carcinomatous invasion of the corpuscle has been noticed, but as a rule the Pacinian body is very resistant to the surrounding cancer cells. Pacinian corpuscles are of very frequent occurrence in painful amputation stumps or "irritable scars." They may be hyperplastic, edematous or atrophic, but in the majority of cases show no change, even when surrounded by dense scar tissue. Just what part these compressed Pacinian corpuscles play in the production of pain or abnormal sensations cannot be definitely told.

It would appear from the above cases that edema or cystic change is the most common primary, as well as secondary, pathological condition of the Pacinian corpuscles. The exact significance of this condition cannot at present be stated; nor in the primary cases is the genesis of the condition clear. In these cases the edema is probably to be referred to some local circulatory changes, probably to changes in the blood-vessels of a sclerotic or inflammatory nature. In the other cases the secondary nature of the affection is clear.

Inasmuch as the physiology of the Pacinian corpuscles is still in doubt, the clinical significance of these changes cannot at present be known. The presence of large numbers of the corpuscles about the pancreas would indicate that they serve some important sensory function, probably relating to intra-abdominal pressure; and we are justified in assuming that any extensive disease of these bodies would produce important disturbances and give rise to clinical symptoms. The intense abdominal pain occurring in acute pancreatitis may be explained by the involvement of the Pacinian corpuscles and the nerve trunks in the vicinity of the pancreas. As Osler has suggested, death in these cases may result from shock caused by such involvement. That compression of the Pacinian corpuscle does not always give rise to severe pain is shown by the case of scirrhous carcinoma of the mamma. This case may, however, be explained by the assumption that the nerve trunks had been destroyed by carcinomatous infiltration, the more resistant corpuscle remaining preserved. The paucity of observations and our lack of

knowledge regarding these structures make desirable more careful investigations as to their physiology and pathology. ALDRED SCOTT WARTHIN.

Packard, John Hooker.—Born in Philadelphia, Aug. 15, 1832. He received the degree of M. D. from the University of Pennsylvania in 1853. During the Civil War he was an Acting Assistant Surgeon, U. S. Army. From 1863 to 1884 he was one of the surgeons to the Hospital of the Protestant Episcopal Church in Philadelphia. In the latter year he was elected on the staff of the Pennsylvania Hospital. His death occurred in 1907.

Of his published writings the following deserve special mention: "Handbook of Minor Surgery," 1863; "Lectures on Inflammation," 1865; and "Handbook of Operative Surgery," 1870. He also translated Malgaigne's Treatise on Fractures, 1859.

A. H. B.

Pagel, Julius Leopold.—Born at Pollnow, Pommerania, Germany, on May 29, 1851. He studied medicine at Berlin during the years 1871–1875, his principal teachers being Du Bois-Reymond, Traube, Virchow, and August Hirsch; and he settled there as a practising physician in 1876. From his earliest years as a student, he was especially interested in the history of medicine, and he became in time one of the leading German authorities on that subject. In recognition of his achievements in this branch of medical science, the University of Berlin made him at first titular professor, and finally Professor Extraordinary, of the History of Medicine. He died Jan. 31, 1912.

Of Pagel's published works the following deserve to receive special mention: "The Development of Medicine in Berlin," 1897; "Introduction to the History of Medicine," 1898; "De Mondeville's Anatomy," 1889 (edited); "De Mondeville's Surgery," 1892 (edited); and the works of Nicaise and of Congenis, 1893 (translated and edited). A. H. B.

Pagenstecher, Alexander.—Born at Wallan, near Wiesbaden, Germany, on April 21, 1828. He studied medicine at the universities of Giessen, Heidelberg, and Wuertzburg, and received the degree of Doctor of Medicine from the latter institution in 1849. During the years 1851 and 1852 he devoted himself to the study of ophthalmology—first, under Sichel, senior, and Desmarres, in Paris, and then under Albrecht von Graefe in Berlin. Soon after his return to Wiesbaden he built, with his own funds, an Ophthalmic Hospital for the poor, and devoted all his energies to the efficient management of this institution. Thanks to the success which he attained in these efforts and to the large percentage of cures which resulted from his operations, eye patients soon began to come from all quarters of the globe to consult him about their ailments. In 1857 he was made a Hofrat. He died on Dec. 31, 1879, in consequence of a wound which he received during a hunting excursion.

Unfortunately, very few reports of Pagenstecher's rich ophthalmological experience have been published. Of these, the treatise entitled "Zur Iridodesis," published in von Graefe's *Archiv*, viii, deserves to receive special mention. A. H. B.

Paget, Sir James.—Born at Great Yarmouth, England, on Jan. 11, 1814. He studied medicine at St. Bartholomew's Hospital, and retained some connection with that institution throughout the remainder of his life. At first, he was an Assistant Surgeon; then he became Surgeon; and, finally, he held the position of Consulting Surgeon up to the time of his death. In 1836 he was made a member, in 1843 an Honorary Fellow, and in 1875 President, of the Royal College of Surgeons, England. He was also Serjeant Surgeon to the Queen and Surgeon to the Prince of Wales. In 1871 he was made a baronet. When he died, on Dec. 30, 1899, he was the Nestor among English surgeons, and one of the most distinguished members of the Medical Profession at large.

Sir James Paget was one of the first men in England to take up the study of pathological histology, and he made a number of important contributions to this branch of medical science. He was a keen observer and an untiring and not easily discouraged worker; and he employed precise and delicate methods of research. He deserves special credit for his studies with regard to nutrition, hypertrophy and atrophy, the healing of wounds, fatty degeneration of the small blood-vessels of the brain, inflammation, and tumors. His name will always occupy an honorable place in the history of medicine on account of the bone disease to which he gave the name of "osteitis deformans" (Medical Transactions, 1877 and 1882), and also on account of the "disease of the nipple" which he first described in the St. Bartholomew's Hospital Reports for 1874—a disease which begins apparently as a simple eczema of the nipple of the female breast and then develops into a true cancer of that organ. For many years he cherished a warm friendship for Rudolf Virchow, of Berlin, the famous pathologist. Indeed, his frankness of manner and kindly disposition made friends for him on every side. On the other hand, he had the strongest possible dislike for those who, upon one pretext or another—the anti-vivisectionists, for example—endeavored to arrest the advance of medical science.

Sir James Paget made relatively few large contributions to medical literature. The titles of these few are as follows: "Catalogue of the Pathological Museum of the Royal College of Surgeons;" "Lectures on Surgical Pathology;" "Lectures on Tumors," 1851; and "Clinical Lectures and Essays," 1875.

A. H. B.

Pagosa Springs.—Archuleta County, Colorado.

POST-OFFICE.—Pagosa Springs. Hotels and boarding-houses.

ACCESS.—Via Denver and Rio Grande Railroad.

This resort is located in a picturesque, heavily wooded mountain region, at an altitude of about 7,000 feet above the sea-level. Bear, elk, deer, and wild turkeys abound in the neighboring mountains, and it is said that a basket of trout may be taken at any time without going beyond the village limits. The country is new, but is fast being developed, and hundreds of people from different parts of the United States camp out in the neighborhood every summer in order to avail themselves of the salubrious climate and many other attractions to be found here. There is considerable snow in January, February, and March, but during the remainder of the year the weather is clear and beautiful. The summer temperature reaches 90° F. at times, but owing to the bracing atmosphere no discomfort is felt. The nights are always cool. There is but one mineral spring at Pagosa. It is situated on a small elevation and from it the water issues through crevices in various directions. The water supply is quite inexhaustible, as it is estimated that the combined currents from the spring would form a stream three feet deep and six feet wide. The following analysis is supposed to have been made under the auspices of the United States Government when it maintained a fort at this point:

Pagosa Hot Springs.
One United States Gallon* Contains

Solids.	Grains.
Sodium chloride	61.81
Sodium carbonate	83.27
Sodium sulphate	150.21
Calcium carbonate	41.76
Magnesium carbonate	6.65
Lithium carbonate	3.28
Potassium carbonate	2.80
Iron protoxide	0.16
Manganese protoxide	0.11
Calcium fluoride	0.30
Calcium phosphide	0.03
Silica	0.71
Total	351.09

Temperature of water, 165° F. Elevation, 7,000 feet.

* Converted from grams per liter.

The waters are said to possess valuable properties in the treatment of rheumatic affections, gout, syphilis, and anemic conditions. Emma E. Walker.

Pain.—From a restricted philosophical view pain may be regarded as a reaction of the organism, in part or as a whole, to harmful influences, giving a warning in consciousness that some activity prejudicial to the health of the tissues is operative.

The movements of expansion and contraction in protoplasm, the biologists say, are primordial expressions of the pleasure-pain sense; expanding in response to pleasure-giving (healthful) and contracting in reaction to pain-giving (harmful) impulses. These reactions are considered the germ of the idea which by numerous multiplications, complications, and added phenomena have come to make the many-sided figure of the human pleasure-pain sense.

The pain of trauma, in a bruised bone, or the discomfort of a mechanical process, as the pressure of an exudate or transudate, the irritation of an inorganic or organic toxic agent, the pain of ulceration or of necrosis—these are of the types of painful sensations, viewed in a narrow sense, which the physician most often is called upon to treat. But there may be pain in consciousness connected with more complex processes than those just mentioned. The pain of fear, of anxiety, of dread, of anger, even the peculiar pain of the "sick soul" and the ecstatic states, and of other and various emotional conditions, are no less real pain than those of an irritated or injured sensory nerve.

Pain therefore, considered biologically, is the record in consciousness, at the sensori-motor level of the nervous system, of harmful contacts with reality, and teleologically warns the individual of such realities with the view of forcing a better adaptation. It has developed out of unconscious, negative and positive tropisms, acting through the vegetative nervous system at phylogenetically older levels; and at psychical levels develops into fear, as a general symbolic reaction to socially required realities.

Of the intricacies and the extraordinary width, breadth, and depth of the pleasure-pain sense only a most extensive study of the ancient and current literature of anthropology, neurology, psychology, and sociology can give an adequate idea, and the present discussion is limited in scope to the narrow field of that which may be termed pain in the common-sense view of the term—the reaction of the sensory nervous system to a prejudicial activity. It will be limited to the painful sensations of the periphery (the epiblastic substances—the skin and external mucous membranes), of those organs and surfaces which are formed by involution of the primary epidermal structures—as the intestinal canal, the bladder, the pleuræ; further, to those pains which occur in the mesoblastic structures—the muscles, the bones, the viscera, etc.

Varieties of Pain.—From simple discomfort to agony the gradations of pain are many, but a few types seem to be associated with recognizable types of lesion. Two types of pain may be distinguished at the outset—*acute* and *chronic*—indicating in a general way, first, the more violent reaction of the sensory nervous system to an irritant; and, secondly, that of the more prolonged and habitual protest of nature against the harmful influences of a chronic process. Acute pains usually call for immediate diagnosis, if not immediate treatment; chronic pains, as a rule, demand a study of the more involved and intricate processes of nature.

Pain, again, is spoken of as *periodic*, *recurrent*, *alternating*, or *continuous*.

As to character, *acute darting* pains are characteristic of the neuralgias, myalgias, and neuritides—such pains are frequently *paroxysmal* or *remitting* in type, coming and going with great suddenness and leaving no trace of their presence, save at times a certain sense of soreness after frequent attacks. Such pains, moreover, are distributed usually in definite anatomical areas, which fact is of the utmost importance in their diagnosis and treatment. In many instances this type of pain is recognized as shifting in its distribution. At one time the nerve distribution in the foot is affected; again, the same nerve area of the thigh, then the leg representation; again, the painful sensations may be distributed over a definite segment area; on one side or on opposite sides of the body.

Colicky pains are characteristic of affections of the hollow viscera. The stomach colic of poisoning and of distention and obstruction of the intestine, the tenesmus and pain in the ureter and bladder from urethritis, pyelitis, cystitis, etc., are the results of the cramp-like muscular activities of these organs, usually engaged in the process of ejecting, or trying to eject, a harmful occupant. In the diagnosis of these pains the sense of muscular effort is often present in the patient's consciousness and is a useful guide. Careful questioning of a discriminating patient will often reveal much. In the treatment of these conditions the carrying out of nature's indications is rational. Thus, at the present time, catharsis and enteroclysis are more frequently employed for the initial stages of cholera morbus, diarrheas, and dysenteries than are narcosis and muscle paralysis by opium and similar drugs.

Boring or *growing* pains are deep seated, illy defined pains frequently found in visceral disease. The bones, the muscles, the meninges, the spinal column, the liver, or other deep-seated viscus may be involved. Aneurysms, new growths, and other lesions in these more remote localities are often the cause of *dull* pains. It is usually advisable to regard them at their worst if regrets of faulty diagnosis are to be avoided. Many of the brilliant diagnoses of the specialist may be anticipated by the family practitioner, if sufficient consideration is given to all dull pains of a persistent chronic or remittent nature. The so-called growing pains may be classed in this category and too frequently prove to be precursors of acute or chronic joint lesions, which on development entail much misery and suffering on the young. *Movement* pains are those which are increased by motion of the joints or of the muscles and are indicative of some lesion in these structures.

Pain Appreciation.—If pain be regarded as a reaction, evidently two factors, at least, are involved in its appreciation. The character of intensity of the inducing agency and the individual's susceptibility. Since each individual's own experience is the only guide to the physician's estimation of the intensity of the painful feeling, much judgment and sympathy are needed correctly to gauge the patient's susceptibility. Pain to many is but an incident. They are either anesthetic or stoical, either really feeling little or able to control their expressions of pain; others, again, are hyperesthetic or exaggerational; either

they really are extremely susceptible or they possess little or no control over their feelings. At all events the grade of the patient's own feeling is the true measure of the pain for themselves, but it may not be a useful guide in the diagnosis of a disease process.

It has become popular, since the studies of Lombroso and his school, to generalize regarding pain susceptibilities among individuals in certain occupations or professions, or among the peoples of a country. Thus the Teutons are reputed to be relatively nonsusceptible; that thieves, prostitutes, and the like are anesthetic. Such generalizations are founded on the most flimsy evidence and are based purely on half-truths at best. Moreover, the question of control over one's expressions of pain is rarely taken into account by many of these students.

Pain that is acute and severe in character usually causes a well-known picture of contracted muscles, dilated pupils, cold wet hands and feet, a picture closely resembling and indeed inducing at times the well-known act of fainting.

Pain Location.—For the most part the feeling of pain is referred to the diseased area, and when lesions are found to be superficial and within reach it is easy at once to distinguish their true nature and to locate them correctly, and then to apply the proper treatment. When no superficial lesion is found, the question arises whether the pain sensation is in direct relation to an adjacent organ or whether it is a referred sensation from a more remote viscus.

Of the facts which help to a correct judgment the grade of pain intensity is one of the most important. Those pains which are less intense and more illy defined are more liable to be referred pains from a more remote area.

By the researches of Dana and Head the mapping of areas of referred sensations has become an almost definite matter. Head has shown that a diseased viscus very frequently, if not always, sends sensory impulses to the spinal cord, which impulses are felt as irregular pains, usually dull, at times very acute, in the skin area supplied by the sensory nerve of the spinal-cord segment related to the viscus segment. By means of the work of this author and others many of the earlier charts illustrating referred pains are being revised, and more definite conclusions are now possible.

Pain Pathways.—The pathways taken from the sensory receptors to the cortex are extremely intricate, yet in general four types, or combinations may be distinguished: Peripheral pain, where the lesion occurs somewhere between the periphery and the spinal cord; spinal cord localizations; optic thalamus pains; and cortical pains or sensory disturbances. Pain moreover may be distinguished as protopathic and as deep sensibility pain. The latter is the type produced by the contractions of unstriped muscular fibers. Peripheral nerve pains are usually brought together under the broad heading neuralgia and neuritis. This is only a group term. It means nothing specific, and offers no clue to etiology nor to treatment. These neuralgic pains represent a variety of lesions ranging from hemorrhage, pernicious anemia, leucemia, parasites, various toxemias, as from lead, alcohol, mercury, arsenic; from infections such as tonsillitis, influenza, typhoid, malaria, measles, gonorrhea, streptococcus; from constitutional states such as diabetes, nephritis, hypothyroidism; lesions of the nerve trunk or posterior ganglion from herpes infections, wounds, pressure, new growths. Reflex neuralgias from visceral disease are frequent. Plexus pains usually present a syndrome known as *radiculitis*. Here the sensory nerve roots are usually involved. The pains of sciatica are classically of this general type. The pains have a tendency to appear paroxysmally, in crises, are lancinating in character, and are best compared to tabetic pains which are usually of this order. The nerve trunks are usually painful and radicular sensory anomalies are present in the affected root distribution. At times there is an accompanying astereognosis. Cervical radiculitis usually is accompanied by atrophies and by pupillary signs (Klumpke signs). Brachial radiculitis is usually syphilitic. In disseminated and lumbar types the diagnosis of tabes must be carefully considered. In the spinal cord the pain pathways undergo a distinct regrouping. With the thermal pathways they pass to the opposite side of the cord after a longer or shorter course. Any lesion in the cord, notably one about the central canal, which cuts these fibers gives rise to the typical dissociation phenomenon, so classically demonstrated in syringomyelia.

Midbrain sensory syndromes are extremely complicated. They are best discussed in Dejerine's Semeiologie and in Jelliffe and White, Diseases of the Nervous System. Thalamic pains, from lesions of the sensory pathway synapsis in the thalamus, are characterized by their great intensity and their resistance, even to powerful analgesics. Furthermore they are usually accompanied by other features of the thalamic syndrome (*q.v.*). The chief features are: (1) Persistent hemianesthesia, more or less marked for superficial sensibility, tactual pain, temperature; most marked for deep sensibility and hence loss or diminution of postural sense with various degrees of astereognosis; (2) mild hemiplegia which usually recovers soon; (3) mild hemiataxia, with choreoathetoid movements; at times adiadochokinesia; (4) paroxysmal shooting pains, very severe; (5) overresponse to affective reactions, particularly in the involved side, with increased emotional response to sensory stimuli. The thalamic syndrome, usually due to a hemorrhage or syphilitic thrombosis, is most frequently mistaken for an hysterical reaction.

Cortical Pains.—The sensory pathways from the thalamus to the cortex spread out in a number (5) of groups. Lesions of the postcentral gyri usually result in various types of anesthesia, paresthesia, and generalized sensory phenomena which require great detail in discrimination.

Smith Ely Jelliffe.

Schmidt: Pain, translated by Vogel and Zinsser.
Behan: Pain.

Palm Beach, Florida.—This popular and fashionable winter resort is situated in Southern Florida on the east coast, in latitude 26° 57′, about two hundred and eighty miles south of Jacksonville. It lies upon a narrow strip of land between Lake Worth and the Atlantic Ocean. The vegetation at this latitude is naturally tropical and luxuriant, and art has added to the natural beauty by parks, gardens, and paths running through groves of palms and tropical trees. Flowers abound, and such tropical fruits as the banana, pineapple, guava, tamarind, and mango are found here. Indeed, nature and art have combined to render this spot peculiarly attractive and fascinating. The accommodations are luxurious and consequently expensive. There are two large hotels affording every comfort, and several smaller and less expensive ones. There are also numerous fine private residences. Many means of recreation are offered the visitor: cycling through the many beautiful paths; fishing, swing, sailing, shooting, surf bathing, swimming in large salt-water pool, and golf upon the fine and extensive links. Hot salt-water baths are to be had in some of the hotels. Palm Beach is easily and comfortably reached direct by railway from Jacksonville. One is referred to the article upon *Florida* in this Handbook for an extended consideration of the climate of Florida, including this region. In this article will be found the climatic data for Jupiter, which is only seventeen miles north of Palm Beach, and which therefore has essentially the same climate as that of Palm Beach. The average mean tempera-

ture (Fahrenheit) for the months of December to March inclusive, is: December, 67.2°; January, 63.4°; February, 66.7°; March, 68.8°. The maximum temperature for the same months is: December, 82°; January, 83°; February, 87°; March, 89°. Minimum, December, 41°; January, 38.5°; February, 39.8°; March, 44.8°. The average relative humidity is 82 per cent. The average number of clear and fair days is: December, 23.9; January, 24; February, 22.1°; March, 27.1. The average precipitation for December, 2.88 inches; January, 3.43; February, 2.72°; March, 2.59. There is an occasional cold wave, lasting two or three days sufficiently severe to call for warm clothing. There are no evening chills such as occur in many other resorts.

The distinguishing characteristics of the winter climate of Palm Beach, are warmth sunshine, equability, and moisture. It is a warm, moist, marine climate of tropical characteristics. Such a climate is well suited for elderly and feeble persons, convalescents of a certain kind; for persons affected with neurasthenia or with chronic bronchitis, and for the valetudinarian in general, but not for those who are affected with pulmonary tuberculosis. Already established chronic diseased are thought to be delayed in their progress by the influence of this subtropical sea climate, vide "The Effect of Florida Climate upon Acute and Chronic Disease" by F. Fremont Smith. [Transactions Am. Climatological Assoc., vol. xxiii., 1907.] For one who desires to escape the inclemency and strain of a northern winter and live an outdoor existence in the midst of attractive surroundings, and who, moreover, is able to pay for luxurious accommodations, Palm Beach can unqualifiedly be recommended. Further, it is easily and comfortably reached from the North. There is little or no danger of contracting acute or climatic diseases in this resort. Good medical service is at hand, which is a matter of the first importance in a health resort. The season extends from December to March.

Sixty-seven miles south of Palm Beach is *Miami*, the port of departure for Nassau which is reached in fifteen hours. It is a town of 5,471 inhabitants. The "Royal Palm," a large and luxurious hotel, is situated here in the midst of a large tropical park. The climate is essentially the same as at Palm Beach, and much the same sort of outdoor life and amusements are afforded the visitor here as at the former place. There are good fishing, golf, tennis, a casino, and swimming pool.

EDWARD O. OTIS.

Palmer, James Croxall.—Born in Baltimore, Maryland, June 29, 1811. He received the degree of Doctor of Medicine from the University of Maryland in March, 1834, and was immediately afterward commissioned Assistant Surgeon in the United States Navy. His first voyage was made, on the frigate "Brandywine," to the Pacific station, where, in Jan., 1835, he voluntarily exchanged to the sloop "Vincennes," bound on a cruise through nearly all the South Sea islands, to China and other ports, and so around the world, home. On July 17, 1838, he was ordered to the store-ship "Relief," of the exploring expedition under Lieut. Charles Wilkes. In October, 1841, he received his commission as Surgeon of the U. S. Navy. His service during the following twenty-two years was extremely varied and most eventful, but it is not practicable here to enter into any of the details, except to mention casually the fact that Surgeon Palmer was attached to Admiral Farragut's flag-ship "Hartford" at the battle of Mobile, Aug. 5, 1864, in which, out of six members of the medical staff, two were killed outright. On March 3, 1871, he was commissioned as a Medical Director, and on June 10, 1872, as Surgeon-General. He died in Washington, D. C., April 24, 1883.

A. H. B.

Palmyra Mineral Springs.—Jefferson County, Wisconsin.

POST-OFFICE.—Palmyra Springs. Hotel.

ACCESS.—Via Chicago, Milwaukee and St. Paul Railroad to Palmyra, 118 miles north of Chicago and twenty miles west of Waukesha.

Palmyra is a pretty little town of 1,000 inhabitants, nestling in the foothills of the famous Kettle Range of Wisconsin. The location is 850 feet above tide-water, and it combines many of the features sought after by the summer seeker for health or recreation. This entire section is favored with a salubrious climate, and is altogether free from malaria. The soil is dry, sandy, and porous, overlying glacial deposits of gravel, which affords the best natural facilities for through drainage. The scenery here is noted for its tranquil beauty and loveliness. In his attractive brochure on "Summer in the Northwest" Mr. W. J. Anderson informs us that the beautiful little Spring Lake, or Palmyra Lake, as it is generally called, "may be classed as one of the gems of Wisconsin. Its bottom is covered with mosses, ferns, and other aquatic plants, which in midsummer bloom and blossom as a garden. It is fed by numerous mineral springs in the vicinity, and affords an enticing prospect for the angler or the lover of boating." Seven miles distant is the Scuppernong trout pond, which is said to contain millions of trout of all varieties and sizes. Many other beautiful lakes are within easy driving distance, over excellent roads. A sixty-five acre grove of native oaks with its winding walks and shaded nooks adds much to the attractiveness of the place. The great Geyser Spring is thirty-eight feet in depth and fifty feet across the surface, and supplies 10,000,000 gallons of water per day. The water is soft, pure, and palatable, and is believed to possess remedial value. The mineral springs at Palmyra are very numerous. A cluster of half a dozen in the spring park, which could all be covered by a canvas forty feet square, are quite dissimilar in taste, of varying temperature, and of different analysis. One spring is slightly thermal, having a temperature of 72° F.; another, ten feet distant, is a little cooler (62.5° F.); while others vary in temperature from 50° to 52° F. Another group is known as Magnesian Springs. They are remarkably pure and free from organic matter. Following are analyses of three of the springs, No. 1 being by Prof. W. S. Haines, and Nos. 2 and 3 by Prof. Bode.

Spring No. 1.—One United States gallon contains: Sodium sulphate, gr. 0.94; potassium sulphate, gr. 0.23; calcium bicarbonate, gr. 15.70; magnesium bicarbonate, gr. 10.94; magnesium chloride, gr. 0.18; iron bicarbonate, gr. 0.5; calcium phosphate, a trace; alumina, a trace; silica, gr. 0.70; organic matter, a trace. Total, 29.19 grains.

Spring No. 2.—One United States gallon contains: Sodium chloride, gr. 0.21; sodium sulphate, gr. 0.64; sodium bicarbonate, gr. 0.16; calcium sulphate, gr. 0.30; calcium bicarbonate, gr. 9.86; magnesium bicarbonate, gr. 7.91; iron bicarbonate, gr. 0.6; alumina, gr. 0.19; silica, gr. 0.61; organic matter, gr. 0.35. Total, 20.83 grains.

Spring No. 3.—One United States gallon contains: Sodium chloride, gr. 0.43; sodium sulphate, gr. 0.40; sodium bicarbonate, gr. 0.18; calcium sulphate, gr. 0.80; calcium bicarbonate, gr. 12.84; magnesium bicarbonate, gr. 10.14; alumina, gr. 0.22; silica, gr. 0.90. Total, 25.91 grains.

These waters all possess mild diuretic and antacid properties. The water of Spring No. 3, being entirely free from organic matter, is well adapted for carbonating and bottling. The numerous topographical, climatic, and other advantages of Palmyra render it a suitable resort for a large variety of ills and ailments. The spring waters exert a beneficial influence, especially in rheumatic troubles and dyspepsia, although their use is also extended to functional hepatic dis-

orders, the early stages of Bright's disease, and to eczema, pityriasis, and other skin troubles.

EMMA E. WALKER.

Palpitation.—See *Heart, Functional Disorders of.*

Palsies, Infantile Cerebral.—This comprises a large group of disorders which in the main result in various forms of paralysis. It is a heterogeneous and motley array and is classed in one place as cerebral palsies of childhood for practical purposes only. It must be remembered that the classification has no pathological nor etiological significance, therefore, is not a truly scientific grouping. This can be seen immediately when the etiology is discussed. The cerebral palsies of children occur (1) while the child is in the uterus, from hemorrhage or (2) at birth, usually from traumata, or (3) immediately following birth as the result of accident or disease. Certain infantile cerebral palsies of the prenatal period are due to poliomyelitis, others may be congenital ageneses of an hereditary character, or, in the vast majority of cases, such failure of development is due to parental syphilis. At birth the crushing of the bones, pressure of forceps with the resulting hemorrhage are the frequent causes. Following birth, hemorrhage and thrombosis from the traumata, from encephalitis, from gonorrhea or other septic microorganism, which may emigrate from an infected umbilical cord. Polioencephalomyelitis is a frequent postnatal cause. These are the more usual etiological factors. Practically all of the symptoms present are residuals. They are for the most part unalterable. The main characteristic defects found are various forms of hemiplegia with increased spasticity, atrophy, increased reflexes and trophic disturbances. Epileptic convulsions are usually present, and hence many of these cases are thought of and treated as epileptics. In some there are choreoid and athetoid movements. Bulbar palsies may be present. All four extremities may be involved, making up the so-called diplegic cases. In many of these cases the mental development is defective, and hence the so-called symptoms of idiocy and imbecility. The cerebral defect varies enormously. In the older literature one will find a patient suffering from juvenile paresis in this group.

Therapeutically the indications are to find out the etiology. In mild intrauterine and postnatal poliomyelitis (encephalitis) cases there is often a mixture of flaccid and spastic states. Here muscle training may do a lot. It is also useful for the spastic states due to hemorrhage. Surgical intervention may be called for, but the general trend should be against any surgical procedure until thoroughgoing muscle-training therapeutics have been put into practice.

SMITH ELY JELLIFFE.

Panacea Springs.—Warren County, North Carolina.

POST-OFFICE.—Littleton. New Panacea Hotel.

ACCESS.—Via Seaboard Air Line Railroad. These springs and hotel are situated three miles from the town of Littleton, at an altitude of 476 feet above the sea-level. Automobiles meet trains.

The location is in a beautiful valley in the foothills of the Blue Ridge Mountains, surrounded by picturesque hills covered with rocks of immense size, and still clothed in their primeval forest growth of gigantic oaks. The meteorological conditions which prevail here are of a salutary character, there being neither long droughts nor excessive rains. The springs are fifteen or twenty in number and flow about five hundred gallons of water per hour. The following analysis has been made by Samuel P. Sadtler and Son, consulting and analytical chemists, of Philadelphia, Pennsylvania:

	Grains per U. S. Gallon.
Silica	1.073
Alumina	0.058
Potassium chloride	0.331
Sodium chloride	0.065
Sodium sulphate	0.195
Sodium bicarbonate	3.202
Ferrous bicarbonate	2.932
Manganous bicarbonate	0.713
Calcium bicarbonate	2.837
Magnesium bicarbonate	1.979
	13.385

The water is tonic, constructive, and alterative. It is very beneficial in dyspepsia, bladder, kidney, and liver affections, and in skin diseases. It is very useful in chronic diarrhea and in the debility which usually accompanies this disease. It is recommended highly also in the debilitated states attending uterine and ovarian diseases and in restoring anemic and puny children.

The climate is balmy, yet invigorating, much like that of the world-famed south of France, with the added attraction of the majestic trees of primeval forests.

The modern and commodious hotel and the grounds as well are lighted by electricity. The cuisine is of the best, the table being supplied from a garden and dairy owned by the Springs Company. A large garage has recently been built. Daily concerts are given, and there is dancing at night in the new ballroom. Boating and fishing may be enjoyed by the guests.

EMMA E. WALKER.

Panaritium Analgicum.—*Synonym:* Morvan's Disease. This curious and extraordinarily rare disease was first described by Morvan, of Brittany, in 1883. In applying the name analgic panaritium, or "painless whitlow," Morvan was obviously more influenced by the salient clinical feature of the disease than by any consideration for its underlying pathology. Viewed in the light of the more critical tendencies of recent years, the desirability of retaining it as a clinical entity, to the burden of an already overcrowded neurological nosology, seems more than doubtful.

The opportunities for investigating the disease, even in the services of large hospitals, are so meager that little or no satisfactory advance has been made in our exact understanding of its genesis and morbid substructure. It appears to consist of a syringomyelic condition—or of the associated gliomatosis—plus a peripheral neuritis.

In the few cases in which a microscopic examination of the cord has been made, the connective-tissue overgrowth appeared in the posterior part of the gray matter and in the posterior columns.

It is practically certain that syringomyelia takes its origin in a developmental defect. As the primary morbid condition of the disease under consideration is analogous to that of syringomyelia in all essential details, it seems to the writer much more reasonable to regard the extra feature of Morvan's disease, the peripheral neuritis, of identical origin. This point of view makes the two morbid processes practically alike in all respects except topography, and the doubt arises as to whether this single feature of dissimilarity is sufficient to establish Morvan's disease on the plane of a clinical entity. Repeated observations of the apparent fortuitousness of the morbid distribution in cases of other developmental defects should tend, by analogy, to reduce the present distinguishing features of syringomyelia and what we now term Morvan's disease to the vanishing point, and such a result is desirable for obvious reasons.

As the clinical features of the two diseases now stand, there is nothing upon which we may rely absolutely for differentiation between them. Both

are apt to give the first clinical manifestations of their presence in the first half of adult life, and both are alleged to follow some traumatism or to arise in consequence of abuse of function. How important local traumatism may be in the production of Morvan's disease it is difficult to say, owing to the natural rarity of the affection. It probably has about as much etiological value, however, as that other frequently alleged causative agent in nervous diseases—exposure to cold and wet.

In Morvan's disease the symptoms begin as a rule in the upper extremities. Of these the most striking are the whitlows, which are usually, though not invariably, painless, owing to the loss of all forms of sensation preceding them. With the whitlows there may be recurring ulcerations on various parts of the fingers. These ulcers are deep and not unlike the perforating variety observed in tabes. They are accompanied by cracks in the skin, and the nails shrivel and split. Although the occurrence of the whitlows is the striking feature of the disease, it is not the most important or serious. As has been said, they occur as a rule subsequently to the abolition of all forms of sensation, but they have important precursors in the form of muscular weakness and wasting in the hands and forearms. Although the trophic mischief is practically limited to the hands, and the muscular wasting does not go above the forearms, the sensory loss may involve the entire arms, parts of the trunk, and even the face. Sufficient vasomotor derangement to cause lividity and pallor of the skin often precedes and accompanies the nutritional disturbance. An affection of the shoulder-joint has been noted. When the ulcerations of the fingers involve the terminal phalanges, the latter may be entirely destroyed. The electrical irritability of the nerves involved in the affected parts pursues variations, as the disease progresses, similar to those observed in the progressive atrophies of spinal origin, a gradually increasing quantitative loss, followed by inversion of the formula. The feet are rarely the seat of the painless ulceration; although the legs may be weak and the knee-jerks exaggerated, owing probably to the partial implication of the nutritional arteries of the lateral columns in the overgrowth of tissue. The course of the disease is extremely slow, extending over many years. In certain cases it has appeared to be arrested.

In the matter of differential diagnosis there are no particular difficulties except in regard to syringomyelia. Here, in the opinion of the writer, there is no absolute distinction. For certain authorities the retention of tactile sensibility and the absence of the whitlows are sufficient to rule out Morvan's disease in a doubtful case. In Raynaud's disease the vasomotor disturbance is paramount and the loss of sensibility, when it exists, is not alike in kind or degree. In sclerodactyla there is no sensory loss and no tendency to destructive ulceration of the finger ends. In anesthetic leprosy there are no ulcerations whatever, while there is a tendency to pigmentary deposit in the skin areas involved.

Owing to the nature of the malady, the question of treatment is easily settled. No drugs are specifically indicated. Even symptomatic treatment is of little importance because of the practically painless course which the disease pursues. Iron, arsenic, and strychnine are among the drugs used, but it is more than doubtful if they have exerted other than a general effect. JOSEPH WILLIAM COURTNEY.

Pancoast, Joseph.—Born in Burlington County, New Jersey, in 1805. He was graduated in 1828 from the medical department of the University of Pennsylvania. In 1831 he began teaching practical anatomy and surgery, and in 1834 he was elected one of the Physicians of the Philadelphia Hospital, Blockley. From 1838 to 1845 he was one of the Visiting Surgeons to the same hospital. In 1854 he was elected one of the Surgeons of the Pennsylvania Hospital. In 1838 he was chosen Professor of Surgery in the Jefferson Medical College, and in 1847 he was elected to the Chair of Anatomy in the same institution. Being of an inventive turn of mind, and thoroughly devoted to surgical work, he discovered numerous ways in which the technique commonly adopted by the surgeons of that period might be improved. His death occurred on March 7, 1882.

He was a frequent contributor to periodical medical literature, and he also published a number of monographs on pathological and surgical topics.

A. H. B.

Pancoast, William H.—Son of the preceding; was born in Philadelphia, Oct. 16, 1835. He pursued his medical studies at the Jefferson Medical College, and graduated from that institution in 1856. Shortly afterward he went to Europe, spending two and a half years in visiting the great hospitals of London, Edinburgh, Paris, Vienna, and Berlin. Upon his return to this country he began the practice of his profession in his native city, and soon acquired considerable reputation as a bold, rapid, and skilful surgical operator. In 1859 he was elected Visiting Surgeon to the Charity Hospital, Philadelphia, and he held the position for ten years. In 1886 he was chosen one of the Visiting Surgeons to the Philadelphia Hospital. In 1874 he was elected Professor of General Descriptive and Surgical Anatomy in Jefferson Medical College. His death occurred on Jan. 5, 1897.

He was an occasional contributor to periodical medical literature. A. H. B.

Pancreas, Anatomy of the.—The pancreas is a digestive gland concerned with the production of an important secretion which it pours into the duodenum. It likewise has important internal secreting functions associated with the control of the carbohydrate metabolism of the body.

The gland is an elongated, tongue-shaped mass of tissue, of a creamy red color, situated on the level of the upper lumbar vertebræ, stretching transversely across the posterior surface of the abdominal cavity from the duodenal loop on the right to the spleen on the left. The dimensions of the organ are highly variable and have not been sufficiently correlated with age, weight, physiological condition, and previous history to give the data much comparative value. Schirmer who has investigated a large material gives the length as 22 to 26 centimeters though occasionally it may be as great as 30 centimeters. The weight varies from 67 to 105 grams according to Krause, but may reach as high as 162 grams according to Schirmer.

For descriptive purposes the gland is divided into three portions designated respectively as the head (caput pancreatis), body (corpus pancreatis), and tail (cauda pancreatis).

The head of the gland is the disc-like portion which occupies the horseshoe-shaped loop of the duodenum. It corresponds in position to the bodies of the first and second lumbar vertebra, its lowest point being as a rule at the level of the disc between the second and third vertebral bodies though it may extend even lower than this. The lower portion of the head, corresponding to the long mesoduodenal lobe of lower mammals forms a hook-like process (processus uncinatus) moulded around the superior mesenteric vessels, which occupy a groove, the incisura pancreatis.

The head is connected with the body of the gland by a narrow neck which overlies the superior mesenteric vessels. The body and tail of the pancreas

constitute the tapering tongue-shaped mass of the organ extending from the middle line of the body to the spleen.

Located in the mesoduodenum and mesogastrium posterius, which, in later fetal and extrauterine life are fused with the parietal peritoneum of the posterior abdominal wall, the pancreas is fixed in position, except a small portion of the tail, which possesses a moderate and variable degree of mobility, corresponding to that of the organs to which it has omental attachments, namely, the spleen and stomach. Although of rather firm consistence, it presents by reason of its lobular structure and loose stroma, a certain degree of plasticity adapting itself in shape to the organs with which it comes in contact.

The anterior face of the organ, except in the head, where it is overlapped by the fascial fusion of the transverse mesocolon with the mesoduodenum, forms a part of the posterior wall of the bursa omentalis or

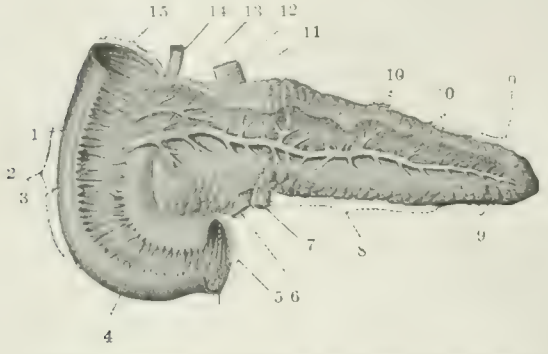


Fig. 4223.—Pancreas with Neighboring Organs Viewed from in Front. (Sobotta.) 1, Duodenal papilla; 2, descending portion of duodenum; 3, orifice of greater pancreatic duct; 4, head of pancreas; 5, lower portion of duodenum; 6, superior mesenteric vein; 7, superior mesenteric artery; 8, body of the pancreas; 9, 9, tail of the pancreas; 10, 10, great pancreatic duct; 11, anastomosis between the greater and lesser pancreatic ducts; 12, vena cava; 13, lesser pancreatic duct; 14, ductus choledochus; 15, upper portion of duodenum.

lesser sac of the peritoneum. It is deeply grooved by the stomach, but extends above the level of the lowest part of the the curvatura minor where it forms a thickening called the tuber omentale which is in relation anteriorly with the left lobe of the liver. The anterior face of the head is crossed by the transverse colon, and by the superior pancreatico-duodenal artery. Below the transverse colon the lower portion of the head comes into relation through the mesocolon with the small intestine.

The posterior surface of the pancreas is in relation, from right to left, with the common bile duct, the right renal artery, the vena cava inferior, the aorta, superior mesenteric vessels, ganglia celiaca, and plexus celiacus, splenic vein, left suprarenal gland, and left kidney. The splenic artery runs in a groove along the upper margin partly overlapped by pancreatic tissue, and some of its branches cross the anterior face of the tail to reach the spleen.

The *blood supply* of the pancreas is derived from branches of the arteria celiaca and arteria mesenterica superior. From the former are derived the arteria pancreatico-duodenalis superior, which crosses the anterior face of the head to reach the duodenum, giving off branches to the pancreas and the duodenum, and the rami pancreatici derived from the arteria lienalis in its course along the upper margin of the pancreas. Small branches enter the pancreas also directly from the arteria hepatica. From the superior mesenteric artery is derived the arteria pancreatico-duodenalis inferior which ascends along the duodenum to anastomose with the superior artery with which it shares the chief blood supply of the caput pancreatis.

The *nerve supply* of the pancreas consists for the most part of unmedullated nerve fibers, derived from the plexus celiacus, which accompany the arteries into the gland, and which terminate finally in fine plexuses around the ultimate anatomical elements of the pancreas. Along the course of these nerves, situated in the interlobular connective tissue of the pancreas, are numerous sympathetic ganglia.

The *main duct* of the gland (ductus pancreaticus Wirsungi) begins in the tail of the pancreas, and runs from left to right through the substance of the gland, but rather nearer to the posterior face of the gland, receiving on its way numerous branches which enter it from the pancreatic tissue, and gradually increasing in size. Near the duodenum it lies parallel with the ductus choledochus, with which it enters the wall of the duodenum, traversing the latter obliquely to open into the bowel, either alongside of the ductus choledochus or by a common opening on a papilla situated at the lower end of the plica longitudinalis duodeni. At its termination it is surrounded by circular muscle fibers which merge with the sphincter muscle of the common bile duct.

In probably more than ninety-nine per cent. of the cases a second duct is present the ductus pancreaticus accessorius (Santorini), though it does not always have an independent opening into the bowel. In 397 cases collected from the literature by van Balen Blanken an accessory duct was missing in only four cases. Though fairly constant in its occurrence it is highly variable in its morphology and relations, thus giving the impression of a vestigial structure. Its duodenal opening when present is usually 2.5 to 3.5 centimeters nearer to the pylorus than the opening of the main duct. This opening, however, may be wholly lacking or reduced to microscopic dimensions in which case the accessory duct pours the major portion of its secretion into the main duct which it joins after a course of five to six centimeters through the head of the gland. This duct represents an independent embryonic pancreatic anlage, and, in a few cases retains complete independence from the main pancreatic duct. In some cases, also, it becomes the main pancreatic duct, the ductus pancreaticus in these cases falling behind in development. In some mammals, as for example the rabbit and guinea-pig, it constitutes the sole channel of egress for the secretion of the gland.

The pancreas is a compound racemose gland composed of lobules bound together by a loose connective-tissue stroma in which run the blood-vessels, nerves, and excretory ducts.

This stroma, according to Flint, is a fibrous connective tissue which possesses little fasciculation except in the neighborhood of the great ducts. The amount of intralobular connective tissue is extremely small, though it may be thickened into a capsule around some of the large islands of Langerhans. It forms the delicate reticulated fibrous basement membranes which surround the ultimate divisions of the glandular elements.

The main duct and its primary branches are lined by a simple epithelium, consisting of cylindrical cells and goblet cells, and supported by a rather dense lamina propria consisting of fasciculated white fibrous tissue containing a network of fine elastic fibers. The intralobular ducts consist of a layer of low columnar cells supported by a delicate reticular basement membrane. The terminals of the intralobular ducts are continued for a short distance as somewhat flattened cells into the cavity of the acinus where they constitute the so-called centroacinous cells.

Along the main duct and its primary branches are small glands consisting for the most part of mucous cells, but containing also goblet cells and undifferentiated duct epithelium. In the guinea-pig, and probably also in man there is present a system of fine

tubules, lined by epithelium of a low order of differentiation, which connect the different segments of the duct with one another, and bridge between the separate branches, so as to form a complicated net of epithelial tubes. These represent the source of new pancreatic tissue, though probably not the only source.

The *secreting elements* of the pancreas concerned in the production of the external secretion are called the pancreatic acini. These vary much in shape from a simple acinus, to a short-branched tubule. Each acinus consists of a single row of pyramidal epithelial cells which are the ultimate secreting elements. In the center of the acinus is a lumen small in size when the pancreas is at rest, but expanded by secretion when the organ is active. In preparations made by the silver chromate impregnation method this lumen is seen to extend in the form of short blind channels between the individual cells of the acinus.

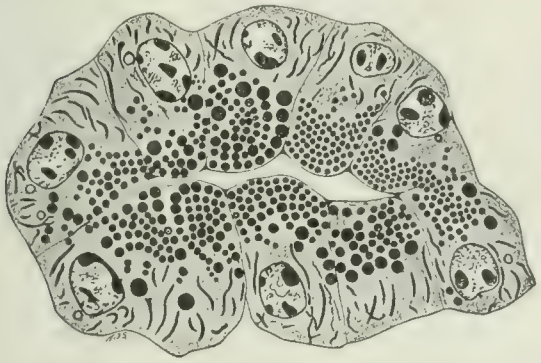


FIG. 4224.—Section of a Pancreatic Acinus of the Guinea-pig, showing mitochondrial filaments imbedded in homogeneous basal substance. (Bensley, Am. Journal of Anatomy, XII.)

The secreting cells of the acinus differ in appearance according to the physiological state of the organ, the difference being due to the varying content of the cell as regards the antecedents of the secretion. In the moderately charged gland the cell shows two distinct zones, viz., a central zone charged with large round highly refractive granules, the so-called zymogen granules, and an outer zone which is glassy clear and homogeneous, except for a slight radial striation. Studied under the best apochromatic objectives, the clear outer zone is seen to be made up of a transparent basic ground substance in which are suspended coarse filaments which are oriented for the most part in the direction of the long axis of the cell. These filaments are mitochondria, a kind of granule found in all protoplasm but present in unusual amount in the acinus cell of the pancreas.

In stained preparations the ground substance of the basal zone stains strongly with nuclear dyes, hence is often called the chromophile substance. For this reason some observers are of the opinion that this substance is of nuclear origin, but whether it is nucleoprotein in nature or not is not yet demonstrated.

The nucleus is spherical in outline, rich in chromatin, and contains usually a well-defined oxyphile nucleolus.

During rest the pancreatic cell accumulates secretion antecedents and the granular zone increases in dimensions at the expense of the basal chromophile zone. Some observers consider that the chromophile substance is used up in this process and hence that it, also, is an antecedent of the secretion, which is thus in part of nuclear chromatic origin. Others consider that the mitochondria are the remote antecedents of the zymogen granules. The facts at present available do not permit a decision in favor of either of these views.

During activity the granules are used up in the production of the definitive secretion, and hence, after a long period of secretory activity, the granules may be reduced to only a few along the free border. At the same time the cell becomes reduced in size, and the chromophilic zone of the cell is relatively increased. Whether the latter is due to an actual increase in the chromophilic material or to a mere readjustment is not yet determined. The highest degree of exhaustion of the cell may be induced in animals by the prolonged use of secretin intravenously, coupled with withdrawal of blood. Under these conditions many cells may be wholly devoid of zymogen granules.

The internal secreting function is served, in part at least, by elements called the islets of Langerhans, which collectively constitute the endocrine gland. These are small masses of epithelial tissue scattered throughout the substance of the pancreatic lobules, varying in size from a few cells to structures one or more millimeters in diameter. The numbers of these structures in the human pancreas have been most accurately determined by Clark, who employed the method of staining them in the surviving pancreas by neutral red, or janus green, thus permitting an actual count without involving computations. He found that the number varied from 3.72 per milligram of tissue to 20.23, giving a total number for the whole pancreas of 208,369 to 1,760,000 for the adult. As Opie has shown, the number in the tail of the pancreas is usually higher than in the body and head though in exceptional cases this condition may be reversed.

Each islet is composed of anastomosing cords of epithelial cells supported by a delicate reticular connective tissue, and separated from one another by large capillary blood-vessels. The richness of the capillary net has led many to compare them with glomeruli.

The cells of which the islets are composed are of at least two kinds called by Lane respectively *A* cells and *B* cells, the latter constituting the main mass of the epithelial tissue of the islet. These two types of cells are distinguished from one another, and from the acinus cells, by the character of their products, the granular secretion antecedents which are stored in the cell. The presence of these two sorts of cells probably indicates a similarly complex internal secreting function.

The blood supply of the islets is distinguished by its richness, and by its direct arterial source. In the larger islets direct branches of the intralobular arteries enter the islet and break up into wide capillaries within it. These capillaries communicate with those of the surrounding tissue, whence the blood enters the small venules of the lobule.

The question of the relationship of the islets to the duct system on the one hand and to the acinus tissue on the other has given rise to much controversy, largely due without doubt to the inadequacy of the methods employed for its investigation. Laguesse has shown, however, that continuity is the rule, and that even where the islets appear to be separate altogether from the remaining epithelial tissue of the pancreas they are really connected with one of the ducts by a short epithelial stock. Inside of the lobules continuity is frequent, cell columns of the islets being directly continuous with the acini surrounding it.

Even though tissue continuity exists between the islets and the acinus, and between the islets and the duct system this continuity does not mean that the islets are transformed acini, or that they discharge a secretion into the duct system. The condition indicates only the mode of the origin of the islets and acini from a common undifferentiated epithelial type.

The question of the physiologic independence and permanence of the islets has also been much discussed, some observers claiming that acinus tissue could be readily transformed into islet tissue by prolonged secretion, or by inanition, others that the islets and the acini represented portions of the pancreatic tissue which were differentiated for separate functions. This

problem is still under discussion though the weight of evidence seems at the present moment to favor the view that the islets represent a specialized pancreatic tissue endowed with a special internal secreting function. In favor of this view are the experiments of Schulze, Ssobolew, and others which show that after the ducts of the pancreas have been tied all of the acinus tissue eventually disappears, leaving a pure endocrine gland consisting solely of islets of Langerhans; and the experiments of Allen and Homans, which show that when the pancreas is surgically reduced to a sufficient degree in the cat and dog, the glycosuria which becomes more pronounced from day to day is associated with progressive degenerative changes in the cells of the islets of Langerhans.

R. R. Bensley.

Pancreas, Diseases and Injuries of the.—Congenital Abnormalities.—Of these the condition of *accessory pancreas* is the most important. Opie found it present ten times in 1,800 autopsies; the true frequency is probably higher than this. The accessory glands are usually about the size of a pea. They are usually found in the muscular coat of the bowel or the stomach and, as might be expected, most often in the upper part of the alimentary tract, the stomach, the duodenum, and the upper end of the jejunum. In cases where the whole pancreas has been removed and diabetes does not develop, it is usually assumed that accessory glands are present and have sufficed for pancreatic function.

Congenital *absence of the pancreas* is extremely rare. According to Deaver and Ashhurst, three such cases have been described by Lancéreaux.

Anatomically the head of the pancreas may surround the duodenum completely, forming a ring around the bowel (*pancréas annulaire*). In one case, reported by Widal, this simulated congenital stenosis of the pylorus and he saved the patient by a gastroenterostomy.

Displacement of the pancreas is very rare and represents usually a pathological condition induced by traction on the part of solid tumors or a wandering spleen. In a few instances the pancreas is prolapsed through stab wounds in the abdomen. The pancreas is perhaps more movable than has been ordinarily supposed. According to Körte, the organ has been found three times in congenital umbilical hernia and also in two cases in umbilical hernia in adults.

Atrophy of the pancreas has been assumed in very rare instances to be a congenital deformity or the result of congenital lues. Byrom Bramwell has described cases of "pancreatic infantilism," characterized by the evidence of absence of pancreatic function to a large degree (fatty stools which were probably due to such atrophy). The condition is, of course, not so uncommon among adults as the result of chronic fibrosis with fatty replacement, but that is another matter.

Pancreatitis.—*Pathogenesis.*—The writer would like at the outset to make one or two somewhat arbitrary statements, which, while suffering possibly some exceptions, are yet in his opinion to be taken as true in the main. They are the more important in that they contradict generally the accepted ideas of say ten years ago.

First, the term "pancreatitis" is a misnomer in so far as that term, taken clinically or pathologically, suggests an inflammation due to bacterial action. The termination "itis" has come so universally to be considered as indicating a bacterial inflammation that it would seem necessary to lay some emphasis on the fact that bacteria play but a small part in the causation of the pancreatic swelling which we ordinarily call pancreatitis. Suppurative pancreatitis is rare as compared with the inflammation which resolves. When bacteria are found, they represent usually a complication of the original lesion.

The second statement is that such varying conditions (hitherto described as distinct and separate entities) as hyperacute pancreatitis with hemorrhage and sudden death, pancreatic apoplexy, acute hemorrhagic pancreatitis, pancreatic necrosis, gangrenous pancreatitis, suppurative pancreatitis, pancreatic cyst (in some cases), and chronic sclerosing pancreatitis, all represent merely different stages of one disease, or varying reactions to the causal agent. It has been the custom in text-books to describe these various lesions under separate headings, and one is struck with the amount of repetition in such descriptions. We believe that it will conduce to clearness if we describe pancreatitis as a single disease with varying manifestations. This ought to render its symptomatology more comprehensible, and will be the more possible in that the work of recent years has advanced our knowledge of the etiology of pancreatitis very considerably and has also unified it. Let us begin, therefore, with a consideration of its pathogenesis.

It has been the custom in text-books to point out certain so-called predisposing causes of pancreatitis, of which the chief are obesity and alcoholism, and to indicate that certain general and local diseases, in particular lues, arteriosclerosis, and local endarteritis obliterans, may bring about sclerosis and in that sense chronic inflammation of the gland; also to point out that the taking of a large meal has very often preceded an acute attack. These considerations, of course, have a very indefinite value. What it imports to know is the actual immediate causative factor.

The premise may be laid down that pathologically we find a continuous series of changes in the gland structure, from that of diffuse fibrosis and atrophy of the organ in chronic cases, through the edematous swelling and cloudy degeneration of subacute inflammations, through the slightly more acute parenchymatous lesions with small areas of necrosis, up to the acute and hyperacute cases characterized by large areas of primary necrosis, with or without complicating hemorrhage, and usually with areas of disseminated fat necrosis. The one runs into the other. The acute case pathologically speaking, may pass into the chronic form. This in its turn may go on to a hyperacute lesion with sudden death.

This unity in the pathological picture suggests very strongly a unity in causation. What is then the immediate causative factor?

We may set aside for the time such cases as are clearly due to chronic general disease, particularly arteriosclerosis and syphilis, in which the pancreatic lesions frequently give rise to no clinical symptoms, being essentially chronic and only part of a general process. What we are now considering is the ordinary attack of pancreatitis so called.

There are conceivable five routes by which infection or any other causal agent may gain access to the pancreas: (1) From the gall passages coming downward. (2) From the duodenal contents working upward through the papilla of Vater. (3) By direct propagation from ulcers or infections in neighboring structures, particularly ulcers of the stomach and duodenum. (4) By way of lymphatics, especially the lymphatics of the gall-bladder. (5) By way of the blood. Let us take these seriatim.

It has been urged that in such general diseases as arteriosclerosis, endarteritis obliterans, chronic alcoholism, typhoid, malaria, lues, tuberculosis, mumps, and hepatic cirrhosis, in which pancreatic lesions have occurred, the infection must have come by way of the blood. This is probably true, but obviously the application can be made only in a very limited number of cases of pancreatitis; as a matter of fact, pancreatitis as a complication of these diseases is an extremely rare event.

It has been urged, chiefly by Maugeret, later by Arnsperger, and last by Deaver, that pancreatic inflammations are due to the transport of infection from

the gall-bladder or the common duct by way of the lymphatics draining these structures. These authors base their arguments upon the fact that, in many cases of pancreatitis, the glands lying upon the head of the pancreas are found enlarged, and they assume, without much apparent reason, that infection has spread to the pancreas not only against the normal lymph current but right through the lymph glands. It would seem more natural to consider that these swollen glands which they find to be present are swollen by the transport of an infection or toxin from the pancreas rather than from the gall-bladder or common duct. To the writer this whole theory appears extremely far fetched. The fact that many cases of pancreatitis are unaccompanied by either stones or obvious infection in the gall passages is also evidence against this view.

It would seem probable that in a few of the reported cases pancreatic inflammation has been the result of a direct extension from ulcerations of the stomach or duodenum. In particular, this seems to have been the case in two patients whose histories are given by MacCarthy of Rochester, Minn. Such cases, however, are rare, and such a mode of causation must be quite exceptional.

There remain for consideration the two other theories, by which, according to some, the cause of pancreatic swelling is to be found in the presence of stones or infection, usually both, in the gall passages; according to others, the duodenal juices gain access through the papilla of Vater, and so into the pancreatic duct. While both these theories are supported in a general way by both clinical and experimental evidence, they both stop short of explaining the final step—the step, namely, which would explain the entrance of noxious material either from the gall passages or from the duodenum into the pancreas. This has hitherto been the missing link.

A large amount of experimental work has shown that all the varieties of pancreatic inflammation which we find in the human can be reproduced experimentally by the injection with a syringe of various substances directly into the pancreatic duct, or by the plugging of the exit of the pancreatic secretion by means of ligatures or the injection of aseptic solidifying substances into the duct. Thus it has been abundantly shown that such aseptic plugging of the external secretion will produce chronic pancreatitis; that the injection of suspensions of bacteria may cause either chronic or acute pancreatitis; that the injection of aseptic bile mixed with gall-bladder mucus will produce a subacute or a mild swelling of the organ, while, if the bile is unmixed with mucus, the reaction is more severe; that the injection of infected bile is apt to produce a very acute pancreatitis, which is primarily necrotic; and finally that the injection of duodenal contents holding enterokinase will produce a similar pancreatic necrosis with very rapid death. It has been maintained that in all these injection experiments the primary lesion is a traumatism of the pancreatic cell, either by the point of the syringe or by the chemical action of the injected substance, and that in all these cases, even where suspensions of bacteria are employed, the primary phenomenon is pancreatic necrosis. (See particularly the article of Opie and Meakins.) All this is undoubtedly true, but none of it explains how bile, either infected or not, or how duodenal contents are forced into the pancreatic duct. It must be assumed that ordinarily bile passes straight past the mouth of the duct of Wirsung into the intestine; and, on the other hand, that duodenal contents cannot under ordinary circumstances force the gateway of the papilla of Vater. This last has failed in experimental conditions, even when the duodenum was ligated above and below and its contents put under pressure. Williams, of Buffalo, has urged that duodenal contents very possibly flow back into the common duct immediately after a gallstone has passed through the papilla of Vater and left it stretched and patent for a little time. Even so, it is difficult to understand how such contents could be driven up into the pancreatic duct in the absence of high pressure in the duodenum, and high pressure is difficult to understand in the absence of obstruction of the duodenum.

Such considerations as these, together with the observation that in at least one-half of the cases of pancreatitis there were present no gallstones, and in a large proportion of the other half gallstones were obviously quiescent and confined to the gall-bladder, led the writer to begin an inquiry which had for its object the finding of some force, normally present, which might be capable of determining the flow of noxious material into the substance of the pancreas, presumably by way of the pancreatic duct. It was soon found, from manometer observations of hydrostatic pressure in the common duct, that there existed a sphincter at the outlet of the common duct surrounding the neck of the ampulla. This sphincter was found to resist the passage of fluid into the duodenum (the fluid being introduced into the gall-bladder) under known pressures amounting to anywhere from 300 to 700 or 800 millimeters of water). When it is considered that the normal pressure under which the bile is secreted by the liver—this secretion being a continuous one—is from 100 to 130 or 140 millimeters of water, it becomes clear that the sphincter of the common duct is capable of withstanding a pressure from three to six or seven times greater than that of bile secretion. It might almost seem as if the gall-bladder were the natural consequence of this sphincter, and phylogenetically a phenomenon of adaptation, resulting from a primary or preceding formation of the sphincter. Indeed, when the gall-bladder has been removed, it is common to find at a subsequent laparotomy dilatation of the stump of the cystic duct into a new, though small, gall-bladder, or else a considerable dilatation of the common duct.

It may here be said, parenthetically, that although the writer did not know it at the time, this sphincter had been discovered by an Italian physiologist, Oddi, and his observations were published as far back as 1883, but it remained generally unknown save to physiologists. In what follows I shall refer to it as the sphincter of Oddi or the sphincter of the common duct.

The next step was, obviously, to demonstrate experimentally whether this sphincter could under any circumstances, as for instance by getting into prolonged spasm, dam back the bile and so bring it under pressure sufficient to force it into the pancreatic duct. It was sought to answer this question experimentally by introducing a solution of ferric chloride with two per cent. of gelatin into the gall-bladder under a known manometric pressure, at the same time opening the duodenum and watching its flow from the papilla. In five out of six cats it was discovered by appropriate staining methods that the iron solution had penetrated the pancreas in the greater part of its extent. This was accomplished either by suddenly raising the pressure to 700 to 800 millimeters of water or by the application of from five to fifteen per cent. of hydrochloric acid to the duodenal mucous membrane overlying the papilla—a procedure which would always set the sphincter in spasm.

While these experimental results cannot be transferred without reserve to the human, they are nevertheless most suggestive. The anatomical relations of the pancreatic ducts to the common duct and the ampulla of Vater in the cat correspond fairly well with those that are found in man. It seems to the writer that these facts offer at least a sufficient basis upon which to establish a reasonable hypothesis as to the immediate cause of pancreatitis.

The one fact which we possess in clinical and pathological observations bearing upon this subject is the well-known observation of Opie, who found in a fatal

case of pancreatitis a retroinjection of bile into the pancreas as the result of a stone lodged in the ampulla of Vater, which was of so exact a size that it occluded the outlet of the common duct, while leaving open the entrance into the pancreatic duct. Opie demonstrated by the anatomical examination of 100 cadavera that in about thirty per cent. of cases the duct of Wirsung opened into the common duct far enough away from the papilla to allow the occurrence of such a set of circumstances as had been present in the case described. It is obvious, however, that such a fortuitous combination of circumstances cannot often be present in cases of pancreatitis. And, as already remarked, an examination of the records of the Royal Victoria Hospital, Montreal, showed that in over half of the cases of pancreatitis gallstones were absent, and that in a large proportion of the remainder they were present only in the gall-bladder.

Under these circumstances it may be permissible to advance the following hypothesis: the cause of pancreatitis is most frequently to be sought in the entrance of bile, sometimes of infected bile, rarely of duodenal contents, in minute quantity which has found its way through a temporarily dilated papilla (recent passage of stone, as suggested by Williams) into the main pancreatic duct. The mechanism by which this is accomplished is to be found in an abnormal working of the sphincter of the common duct, presumably a spasm lasting for an undue time so as to raise sufficiently the general pressure in the gall-bladder and extrahepatic bile passages. Under these circumstances the very low pressure under which the pancreatic secretion is ejected from the gland offers no resistance to the inflow of the contents of the common duct.

It is the writer's conception that such an injection of bile into the pancreas may not infrequently occur, but when the bile is normal and contains its due amount of mucus, no harm is done to the pancreatic cell and no clinical symptoms are evoked. Flexner showed the truth of this experimentally. On the other hand, when by reason of occlusion of the cystic duct the bile remains unmixed with mucus derived from the gall-bladder epithelium, then, as Flexner again showed, the effect of the bile salts (sodium taurocholate) upon the pancreatic cell is more pronounced, and there occurs a mild aseptic inflammatory reaction, which, it may be supposed, would be sufficient to cause a moderate degree of pain. Such a condition subsiding rapidly, as one might expect, would give a comparatively mild and short clinical disturbance. This, one may believe, represents a certain number of those short and subacute attacks of pain in the pit of the stomach which have been so frequently diagnosed as gastritis, or simple upset of the stomach, or gallstones, or peripyloric adhesions, or ulcer. If again the bile happens to be infected, it becomes easy, upon the basis of a great deal of experimental evidence, to understand the occurrence of more severe grades of pancreatic inflammation. The writer in laboratory work has found that the worst cases of hemorrhagic pancreatitis follow the injection of the pancreatic duct with a small amount of bile infected by *B. coli* and allowed to stand in the incubator for some days. These represent the cases of severe pancreatitis which seem to follow upon and in some way to be dependent upon a long history of stones in the common duct with cholecystitis and cholangitis. The fact, however, that so many cases of pancreatitis are unaccompanied by gallstones or even by gross infection of the bile, suggests the possibility of the entrance of duodenal contents upward into the common duct and their later retrojection into the pancreas. Just how this occurs in the absence of gallstones which might overdilate the papilla and paralyse the sphincter of the common duct for some little time after their passage, it is difficult to understand, but it is not unreasonable to guess that there might occur moments during which the sphincter of the common duct was relaxed and at the same time the duodenum contracted below the papilla, while the stomach was forcing contents under pressure into the duodenum. If at this moment even a small amount of duodenal contents containing enterokinase flowed up into the common duct and was there held by subsequent closure of the sphincter of the common duct, it is clearly possible that enterokinase might be forced into the pancreatic duct with or without bile, and there activate trypsinogen, forming active trypsin. This ferment might then attack pancreatic cells causing necrosis, and necrosis would be the first link in the chain leading to widespread pancreatic necrosis with hemorrhage, or such necrosis might stop short at a lower level of destruction and of inflammatory reaction.

In this way one might picture to oneself, with what seems to me quite sufficient evidence to go upon, the mechanism by which from one common cause all grades of pancreatic inflammation and pancreatic necrosis, from the least to the greatest, may be produced. It is this unity of the picture that I would like to emphasize. The slight attack of pancreatic swelling (such as the writer has been able to demonstrate by laparotomy after making a diagnosis) which passes off after even a few hours of epigastric pain, is in essence not different from the terrible and complete destruction of the gland with hemorrhage which leads to death in an hour or two. Necrosis or gangrene, suppuration, hemorrhage, even the replacement fibrosis of the chronic cases, are all merely variants of the one thing, and represent differences in virulence of the material which has gained entrance to the pancreas and of the reaction on the part of the parenchyma.

Pathology.—Although it has seemed wise to the writer in discussing the pathogenesis of pancreatitis to emphasize the unity of the general picture, and although this unity is also found in the pathological picture, it is still necessary in describing the gross and histological anatomy of the disease to set up, as has been done in the past, certain types. There is a chronic pancreatitis and there is an acute pancreatitis, and between the two there are various stages.

Chronic pancreatitis, like inflammatory lesions in other organs, is characterized chiefly by a new formation of fibrous tissue in the gland. Following Opie we distinguish two types: the one—interlobular, in which the fibrosis is confined to the stroma separating the lobules; the other—interacinar, in which the fibrous tissue invades the lobules and separates the acini and sometimes even the individual cells from each other. Opie says that when the interlobular tissue is the seat of predominant change, the gland is hard and dense, and has a nodular or granular surface. In the interacinar type, on the other hand, the organ tends to become tough rather than hard, and the surface is smooth. Not infrequently, however (he adds), the pancreas affected with either variety of inflammation may be so little altered that the lesion is recognized only on microscopical examination. Abundant fat infiltrating the newly formed tissue between the lobules and acini may obscure the gross characters of both types. It would appear that the interlobular form usually follows partial or complete occlusion of the pancreatic ducts, and the same picture can be produced experimentally by ligation of the ducts or by filling them with a solidifying substance. It is peculiar, however, to this form that the islands of Langerhans remain completely unaltered, except in very advanced cases. "The islands of Langerhans resist the sclerotic process which follows the damming back of secretion upon the gland and finally suffer only when the acini are almost entirely destroyed and replaced by dense scar-like tissue."

In the other form, interacinar pancreatitis, the fibrosis is diffuse but somewhat irregular in distribu-

tion. This type is much less common than the interlobular form. According to Opie it is peculiar to this form that the islands of Langerhans "are almost constantly surrounded by fibrous tissue, which forms, as it were, a capsule separating them from adjacent acini, which are themselves abnormally separated from one another." His conclusion is that the islands suffer in common with the acini and suffer early. The observations of Opie have led him to defend the theory that in this form glycosuria is apt to be fairly early and permanent, as the result of the early involvement of the islands, while in the interlobular form, in which the islands escape interference from newly formed fibrous tissue, glycosuria is infrequent and very late.

A very considerable infiltration with fat is quite frequent in association with chronic interstitial inflammation. Opie says that the lesion is analogous to the fatty infiltration that accompanies atrophy of a voluntary muscle. "Lipomatosis, which is not infrequently found with diabetes mellitus, usually accompanies interstitial pancreatitis."

Interlobular pancreatitis is usually due to occlusion of the pancreatic ducts by gallstones, pancreatic calculi, or other obstruction to the outflow of the pancreatic juice, or, in other cases, it follows upon acute ascending inflammation of the pancreatic ducts. On the other hand, interacinar pancreatitis seems to be most frequently a phenomenon of generalized arterial sclerosis. Whereas the former is frequently associated with fairly well-marked clinical symptoms suggesting attacks of inflammation, the latter is usually a quite symptomless process which ultimately makes itself known only by the evidence of disturbed digestion, depending upon a complete or almost complete destruction of the secreting gland substance with consequent failure of ferment action. It is in these cases that we find the bulky white fatty stools containing undigested muscle fiber, which portray the lack of trypsin and lipase.

Acute Necrosis of the Pancreas.—At the other end of the line from chronic pancreatitis there comes that acute or hyperacute pathological condition which in the past has been variously termed pancreatic apoplexy, hemorrhagic pancreatitis, acute pancreatitis, gangrenous and suppurative pancreatitis, and for which recently Opie and Meakins have proposed the name of hemorrhagic necrosis. The older names, as we now understand, largely as a result of Opie's work, emphasize far too much the element of inflammation. The word "pancreatitis" must, it is true, hold its own, having come into such general use, but it must be understood that the idea that inflammation is the primary lesion in these acute affections of the pancreas is erroneous. Opie and Meakins have pointed out very rightly that the discussion as to whether inflammation or hemorrhage was the primary factor, is largely rendered null by the fact that neither is. Necrosis is the first lesion, and with the spread of necrosis there may or may not come hemorrhage, according as vessels are or are not destroyed by the necrotic process. In the same way inflammation, that is, bacterial inflammation, may or may not associate itself with the inflammatory changes induced by necrosis. Frequently bacteria are conspicuous by their absence, and in most cases inflammation is peripheral and merely the expression of tissue reaction. Inasmuch as hemorrhage in many cases does not occur, it is, I think, best to adopt the suggestion of Guleke and call these acute swellings of the pancreas which we have been accustomed to terming acute pancreatitis—acute pancreatic necrosis. This conception would include the cases of so-called acute pancreatitis, acute hemorrhagic pancreatitis, pancreatic apoplexy, and gangrenous pancreatitis.

The pathological picture of acute pancreatic necrosis is now fairly well known. The organ is usually enlarged, often to two or three times its normal size. It is hard and edematous, and on cross-section shows a marbled surface. According to the degree of hemorrhage present the surface shows irregular yellow, red, or almost black areas upon a dull white field. The hemorrhage may be very large and give the whole organ a bluish-black appearance. But in many cases hemorrhage is very slight or even absent, and then the surface shows merely a dull white or slightly yellow surface frequently dotted with areas of yellowish-white opaque fat necrosis. In the microscopical picture the necrosis is shown in the disappearance of nuclear staining and the complete destruction of gland cells, ultimately also of the fibrous stroma. The secretory ducts withstand the necrosing process longest, while the blood-vessels early become thrombosed, In later stages there appear the signs of inflammatory reaction surrounding the foci of necrosis. According to the extent of the necrosis one may find the whole gland ultimately extruded as a slough in an abscess cavity, or part of the gland may be softened and shreddy fragments of sloughy tissue sequestrated. In such cases, whether bacteria complicate the picture or not, there is apt to develop an abscess containing broken down tissue and altered hemorrhagic fluid. Such abscesses are apt to point, if the patient lives long enough, in the left lumbar region, although occasionally they may break through into the bowel or the peritoneum.

The most characteristic and striking phenomenon associated with pancreatic necrosis is the condition, first described by Balser, of fat necrosis, which although not always to be found is still very frequent. Many a surgeon when doing an exploratory laparotomy for supposed perforated gastric ulcer has had his mistake revealed to him immediately upon entering the abdomen, by seeing in the omentum these small yellowish-white opaque areas of necrosis of fat, which are quite unmistakable. They are to be found in the liver, and in the peritoneal, mesenteric and omental fat, especially in the neighborhood of the pancreas, but they have been discovered as far away as in the mediastinal, pericardial, or even the subcutaneous fat.

We now know from the work of Langerhans and Hildebrand that fat necrosis is caused by the action of the pancreatic ferments. The neutral fat of the fatty tissue is split by the lipase of the pancreatic juice into soluble soaps and insoluble calcium soaps. Flexner discovered the fat-splitting ferments in these areas of fat necrosis.

It is remarkable how early these foci of fat necrosis may be produced. I have seen them widespread and large as early as eight hours after the onset of an acute attack. The idea of fat necrosis in acute pancreatitis is now so universally known that it is important to warn the physician that in many instances, particularly in the less violent forms, it may be absent. I have seen quite a number of instances in which this was the case.

Another most characteristic phenomenon in the pathology of acute pancreatic necrosis is the blood-tinged serous exudate in the peritoneum which is usually at first sterile, although after a few days it may become purulent. It is probably due to the irritating effect of ferments travelling along the subperitoneal lymphatics.

Symptoms.—If we regard the symptomatology of pancreatitis from the broadest standpoint, including all the forms of the disease from the mildest to the most severe, we may, I think, classify the symptoms into four groups. First, those due to interference with the pancreas itself. These include, naturally, pain and tenderness—presumably from inflammatory pressure upon the sympathetic nerves in the neighborhood. They also include what I may call the chemical signs. I refer to those which are due to the interference with body chemistry, and in particular to the appearance of substances in the urine which are

recognized by the Cammidge test (the so-called pancreatic reaction of Cammidge), the lipase test, and the character of the feces.

In the second place there are those which are due to interference with the excretion of the bile through the common duct, particularly the symptom of jaundice.

Thirdly, there are those which are due to interference with the peritoneum, the expression of what is practically an irritative or chemical peritonitis.

In the fourth place there are those due to interference with the nervous system, chiefly the motor nerves of the bowel, resulting in obstruction and in shock.

This tabulation is to be taken as a very general one. All the varieties of interference mentioned do not by any means occur in every case.

Of the class of *acute pancreatitis or acute pancreatic necrosis* we may distinguish two varieties: the fulminating and the ordinarily acute condition. Fulminating pancreatitis causes death almost immediately or within a few hours, either from shock or from an extraordinarily acute toxemia. I imagine that the cause of sudden or almost sudden death must be the extreme pressure of hemorrhage and inflammatory exudate on the solar plexus, comparable with the prize-fighter's blow in the epigastrium. Acute toxemia is now believed to be due to trypsin intoxication, if we are to depend upon the experimental work of Guleke, Polya, and others.

In this acute class we distinguish perhaps half a dozen chief signs. There is first the shock-like onset simulating that seen in the worst cases of perforating gastric ulcer. The pain is often extraordinarily severe and sudden. Collapse is marked, with its small pulse, shallow respiration, and subnormal temperature. This condition of shock may persist for a number of hours and go on to either death or recovery. Secondly, there is the peculiar lack of febrile signs, at least for a couple of days. The pulse remains slow and the temperature is more often below than above the line. If the patient lives beyond the first two or three days, intestinal obstruction is apt to be marked. Several of our cases have been brought in with a diagnosis of obstruction. This is due certainly to a reflex bowel paralysis. The pain is chiefly epigastric, although in a very short time it may spread over the whole abdomen, and the patient be unable to say in what part of the abdomen his pain really is. Yet even in these cases palpation will reveal the fact that the epigastrium is the seat of greatest tenderness. After the first few hours it is frequently observed that there is also tenderness in the lower half of the abdomen, and further that while the epigastrium is quite rigid there is marked muscular resistance also in the iliac regions. I feel sure that this low-seated tenderness and rigidity are due to the development of an irritative serous peritonitis, which in its turn is the result of the spread of pancreatic ferments along the subperitoneal lymphatics. It is extremely common at operation to find the abdomen full of blood-tinged serous fluid and to see the peritoneum congested and reddened. This rarely goes on into frank suppuration; the serous fluid is usually reabsorbed. So far from leading one away from a diagnosis of pancreatitis, I regard this lower area of tenderness as useful in diagnosis if gastric ulcer is excluded. Finally, after the first two or three days there will often develop jaundice. The swelling of the head of the pancreas presses upon the common duct and causes a true mechanical obstruction to the exit of bile. We know from postmortem observations, particularly those of Opie, that the common duct perforates the head of the pancreas in at least one-third of the cases, and is in these, doubtless, particularly subject to compression from pancreatic swelling.

The case report of one of our typical cases of this variety is as follows:

A. L. H. (Surgical Case No. 10878, Book 72), aged forty-six, was admitted to the Royal Victoria Hospital, Montreal, on November 7, 1905. For the past five years the patient had had attacks of pain about once a year, located in the upper abdomen, but not radiating to the shoulder. The pain was very severe and was accompanied by vomiting and slight jaundice. There was no marked constipation. The stools were not noted. The attacks lasted from two to three days. The patient was an alcoholic.

The present attack began November 2 five days before admission), up to which time the patient had been perfectly well. Pain was severe and reached its maximum rapidly (one and a half grains of morphine being necessary in one hour). It was located chiefly in the upper half of the abdomen and in the right iliac region. On November 3, vomiting occurred, and on November 4 hiccough was noted. Constipation was not marked. There were five voluntary stools in which the attending physician noted free fat. Jaundice developed on the third day.

Upon examination on admission it was found that there was general fulness of the abdomen and general abdominal tenderness, apparently most marked in the right hypochrondrium and in the epigastrium, but the patient was very toxic and apathetic and it was difficult to get any reliable answers from him.

Under the diagnosis of gallstones a cholecystostomy was immediately performed. Bile sand in small amounts was found in the gall-bladder and in the cystic duct, but the bile, the gall-bladder, and the ducts seemed quite normal. There was a mass in the region of the pancreas and the omentum was studded with fat necrosis. The patient died with the symptoms of severe toxemia thirty hours after operation.

It was considered that the gall passages were free from any material infection and that the pancreatitis was due to some infection primarily pancreatic. Postmortem examination confirmed the observation that the bile passages were free and that there were no gallstones in the intestinal tract. The pancreas was swollen to three times its normal size and showed numerous small and one large infiltrating hemorrhage.

Among the clinical signs I have come to think that the location of the tenderness to palpation is the most valuable. In my own mind the diagnostic sentence may be put briefly somewhat as follows:

Given a case of acute abdominal pain referred chiefly to the upper half of the abdomen, if upon examination one finds the greatest tenderness located in the epigastrium about midway between the umbilicus and the ensiform cartilage, extending perhaps one inch or one inch and a half to the right, but in particular a similar distance to the left also, while absent over the gall-bladder region; if, further, in the history there are absent the symptoms of gastric or duodenal ulcer, and if there is no evidence of an acute intestinal obstruction in the way for instance of a strangulated hernia, then one may reasonably say: "This is in all probability a case of pancreatitis."

The Subacute and Chronic Relapsing Forms.—Pancreatitis in the acute form is fairly well known nowadays to the general practitioner. It is so dramatic and so sudden that everybody has read about it and is on the lookout for it. We have the impression that the same cannot be said of the milder forms of the disease. We believe that it is not yet widely known that many of the attacks of acute pain in the upper abdomen, which pass off in a few hours or a few days, are due to a subacute swelling of the pancreas. These cases are too often set down vaguely as acute gastritis, or gastric fever, or gastric ulcer, or are allowed to go without diagnosis.

This type the writer has studied somewhat closely in a late paper. The material upon which it was based comprised the records of thirty-two cases of pancreatitis, acute and chronic, all of which were proved by operation or by autopsy, occurring in the services of the late Dr. James Bell, Dr. A. E. Garrow, and the writer, in the Royal Victoria Hospital. A considerable number, perhaps a score, in which pancreatitis was diagnosed clinically but which lack operative or autopsy confirmation, are not included. Of the thirty-two cases eleven were observed in the service of the writer.

In a preliminary way it may be said that the analysis of the symptoms justifies our concluding that the diagnosis is frequently not especially difficult, not nearly so difficult for instance as in the very acute

cases with hemorrhage and necrosis. Indeed, of the eleven cases in my service it was possible in seven to establish a reasonably sure diagnosis before operation.

If one now takes up the symptoms in order, one naturally begins with that of pain. To put it briefly, the feature of outstanding importance is usually pain in the upper abdomen, recurring at irregular intervals. The situation of the pain is nearly always in the mid-epigastrium. It was so in eighteen of the twenty-one cases, while in three it is set down as being in the right upper quadrant. The sufferer from a gallstone attack, upon the request to place his hand over the site of pain, usually indicates the region of the upper right rectus or further outward; while the victim of pancreatic swelling will almost invariably put his hand directly in the midline or sometimes a little to the left. This is true except during the extremely acute phase of hepatic colic, when the pain is so severe that it frequently occupies indiscriminately the whole upper abdomen and cannot be referred to any one area in particular. But, when the initial pain has somewhat subsided, the value of the localization indicated is considerable. Certain exceptions must be noted. Thus, we have been led into the error (chiefly by this sign) of diagnosing pancreatitis when the real lesion proved to be an acute interstitial cholecystitis, the gall-bladder occupying an unusual position close in toward the median line. Even in this case one might have been saved the mistake, had one paid due attention to the localization of the pain toward the end of the attack just before it subsided entirely; for it was then found to be situated a little to the right and to have disappeared in the midline.

Various anatomical points or landmarks have been given as being particularly indicative of pancreatic swelling. Thus, Mayo Robson's point is situated an inch to the right of and an inch above the umbilicus. Dujardin's "point pancréatique," supposed to correspond to the exit of the duct of Wirsung, lies five to seven centimeters from the umbilicus on an oblique line drawn from the umbilicus to the apex of the right axilla. The experience derived from the cases upon which this report is based does not agree with that of the authors just mentioned. There is no fixed point. In practically all cases the area of tenderness has been mapped out with great care by finger pressure. We think it important that this method of palpation should be employed; for, if one uses merely the palm of the hand here and there in the epigastric region, one gets no more than the evidence of ill-defined tenderness somewhere in the epigastrium. Such a method will do little to distinguish such differing lesions as cholecystitis, gastric or duodenal ulcer, gastritis, high intestinal obstruction, and pancreatitis. On the other hand, by the method of finger-point pressure, advancing gradually from all sides toward the epigastrium as a center, one is easily able to demonstrate in cases of pancreatitis a more or less well-defined area of tenderness, in which there will be one or two points of maximum tenderness, an area which corresponds accurately enough with the anatomical position of the pancreas. As a natural result it will be found that the tenderness can frequently be elicited on the left side as well as in the middle and a little to the right. It rarely extends more than one inch to the right, whereas in some cases, when the swelling affects the whole gland, the tenderness may be followed out nearly to the tail of the pancreas. The point of maximum tenderness is usually found to be exactly in the midline, from one to two inches above the umbilicus. Sometimes this maximum tenderness extends half an inch or an inch to the right, or an equal distance to the left. In our opinion this is merely the result of the fact that the acute swelling of the pancreas occupies usually the head and isthmus of the gland, less often the tail, and also that in the midline the pancreas is nearest to the surface and lies upon the prominent bony bed of the vertebral bodies.

The depth at which the pancreas lies would seem also to be responsible for two other particularities in the matter of tenderness. The first is that there is rarely any superficial tenderness except in the severity of the onset, during which period one will occasionally find a head zone of skin hyperesthesia. During the subsiding stage one will frequently have to go moderately deep with the finger before exciting tenderness. The other is the presence of tenderness in the left costoiliac space behind, in which situation one comes more or less directly upon the left half of the gland. If this portion happens to be swollen, tenderness in this area is a marked symptom. I have never found tenderness in the corresponding region on the right side.

While spontaneous pain referred to the epigastrium, being as it is of a subjective character, is notoriously of uncertain value in diagnosis, this sign of tenderness to pressure, upon which we have insisted at some length, is of very much greater value, inasmuch as it is objective. While the complaint of epigastric pain may represent almost any interference with the sympathetic nerve supply of the whole abdominal cavity, localized epigastric tenderness must, as a rule, indicate a localized epigastric lesion. In general terms it may be affirmed that localized tenderness in the abdomen represents very accurately the site of inflammatory processes. It is for this reason that slight differences in the situation of tenderness possess so great a value in distinguishing between lesions of the various organs which are assembled so closely together in the epigastrium. Before concluding these remarks upon the situation of the pain, we would like to express the conviction that if tenderness is definite to the left of the midline and if one can exclude a cardially placed gastric ulcer, one has in that fact rather strong evidence for the existence of a subacute pancreatic swelling.

The radiation of pain has no regularity. Frequently it goes directly through into the back, without reference to one or the other side particularly. Frequently it extends into the right or left hypochondrium, or both; frequently into the right and left iliac regions, not often to the shoulders. Quite often the patient affirms that it has not radiated anywhere but is fixed in the epigastrium. The variations, we think, correspond in some degree with the severity of the pain.

The degree of pain is frequently characterized by its extraordinary severity. We are under the impression that the pain is more agonizing than that of any other acute lesion of the upper abdomen, including perforated gastric ulcer. Large and repeated doses of morphine frequently fail of their effect.

Its duration is very variable, being according to the severity of the attack. The pain may last, so far as one can judge from the histories, as short a time as a half hour or even less; or it may persist for a week or more.

As to the recurrence of the attacks, this also varies widely. One patient had slight attacks of pain nearly every day for seven months, and then developed an acute attack ending in total necrosis of the pancreas and death in a few weeks. Another had mild attacks about once a month for ten years. Two patients, girls of twenty-one and twenty-two years of age respectively, had had frequent attacks every year since the age of fourteen. Another had apparently had frequent attacks for twenty-five years. In all these one could exclude the possibility of gallstones, which were not present at operation. But in some the presence of adhesions around the pylorus, duodenum, or gall-bladder, even in the absence of gallstones or of the evidence of ulcer, left the diagnosis of the cause of these frequent attacks a little unclear. Nevertheless, in some of these even adhesions were absent, and one is obliged to assume that a short attack of epigastric pain lasting half an hour or less may in all probability

be set down to transient swelling of the pancreas, the cause of which remains obscure. Very possibly a passing obstruction to the discharge of pancreatic juice or a spasm of the papillary sphincter may lie at the root of it.

In three cases the pain amounted only to chronic epigastric distress, with occasional sharper, although still mild attacks of pain. In all these the pancreas was found enlarged and harder than normal, either in the head or throughout the organ.

The incidence of pain in regard to the taking of food seems to be most uncertain. It would seem clear that in some cases at least the taking of any food was liable to provoke an attack, so that some of the patients volunteered the information that they had limited their diet for long periods of time to little more than fluids. So far as one can tell, the carbohydrates are more apt to cause or to aggravate the pain than the other kinds of food; and this is more or less in accord with physiological findings, which go to show that the carbohydrates provoke a large flow of pancreatic juice. In many cases, however, the attack seems to have come on while the patient was fasting.

Like appendicitis, pancreatitis is typically relapsing. In five of these nineteen cases the relapse ultimately took the form of the acute necrosing or hemorrhagic pancreatitis ending in death. Chronic relapsing pancreatitis is therefore a dangerous disease, more dangerous certainly than appendicitis.

The presence of palpable tumor is rare. Only in two cases, so far as one can tell from the histories, has it been present, and both of these were thin women. On the other hand, it is quite frequent to find mention in the histories of an indefinite fulness or enlargement in the epigastric region. It must be remembered that because of its deeply placed position, a swelling of the pancreas must attain considerable size before it can be easily felt. Aortic pulsation, if unnaturally prominent, or too easily felt, is suggestive. In thin people this sign has but little significance, but in stout patients it should arouse suspicion.

The symptom of jaundice in cases in which common duct stones are excluded is of but moderate value in diagnosis. It was present only in nine out of nineteen cases and it was characteristically slight and transitory. One may say of jaundice that it is remarkable rather for its absence in pancreatitis than for its presence.

Vomiting is present as a rule, although in three of the twenty-one cases it was absent. These, however, were of comparatively mild type. Chill is quite frequently found and has some value in differential diagnosis. Emaciation is rarely seen.

Rigidity is usually remarkable by its absence or its slightness, except in the later stages of the more acute cases when the peritoneum becomes involved. It is of course present to some degree but, as the pain subsides, it requires fairly deep palpation to elicit muscular resistance. The respiratory movements are frequently not much limited. It must be remembered that the flanks and the lower parts of the abdomen on both sides are apt to be tender to palpation, although the area of maximum tenderness is in the epigastrium. It is fairly certain that this spreading tenderness is due to a mild peritonitis, set up by the diffusion of the pancreatic ferments along the preperitoneal lymphatics, which excite frequently a serous or even sanguinolent fluid in the peritoneal cavity.

To sum up, in the diagnosis we are inclined to lay the greatest stress on the situation of the tenderness upon finger palpation; the differential diagnosis must bring into consideration chiefly gastric and duodenal ulcer, cholecystitis, cholelithiasis, mesenteric embolism or thrombosis, renal calculus, high intestinal obstruction, and neurosis; all these possess fairly certain signs and symptoms of their own and give fairly clear histories, which we need not recount in detail.

Perhaps the most serious difficulty is found in differentiating the disease from gallstones. When these are confined to the gall-bladder and the symptoms are due chiefly to cholecystitis, the diagnosis is best made from the location of the tenderness on palpation, which in one instance is chiefly in the midline and in the other chiefly in the right hypochondrium. If, on the other hand, the stone is in the common duct, it may be impossible to be sure of the diagnosis. Indeed, as we all know, both conditions are not infrequently present coincidently. But even in such cases the tenderness will usually be found to extend over the midline and to the left when the pancreas is involved coincidently with a stone, and only to the right of the midline or in the midline when stone alone is present. Of course, these somewhat finical differences can be made out, as already said, only upon careful and methodical finger-point palpation.

The same localized tenderness in the midepigastrium or a little to the left is found also in cases of gastric ulcer; but here the tenderness is usually less diffuse than in pancreatitis, more localized to one point; besides which the clinical courses of the two diseases are fairly distinct. It is very unusual in gastric ulcer to get a history of recurring attacks of diffuse epigastric pain with fever. Nor in pancreatitis is it usual to find the rather characteristic aggravation of pain shortly after the taking of food as in ulcer. Duodenal ulcer is easily distinguished by its hunger pain and its relation to the ingestion of food. The pain of pyloric and gall-bladder adhesions may be difficult to exclude, but these practically never give rise to such acute symptoms as does the ordinary attack of pancreatitis.

Upon the whole Dr. Bruère and ourselves are of the opinion that the test for the starch-splitting ferments offers the best chance of positive results. The results with the estimation of lipase, which has been worked out with some thoroughness during the last five or six years, are less encouraging, although by no means without promise; an article on this subject is under preparation. To sum the matter up, it may be said that the finding of amylase in the urine in undue amount is of strong confirmatory value, while its absence by no means excludes pancreatic swelling.

Treatment.—The treatment of pancreatitis, in all save the advanced stages of the chronic disease characterized by the evidence of permanent destruction of the pancreatic tissue, has come to be surgical. Riedl in Germany and Mayo Robson in England were the first to lay down the principles of operation in pancreatitis and particularly to include cases of chronic pancreatitis.

In the very acute form certain indications have to be met. The serous and hemorrhagic fluid in the peritoneum must be evacuated; the engorged pancreas must be packed off; and the bile passages must be freed of stones and drainage supplied for infection that may be present.

With regard to the second point, it is still a subject of dispute whether one should incise the capsule of the pancreas or not. One should not incise the pancreatic substance itself unless to empty hemorrhagic collections which are pointing. The writer's opinion is that in most cases it is unnecessary to do anything more than pack gauze above and below the organ. Access is best obtained by tearing through the gastrocolic omentum, but in addition the gastrohepatic had better also be opened and the lesser sac explored and packed with cigarette drains. No extensive operation on the common duct should be done for the acute cases. They are frequently suffering from shock and it will be better simply to drain the gall-bladder.

For the subacute and chronic cases treatment will resolve itself chiefly into a thorough toilette of the bile passages and gall-bladder and bile drainage. The chapter upon the etiology of pancreatitis sufficiently explains the writer's attitude in this matter. While agreeing with the general recommendation that drain-

age of the bile is a proper procedure, it is to be pointed out that in many of the cases such bile drainage is not for the sake of draining *per se*, except where infection is palpably present, but chiefly as a safety valve for pressure inside the biliary system. With this reservation made, we think it advisable to do a cholecystostomy rather than a cholecystenterostomy, for reasons which are set forth below. The period during which drainage should be kept up varies with the degree of swelling found in the pancreas. For the cases in which the pancreas is greatly swollen and particularly where there has been slight jaundice, we think it advisable to keep the cholecystostomy open for at any rate two months, in order to give ample time for the swelling in the pancreas to subside. The whole cure of pancreatitis must be considered as essentially due to nature's efforts and the cholecystostomy is only the means of preventing any interference with her efforts.

A proper estimate of the constantly active functioning of the sphincter of the common duct ought to assure us that the keynote of the treatment of chronic or subacute pancreatitis is not "drainage of bile" but reduction of excessive pressure in the biliary system. The cholecystostomy that we perform drains but a fraction of the total quantity of bile secreted, unless the common duct is quite obstructed—a comparatively rare event in subacute and chronic recurring pancreatitis. But the cholecystostomy is a safety-valve against undue back pressure on the part of the sphincter, and in this way prevents further entrance of bile into the pancreatic duct, thus giving the pancreatic swelling a chance to subside by natural means. But cholecystostomy is a temporary measure. Cholecystenterostomy, on the other hand, is not to be advised save where the obstruction of the common duct is permanent, and that is very rarely the case with pancreatitis. Several years ago I demonstrated that a cholecystenterostomy in the presence of a patent common duct was simply useless. No bile passed by it at all. And moreover it invites infection. I would suggest that, from the mechanical point of view, the rational procedure to reduce pressure in the biliary system and so avoid a recurrence of the pancreatitis which has been the result of too high a pressure in that system, would be to cut the sphincter of the common duct. This I have done in five dogs and two cats. The operation results in an absolute and permanent abolition of resistance to the exit of fluid into the duodenum. The pressure is immediately reduced to the level of the general pressure in the biliary passage outside of the liver. The sphincter does not regenerate.

I believe that such an operation would be justifiable in certain cases of pancreatitis—not of course in the very acute ones, rather in those which tend to recur in the subacute form or to become chronic, and in which a cholecystostomy, kept open for at least two months, has failed to effect a cure. It means a transduodenal operation, which in itself is no barrier, but it means also, as bacteriological investigations in these seven animals have demonstrated, a liability to an ascending infection of the bile ducts, at least into the gall-bladder, which, though it seemed not to disturb the health of the animals in any way, cannot be disregarded. Such an ascending infection I have seen disappear in the course of two months in one animal. On the other hand, the after-course of the published cases of transduodenal choledochotomy (which must usually cut the sphincter) is apparently so good, in spite of this danger of ascending infection, that I feel the more encouraged to perform the operation if a suitable case should present itself.

While it is certainly indicated in all cases during the acute or subacute stage to do a cholecystostomy, it is a matter of discussion whether one should do the same operation in the chronic relapsing cases during the interval. It is the writer's opinion that this should certainly be done. In perhaps one-half of the cases there will be gallstones to remove and experience shows that a prolonged drainage of the bile to the exterior very frequently results in an apparent cure. The writer has one patient of this type, now well after six years, who had a series of attacks during the year previous to operation and in whom there were no gallstones present.

The results of cholecystostomy and, in certain cases, of cholecystenterostomy have been most gratifying. It is true that recurrence sometimes happens but in the writer's experience that has occurred only in cases that were drained for so short a time as ten days or two weeks. It is important to drain for a long time. The removal of the gall-bladder, unless it is so diseased as to be no longer in a condition to function as a gall-bladder, is to be deprecated. The gall-bladder is always valuable as a sort of safety device through which to drain in the case of later attacks.

Chronic Interacinar Pancreatitis.—There is a form of chronic pancreatitis which is unaccompanied by pain and which consists in a slowly progressive sclerosis of the gland which ultimately advances to such a stage as to destroy practically all of the parenchymatous tissue, including the islands of Langerhans. In contradistinction to the type which we have called chronic relapsing or recurring pancreatitis, in which the picture is that of recurring attacks of epigastric pain, this form goes on without symptoms until the function of the gland is interfered with to such an extent as to cause serious disturbances of digestion, dependent upon the lack of the external secretion of the pancreas in the intestine and also the interference ultimately with the internal secretion presiding over carbohydrate metabolism. In this form there is nearly always present pathologically a picture of what Opie designates as interacinar pancreatitis. The histological picture has already been described.

In some cases this chronic interstitial inflammation, under certain conditions which are not understood, passes through the stage of sclerosis to one of fatty infiltration, usually called lipomatosis. Newly formed connective tissue is occupied by fat, and this at times to such an extent that the whole gland appears changed into a fatty mass, in which only the merest traces of the original gland structure can be found even under the microscope. The etiology of this condition is not clear. Of course in some cases this pathological condition is the result of obstruction of the duct of Wirsung by calculi in the common duct or the pancreatic duct, or by new growths. It is probable also that the acute form may leave pathological changes during subsidence which ultimately go on into the pathological picture just described; but in the group here considered it is impossible to find in the clinical history any such etiological factor as those just mentioned, and one is reduced to considering such conditions as general arteriosclerosis and obliterating endarteritis. Such is the opinion of Hoppe-Seyler and Fleiner, who compare the condition with the contracted kidney of chronic Bright's disease.

The effect of tuberculosis or of syphilis etiologically is extremely doubtful. It is doubtful also whether alcoholism is to be incriminated. The condition is not infrequently associated with cirrhosis of the liver. Opie describes eight such cases out of thirty; and in this respect Opie's observation of a case of hemochromatosis and cirrhosis of the liver was accompanied by chronic interacinar pancreatitis.

Symptoms.—These patients usually give a history of chronic indigestion, and it is probable that this indigestion is not originally due to the pancreatic lesion but rather to actual disturbances of the stomach or duodenum. Ultimately, however, there appear symptoms referable to a distinct involvement of the pancreas. Perhaps the first symptom noticed by the patient is that the stools have become bulky and that

he is apt to have two stools in the day instead of one. Upon examination it is found that the stools are very pale, even whitish in color. An examination of such stools shows that they are largely composed of unchanged fat. Bile is still present in them in normal amount. A search for pancreatic ferments will frequently reveal the fact that they are absent or greatly diminished. Upon examining the patient it will usually be impossible to discover anything abnormal; the pancreas cannot be felt; there is no particular area of tenderness. As to general nutrition, cases vary. In many there is progressive and sometimes rapid emaciation from malnutrition. In others this is very much slower; and in one case observed by the writer there was quite remarkably no loss of weight or of strength during a period of over a year during which, however, tablets of dried pancreatic substance were continually taken. This patient finally died with a fulminating attack of what was almost certainly acute pancreatitis, fatal inside of five or six hours.

Glycosuria may or may not be found. In one case of the writer's it came on only several months after the diagnosis was plain from abolition of the external digestive secretion.

It is doubtful whether anything surgical can be done for these patients, although, to tell the truth, hitherto nothing has been tried. The destruction of the pancreatic tissue is so far advanced before the diagnosis is made and the lesion in the pancreas is so much in the nature of replacement by scar tissue that any operation such as bile drainage could hardly accomplish anything worth while. The damage has been done. The administration of pancreatic substances and putting the patient on a diet largely composed of fats is perhaps all that can be proposed.

Injuries of the Pancreas.—The pancreas is perhaps that organ of the abdomen which is least accessible to injury, not even excepting the spleen, and consequently the recorded cases of traumatism of the pancreas are comparatively few. The organ is so well covered by the neighboring viscera that isolated injury to it is extremely rare. Körte showed that only in about one-third of all cases is the pancreas uncovered by liver or stomach. These are usually cases of gastroptosis. The relative proportion of isolated injuries to those which are complicated by injuries to other organs is impossible to establish inasmuch as the latter are rarely reported. Clinically and pathologically the distinction is usually made on the one hand between complicated and uncomplicated injuries, and on the other hand between subcutaneous and open injuries of the organ.

Subcutaneous injuries of the pancreas are usually caused by crushes, as between the buffers of railway carriages, or by the kick of a horse, or by the blow of a bull's horn. The lesion is usually a crush or a tear of the pancreas with more or less extensive hemorrhage both into the pancreas itself and into the neighborhood. The tear is usually in the midline where the spinal column affords an opposite pole of pressure.

Open injuries are usually caused by gunshot or revolver wounds; occasionally by stabs. Pathologically the case frequently runs on to death by the liberation of pancreatic secretion into the general abdominal cavity. This is peculiarly fatal in the absence of operation, as was shown experimentally by Guleke's observations, in which he created the so-called "internal fistula." If this is not rapidly fatal, the patient is apt to die a little later of a suppurative peritonitis. In other cases the exudate and the pancreatic secretion more fortunately are walled off and gather either in the peripancreatic tissue or, if the posterior layer of the peritoneum is torn, in the lesser sac. In such cases the foramen of Winslow is also frequently closed by inflammatory adhesions, and there results a pancreatic cyst or pseudo-cyst corresponding anatomically to the limits of the lesser sac.

The pancreatic tissue itself always suffers necrosis in the immediate neighborhood of the injury, and this necrosis spreads through a large portion of the organ. A case of Opie and Meakins is extremely interesting in this respect. This was a stab wound which had perforated the anterior wall of the stomach and also the posterior wall, just sufficiently to injure slightly the surface of the pancreas. The wound in the stomach was sutured but the pancreatic injury was overlooked, and the patient die from a rapidly developing pancreatic necrosis with fat necrosis.

In addition to the necrosis there is, of course, usually hemorrhage of varying degree and also fat necroses. The injury to the pancreas in favorable cases may heal with the development of chronic fibrosis or on the other hand go on to suppuration.

A *diagnosis* of isolated injury to the pancreas, whether open or subcutaneous, is rarely possible. It is now so much the rule to operate early in severe injuries of the abdomen that the time necessary for the development of symptoms which might point to the pancreas in particular is not usually given. However, in certain cases in which delay seems justifiable, a diagnosis of probability may be made. On the one hand there will be the absence of signs referable to serious injury of the stomach, bowel, spleen, or liver. If under such circumstances there should develop, after a preliminary period of partial recovery lasting one or two days or even more, an exacerbation of the peritoneal symptoms with pain and vomiting, and tenderness in the upper half of the abdomen, together with the evidence of fluid exudate in the lesser sac, then one should think seriously of pancreatic injury. If, as has happened in a few cases, glycosuria should appear, the diagnosis becomes decidedly probable. It is likely that an examination of the blood and urine for amylase and lipase, if there were time to carry it out, would show an increase well above normal in cases of this sort. This has been shown to be the case with regard to amylase in experimental injuries by Wohlgemuth and by Benczur.

Most of the open pancreatic injuries are gunshot wounds. In the statistics of Mikulicz, of forty-five pancreatic injuries there were twenty-four subcutaneous ruptures, twelve injuries by shot, and nine stab wounds. Naturally these are also usually complicated by injury of neighboring organs. There are, however, four cases recorded of isolated pancreatic shot wounds.

The *prognosis* is in all cases grave; even the isolated injuries of the pancreas are frequently fatal. The outlook varies chiefly with the degree of complication. Often death occurs early from shock, or from hemorrhage from the liver or spleen, or from peritonitis following upon rupture of stomach or bowel. In cases where these injuries are not of themselves fatal or are remediable by operation, the prognosis depends chiefly upon two things: the earliness of the operation and the care that is taken not to overlook a possible pancreatic lesion while attending to the more visible injuries. The case reported by Opie and Meakins is again instructive in this respect. The earlier operation is undertaken, the better are the figures of recovery. Where there is any possibility of the pancreas having been injured, it is particularly necessary for the surgeon to expose that organ thoroughly. This can best be done by going through the gastrocolic omentum, and the opening should be wide enough to expose the pancreas thoroughly. Deaver and Ashhurst advise that it be at least three inches long. The posterior surface of the pancreas must not remain unexamined: it can at least be palpated. If the patient has the good fortune to localize the effusion in the lesser sac, escaping a general peritonitis, his chances are much improved.

Treatment must therefore be chiefly surgical, and the essential point in operation is to find the point of injury in the pancreas and to localize it by packing it

off with gauze. At the operation a lead to the point at which the pancreas is injured is frequently afforded by hemorrhages in the gastrocolic omentum or in the mesocolon. If the organ is found torn cleanly across, Garré advises suturing it. As we know from experimental work, the passage of the duct of Wirsung will frequently be restored after simple suture; but it is important not to insert the stitches in the parenchyma, which will usually cause localized necroses, but to catch with them only the capsule. If there is visible only bruising of the pancreas, it is necessary merely to tampon the region carefully so as to allow the pancreatic secretion a free way to the exterior. In Mikulicz's well-known article the mortality of cases which were not thus packed off was eighty per cent., while in those in which that measure was employed it was only thirty-eight per cent. In practically all cases, whether sutured or merely packed off, a pancreatic fistula develops and persists for a time. As to statistics, Guleke was able to collect up to 1912 thirty cases of isolated rupture of the pancreas, of which twenty-three were operated upon, and of these fifteen were cured by the operation. All the patients who were not operated upon died. Guleke also gives figures concerning shot wounds of the pancreas. Of twenty-five cases, nineteen were operated on and of these eight recovered. The six patients who were treated without operation died.

Pancreatic Calculi.—Upon the whole pancreatic calculi are rare. While it is perhaps not so very uncommon to find at autopsy small stones, even little more than sand particles, in the ducts of the pancreas, there have been, according to Mayo Robson, only eighty cases recorded in the literature. For the greater part they have been accidental autopsy findings. An intravitam diagnosis has been made only six or seven times. The stones are composed practically altogether of either carbonate or phosphate of calcium; frequently of both salts in varying proportions. Their size is rarely larger than that of a bean. They are usually a dull white in color, and their surface may be either smooth or rough. They crumble easily. Sometimes they are single but often they are quite numerous; and they are found either in the main duct or in the smaller ones; sometimes even in the acini.

Etiology.—It is commonly believed that they occur only as a consequence of chronic pancreatitis leading to stagnation of the pancreatic secretion, out of which the salts above mentioned are gradually precipitated. Mayo Robson is confident that there comes into play also an ascending infection of the pancreatic duct, giving rise to a chronic catarrh. Some support is found for this theory in the fact that occasionally abscesses develop in the organ behind the stones; but it must remain doubtful whether bacteria play any material rôle in the original causation. The writer believes that true infection is for the most part absent, save as a secondary event, and that more frequently the entrance of bile into the pancreatic duct, causing a subacute and ultimately a chronic pancreatitis, is the real factor at work.

If stones have been long present in the pancreas, they usually lead to a fibrosis of the gland which may become quite complete and ultimately cause a very considerable atrophy of the secreting substance.

Symptoms.—It can hardly be said yet that there is any clear symptomatology of this disease. Recurring attacks of colicky pain in the epigastrium are said to be the most characteristic feature. They resemble somewhat attacks of biliary colic, but in the recorded histories one point of difference is that frequently the pain of pancreatic colic radiates to the left epigastrium or to the left shoulder blade rather than to the right, while as the attack passes off tenderness is in the midline or to the left. This, however, does not distinguish it at all from the ordinary attack of subacute pancreatitis without stone. It is easier to distinguish pancreatic pain from gallstone pain than to differentiate the pain of pancreatic stone from that of simple pancreatitis. Attacks seem to occur frequently during digestion. They may last two or three hours or as long as two days. The one really sure sign, although it is not often found, is the discovery of pancreatic stones in the feces. Moynihan is very strong on this point. It is claimed that they can be demonstrated by *x*-ray photographs, but a very large number of plates in suspected cases would have to be taken before one tumbled on a pancreatic stone definitely shown. According to the figures of Oser and Lancéreaux, glycosuria is rather frequent, being found in from thirty to thirty-five per cent. of all cases. This naturally represents an advanced stage of destruction of pancreatic tissue, and in this sense glycosuria might help to distinguish cases of stone from those of subacute recurring pancreatitis, in which glycosuria is rare. Fatty stools have been observed, and that again means advanced atrophy of the organ and a long history. Jaundice is rare, but rapid emaciation is comparatively frequent.

From all this it is clear that the diagnosis must practically always remain one of probability. Moynihan's case is perhaps that which is best known, and his diagnosis was chronic pancreatitis with the possibility of a pancreatic stone near the ampulla of Vater—a diagnosis which was confirmed by operation. Altogether the diagnosis has been made correctly in seven cases, but Moynihan's was the first to be operated upon under the correct preoperative diagnosis.

To summarize the question: One may say that when a patient is showing a considerable number of colicky attacks in the midepigastrium, with pain radiating into the back and chiefly to the left, with progressive emaciation, with glycosuria, and with tenderness localized upon finger-point pressure to the anatomical region of the pancreas, and particularly if there is palpable swelling of the gland—under such circumstances one may make a guess at pancreatic stone with the usually accompanying chronic pancreatitis so called.

Treatment.—It is generally advised to try internal treatment, such as baths, massage, diet, hot applications, morphine, and pilocarpine hypodermically. In so far as these represent an attempt to mitigate the pain of the colicky attack, they may be justified, but it is the writer's opinion that the true treatment of pancreatic calculi, as of all forms of pancreatitis, is surgical. The principles of surgical treatment have been set forth in the discussion of chronic pancreatitis and need not here be repeated. Inasmuch as the diagnosis of stone must always be uncertain, except when pancreatic stones have been found in the stools (and even then there may remain a little doubt), the operation is to be undertaken for the relief of the chronic pancreatitis which usually accompanies it or for the occasional cyst which may complicate it. Once inside the abdomen the surgeon will frequently find it difficult to determine by palpation of the hardened and swollen pancreas whether a stone is present or not. Undoubtedly in most cases the diagnosis must rest at chronic pancreatitis, and a possible stone embedded in the center of thickened pancreatic tissue may be left undiscovered. When, however, the stone is lodged at the very exit of the pancreatic duct, especially if as in Moynihan's case it projects slightly into the common duct, it may be felt through the duodenum. Then the duodenum must be opened, the papilla incised, and, if necessary, the pancreatic duct also incised through pancreatic tissue. This was done in the cases of Lisanti, Moynihan, and Mayo Robson. If a stone can be felt in the substance of the gland some distance back from the papilla, it is advised (Robson, Körte) to incise the gland straight upon the stone. In every case the wound in the pancreas must be thoroughly packed with gauze. Up to the present only

four stones have been actually removed from the pancreas (Gould, Lisanti, Moynihan, and Robson). Three of these operations were crowned with success. Gould's patient died. The results, therefore, are really most encouraging. We have been accustomed to think that operative injury to the pancreas was a peculiarly dangerous thing. Probably the statistics of Mikulicz, who years ago emphasized the fact that, when carcinoma of the stomach invaded the surface of the pancreas and was removed with shavings of pancreatic tissue, the mortality was enormously increased, have been influencing surgeons too much. Of recent years the work of Finney and the Mayo Clinic has shown us that the pancreas may be incised with much greater safety than we had thought. The writer has removed a small section of pancreatic tissue for examination in one case of subacute pancreatitis, and has cut through the pancreas into the common duct in a difficult gallstone case, without seeing any ill effect. It is probable that, in view of the seriousness of leaving undiscovered pancreatic calculi, we shall in the future explore the pancreatic duct from the duodenum with greater frequency in cases offering suspicion of calculi.

Cysts.—It is probable that cysts of the pancreas are rather more frequent than was formerly supposed. While the number of recorded cases is not very large, it is safe to say that every hospital of late years contains records of cases that have never been published. Their nature and origin are obscure. It may be said that probably the majority are retention cysts. The most common cause is generally thought to be chronic indurative pancreatitis. The connective tissue in some part of the gland so presses upon or so distorts the excretory duct that the outflow from a part of the gland is arrested. Another cause may be the obstruction of the duct of Wirsung from external pressure, as for instance from a stone in the common bile duct or from an obstructive swelling of the duodenum at the point where the duct enters. A catarrhal inflammation of the duct of Wirsung may cause obstruction. A new growth in the head of the pancreas may act similarly. It is now thoroughly proven that cysts may result from hemorrhages into the pancreas or rather from that condition which we have preferred to call pancreatic necrosis.

There may be multiple cysts. This should be borne in mind when considering the prognosis and possibility of recurrence. Pancreatic cysts vary greatly in size. Those found in autopsy rooms are usually comparatively small. Surgeons report, however, that some of the cysts contain from one to twenty liters. The fluid is generally of a light-brown, coffee, or reddish-brown color, seldom clear (Osler). The lining of the cyst wall may be smooth or sacculated; it is generally surrounded by blood-vessels.

Classification.—Pancreatic cysts may be divided into four main groups (Guleke): (1) Adenocystomata, or so-called proliferation cysts. (2) Retention cysts. (3) Degeneration cysts. (4) Pseudocysts.

Adenocystomata are true neoplasms and may be compared roughly with the adenocystomata of the ovary. They are mostly multilocular, with a glandular structure. There is usually one large cyst and a number of smaller ones. The wall is usually lined with cuboidal epithelium, which, however, may be absent, probably from the pressure of the contents. Trypsin has never been found in them. They are mostly situated in the tail of the pancreas.

Retention Cysts.—These have been observed to develop, although rarely, behind calculi or some other form of obstruction such as a tumor or a scar. They are usually small and take origin in the smaller ducts and acini. Sometimes, however, they develop at the expense of the main duct. The investigations of Dieckhoff and of Tilger seem to demonstrate that the cause of these cysts lies in a chronic interstitial pancreatitis, and this view is now generally accepted, although it must be said that the latter may just as easily represent the result as the cause of the condition.

The *degeneration cysts* are those which result from the softening and cystic transformation of destroyed tissue in the pancreas. According to Lazarus, such cysts develop as the result of toxic or infective lesions, such as may occur in typhoid or in general sepsis, also from the softening of cancers, and finally as the end result of acute pancreatic necrosis by the liquefaction of the dead pancreatic tissue. Lazarus seems to have proved that cysts may be the end result of an autodigestion of effused blood. It is the writer's opinion, as has been set forth in the section on acute pancreatitis, that the entrance of infected bile into the pancreatic duct is probably the frequent primary cause not only of acute necrosis leading to degeneration cysts but also of the chronic interstitial fibrosis leading to retention cysts.

Pseudocysts.—According to Körte, the largest number of cysts of the pancreas that come to operation are pseudocysts. These are distinguished from the true cysts in that they are situated not within the substance of the pancreas but outside it and usually in the lesser omental sac. The contents are usually blood and pancreatic secretion mixed. They have no proper wall and no epithelial lining; their wall is constituted by the peritoneal boundary of the omental sac and by adjacent organs. While they lie altogether outside the body of the pancreas, their origin is nevertheless, in many cases, some lesion of the pancreatic tissue with which at times they still retain a connection. It is probable that they represent peripheral lesions, such as foci of necrosis or tears of the parenchyma, from which the effused or secreted blood or secretion is extruded anteriorly toward the lesser omental sac, while the body of the organ remains intact.

From the standpoint of pathogenesis, speaking broadly, these cysts may be classified as being due to true neoplasms, or to inflammation, or finally to injury. The traumatic cysts constitute a large proportion. Goebel found among 232 operative cases seventy-six traumatic. Lazarus has succeeded in producing experimentally a true traumatic cyst.

Contents of the Cyst.—The fluid has a specific gravity which varies from 1.010 to 1.028. It is usually alkaline and contains albumin to the extent of two to three per cent., also mucin, and sometimes sugar and mineral salts. Its color varies enormously; it may be perfectly clear and serous or almost quite black from admixture of blood. In one case examined for the writer by Dr. Bruère, Director of the Clinical Laboratory at the Royal Victoria Hospital, the fluid gave a definite reaction for bile. While, as was later pointed out, it is possible for hematoidin crystals to give this same reaction, this observation is nevertheless suggestive, and points with some probability to the action of bile in causing the original lesion which led on to cyst. The patient on whom this observation was made had had four months previously an acute attack of epigastric pain, which was clearly one of acute pancreatic necrosis.

According to Körte, the demonstration of pancreatic ferments in the cyst contents always speaks for a definite pancreatic origin of the cyst. This statement is to be modified in the sense that the absence of such ferments is far from proving the absence of a pancreatic origin, and on the other hand it is possible to find small amounts of all three ferments in any cyst which has been accompanied by hemorrhage. Amylase is very commonly found, but has slight diagnostic significance as it is found in many of the other body fluids. Trypsin is frequently absent, but lipase is more often found. It is still impossible to distinguish true cysts from pseudocysts by the demonstration of the presence or absence of these ferments. A positive diagnosis can be made only by the demonstration at operation of the situation of the cyst and its connection, or the contrary, with the pancreas.

Symptoms.—Although pancreatic cysts have been for long the best known of pancreatic lesions (Gussenbauer first diagnosed the condition in 1882), it can still hardly be said that the symptomatology is clear. As a matter of fact the diagnosis has to be made usually from a close consideration of the physical findings. Pain is an almost constant symptom at some time of the history, usually at the time of onset, and this fact indicates the large share which acute pancreatitis has in causation. Frequently, however, the initial pain, which is often extremely severe, disappears, and only later when the cyst has grown to a considerable size does pain reappear, and then probably as the result of distention. In a few cases the initial severe pain is absent. In either event the period of gradual growth of the cyst, which may occupy any time from a few weeks to years, is marked by indefinite symptoms consisting chiefly of gastric distress, loss of appetite, and a feeling of tightness or of weight in the epigastrium. It is peculiar both to the initial pain and to those later feelings that they are situated usually in the midepigastrium and to the left, sometimes running through to the back, and are very rarely felt on the right side. Only later when a palpable swelling appears can one begin to consider the diagnosis of pancreatic cyst. The combination of such a cystic tumor with the previous history, weeks or months before, of acute epigastric pain must always suggest very strongly a pancreatic cyst. But the diagnosis has to base itself very largely on a minute examination of the situation of the mass. As a matter of fact, owing to the very definite anatomical position of the organ, pancreatic cysts in the great majority of cases take up in their growth a more or less characteristic anatomical situation. The figures given in the second edition of this work, taken from Kehr, are still valid. There figures show the relationship of the tumor to the adjoining viscera, especially to the stomach, colon, and intestines.

"The first fact to be clearly established (quoting from Dr. Armstrong's article in the previous edition of this work) is the relation of the tumor to the adjoining viscera, especially to the stomach, colon, and intestines. The inflation of the stomach and colon with air or gas will give great assistance in the determination of this relationship. If the cyst has passed forward between the stomach and colon, pushing before it the gastrocolic omentum, a clear percussion note should be heard above and below the tumor if it is a large one, and if it is small, the distended stomach and colon may meet together in front of it. If the tumor projects forward below the liver and above the stomach, the dull percussion note of the liver may be continuous with that of the tumor. The difficulty of differentiating a pancreatic cyst thus placed from a distended gall-bladder or an echinococcus cyst or other fluid collection connected with the liver would be very great, and probably could be accomplished only by examination of the contents removed by a Pravaz syringe. Possibly by examining the patient in the erect position a line of tympany could be found between the liver and cyst. A pancreatic cyst would not move during inspiration or expiration.

"If the tumor projected forward below the colon, the dull note of the tumor should be easily elicited between the tympany of the colon above and that of the small intestine below.

"It may grow behind and push forward the stomach, or it may pass forward between the layers of the mesocolon, in which case the stomach or colon would lie immediately in front of the tumor. When so situated, it is generally possible, after inflation, to establish the mobility and freedom of the stomach or colon from involvement in the body of the tumor.

"The differential diagnosis between a cystic tumor of the pancreas and a solid tumor of the spleen should not be difficult. To differentiate a cyst springing from the tail of the pancreas from an echinococcus cyst of the spleen—the only cystic growth involving the spleen—may be very difficult, and perhaps impossible, except by an examination of the cyst contents.

"Great difficulty may be found in differentiating between a pancreatic cyst and hydronephrosis. In hydronephrosis the bulging is generally in the lumbar region. There may also be a history of renal colic, of the passage of a renal calculus or blood, or other urinary derangement. An examination of the urine may throw light on the case. A cystoscopic examination of the bladder might show that no urine was entering from that side.

"From large ovarian cysts the history should show that the growth began low down and laterally. Cysts of the mesentery are movable. Aneurysms of the aorta or its branches are pulsating and expansile.

"The aspiration of cysts for diagnostic purposes is a questionable procedure. There is always a danger of puncturing a flattened-out overlying viscus, of wounding some abnormally placed vessel—and the walls of a pancreatic cyst are sometimes very vascular—or of permitting the escape of infective contents—as for instance hooklets in the case of echinococcus cysts—or of pathogenic organisms. An exploratory incision is now so safe that it is to be recommended as an almost universal rule in place of puncture."

A cyst in the head of the pancreas may compress the common duct and cause icterus. The stomach or the bowel may likewise be compressed, even to the point of complete obstruction. Pulsation is frequently found in them, being communicated from the aorta over which they lie. Payr calls attention to the fact that an early and rapid emaciation is very characteristic for pancreatic cysts and that this does not depend upon lack of digestive ferments in the bowel. Weight is rapidly regained after drainage of the cyst. It is very seldom that a cyst destroys the pancreas sufficiently to cause glycosuria.

Prognosis.—"The rapidity of the growth of pancreatic cysts is difficult to ascertain, because the date of their commencement can seldom be determined. They are probably of slow growth as a rule. When following trauma or acute inflammatory processes, however, they may develop into palpable tumors in two or three weeks. Their duration is also uncertain; instances of their being present for thirty or forty years are reported. They sometimes rupture spontaneously into the stomach or intestine, as evidenced by the vomiting or passage by rectum of a quantity of bloody fluid. Their occasional disappearance and reappearance may possibly be explained by the assumption that in this way they periodically empty themselves into the stomach or intestine."

Treatment.—Operation is indicated in all cases of pancreatic cysts or pseudocysts. Two methods have been described. The first, that followed by Gussenbauer in 1882, is the operation of choice and consists in the suturing of the cyst wall to the abdominal wound and drainage. The second, which was proposed and carried out by Bozeman, also in 1882, is extirpation. As to the latter, while a fair number of successful operations by this method have been reported, it is clear that it can never seriously compete with the method of drainage, by reason not only of its difficulty but of its danger. As a matter of fact, in the majority of instances, the serious adhesions to neighboring organs, the danger of wounding large and important vessels in the immediate neighborhood, and the risk of the development of diabetes after removal of a considerable portion of the pancreas, all tend to make extirpation a most serious procedure. On the other hand, drainage of the cyst is easy and, as statistics show, is accompanied by very little danger.

Delagénière calls attention to the importance of an exact palpation of the whole cyst wall outside and inside, so as not to overlook possible stones or adenomatous ingrowths.

Incision will usually be a median one, but a good

rule is to go in over the greatest prominence of the tumor. This will involve incising the cyst either through the gastrohepatic or the gastrocolic ligaments or even through the mesocolon, if the cyst is situated low in the abdomen. The cyst wall must be carefully sutured to the abdominal wound over a small area. If the cyst is very tense, it is advisable to empty it, at least partly, through a trocar, inasmuch as the cyst contents otherwise might gain access to the peritoneal cavity through the needle punctures, and, as in the case of Subbotié, cause death from peritonitis. After opening, it is important to palpate the interior of the cyst in order not to overlook necrotic pieces of the pancreas which should be carefully removed. In rare cases the cyst points into the lumbar region, usually on the left side, and then incision at this point is advisable. In a case of this sort under the late James Bell at the Royal Victoria Hospital, the opening of the cyst which was suppurating gave issue to large portions of pancreatic slough. In such cases recovery is rare.

Precautions must be taken to protect the skin from the eroding action of the pancreatic ferments which are sometimes present. A free use of Lassar's paste, leaving out the salicylic acid, will prevent this. A fistula is apt to remain for a long time, sometimes for years. Many cases after primary closure need reopening because of re-collection. Some patients die of the injury done to the pancreas by the original lesion; others, of chronic infection entering the cyst from the surface; and occasionally there is a death from intestinal obstruction or from hemorrhage in the sac from erosion of a large vessel in the cyst wall. The results of drainage are certainly good in so far as the immediate mortality is concerned, which is only four or five per cent., but can hardly be called good with regard to the late results. For these reasons extirpation is to be attempted under certain conditions: for instance, if the cyst arises from an adenocystoma of the pancreas, or if it takes origin in the tail of the pancreas, where operation is easier. If the patient survives the operation of extirpation, his outlook is much better than with simple drainage. Mortality of total extirpation, according to Goebel, is 10.7 per cent. and according to Guleke, in twenty-one cases, 9.5 per cent.

Tumors.—Tumors of the pancreas are usually malignant. Of benign tumors there have been described only two or three cases. Guleke mentions a tuberculoma removed by Sendler with cure and also a fibroma of the body of the organ enucleated by Körte successfully. The malignant tumors are nearly always carcinomata, and these are usually situated in or near the head of the organ (sixty to eighty per cent. of the cases). On the whole they are not at all infrequent. Many cases have been mistakenly diagnosed as taking origin in the common duct, inasmuch as they usually cause obstruction of the common duct by pressure. Histologically they are, of course, adenocarcinomata, and many of them take on a scirrhous type of growth. They are very rarely of the soft medullary form. Occasionally a carcinoma in the pancreas is secondary to a growth originating in some adjacent organ, particularly the stomach. In such cases they have been supposed at times to be metastatic, but it is fairly certain that in practically all instances they have attacked the pancreas by direct and continuous growth.

Symptoms.—Sauvé in an excellent article has given us a very good picture of the symptoms caused by carcinoma of the head of the pancreas. The symptoms vary according as the tumor is situated superficially in the gland or deeply; that is, whether it compresses the pancreatic duct and the common duct or leaves them free.

If the tumor invades chiefly the surface of the gland, the symptoms of compression remain absent, and in fact very few symptoms are called forth at all. By the time such tumors become palpable, the liver is usually already invaded and the prognosis has become hopeless. On the other hand, carcinoma which invades the deeper tissues of the organ will cause comparatively early symptoms by obstruction of the duct of Wirsung and by pressure on the celiac plexus. In the later stages the common duct is also compressed and icterus appears, while the gall-bladder is apt to be full and easily palpable. The symptom-complex is therefore made up of pains referable to the celiac plexus and rapid emaciation as the result of exclusion of the pancreatic juice, together with jaundice in the later stages. Glycosuria may appear but is usually late; and in a few cases there may be signs of obstruction of the duodenum from compression by the tumor. Those tumors which begin close to the papilla of Vater are characterized by early jaundice, which is progressive and is apt to become deep. The symptoms of pancreatic obstruction usually follow the onset of jaundice, and the comparatively early and rapid obstruction of the common duct not infrequently leads to attacks of pain which may simulate stone, as was the case in a recent patient of the writer's. The jaundice may set in very suddenly in such cases, may become rapidly deep, and may be even partially intermittent. Such patients may come to early operation but frequently under a mistaken diagnosis, usually that of stone.

A palpable tumor is not often found before the case has become quite hopeless. Moreover, metastases in the liver frequently appear early in the history and the glands around the head of the organ are early affected. The tumor is quite apt to spread through the rest of the pancreas by contiguous growth.

When the tumor is situated in the body of the pancreas, the symptoms are likely to be entirely distinct from those of the head as just described. French authors, particularly Chauffard and Leriche, have brought this out very clearly. Carcinoma of the pancreatic body usually grows forward above the lesser curvature of the stomach, and forms ultimately a palpable tumor between the ensiform and the umbilicus. It may grow either toward the head or toward the tail. Icterus is absent unless it has involved the head as a late occurrence. According to Chauffard, the earliest and most marked symptom is the pain caused by pressure upon the celiac axis. Chauffard dignifies the picture with the special name, "the pancreatico-solar syndrome." Pain comes on in one who is apparently in perfect health, rapidly becomes worse, is situated far back in the abdomen, radiates to the back or between the shoulder blades, is uninfluenced by the taking of food or by fasting, and is so extremely severe and persistent that the patient passes day and night sitting up in bed and bent over on himself. The pain is sometimes periodical but is more often persistent. It may be accompanied by vomiting. The appetite may remain undisturbed, but in other cases the patient complains of a sense of fulness in the stomach and bowels and of nausea, which may be brought on by the sight of food or may be spontaneous. There may be a frequent but fruitless desire to go to stool. These symptoms are all reasonably to be referred to pressure on the celiac plexus or on the mesentery near it. They were typically present, save that the pain was not so violent, in a patient of the writer's who suffered from acute tuberculosis of the mesenteric glands in this region. Palpable tumor, according to Leriche, was found in nine out of fourteen cases. The aortic pulsation becomes more prominent, being transmitted by the tumor, and may even suggest aneurysm. It is very rare to find the signs of pancreatic insufficiency such as glycosuria and rapid emaciation. Cachexia is usually late and icterus does not appear unless the tumor has grown far enough to the right.

Carcinoma of the tail of the pancreas, as might be

expected, gives rise to very few and rather late symptoms. It develops in a latent fashion and by the time symptoms appear it is already far advanced.

The duration of the disease is usually short as compared with that of carcinomata elsewhere. Guleke says that, upon the average, death occurs in five months from the onset of symptoms.

The diagnosis when the tumor is situated in the head is not especially difficult. A quietly on-coming jaundice without pain and progressive, together with Courvoisier's symptom and a rapidly increasing cachexia, particularly if ascites eventually occurs, must indicate the probable presence of tumor of the pancreatic head. Nevertheless, such a picture is quite compatible with the condition of chronic pancreatitis; and even with the abdomen open it may be quite impossible to say whether the mass in the head of the pancreas is inflammatory or neoplastic, unless one can find metastases in the pancreatic glands and in the liver. Even in chronic inflammation of the organ the glands about the pancreas may be swollen and firm, and therefore leave one uncertain as to the exact diagnosis. Robson long ago drew attention to this fact, and since then many a surgeon who has given a hopeless prognosis to the relatives of the patient has been happily surprised to find that the cholecystostomy which he has done for the relief of the jaundice has cured the patient. It is hardly permissible, as a rule, to take out a portion of the pancreas for microscopic examination, although this has been done on a number of occasions without harm to the patient.

It is difficult to determine beforehand, even after having made a diagnosis of carcinoma, whether the tumor is situated in the pancreatic head or in the papilla of Vater. The latter, however, is apt to cause jaundice at a much earlier stage. A quiet onset of jaundice in a person apparently healthy must suggest that the tumor is in the common duct.

The tumors of the body and of the tail of the pancreas are much more difficult to diagnose. The occurrence of celiac pain must put the physician on the lookout for this condition. It is said that this pain resembles the gastric crises of tabes very much. In such a case the differential diagnosis is ordinarily not difficult.

Treatment.—Surgery has still but little to do for the relief of tumors of the pancreas. In the extremely rare cases of benign tumor, it is true, extirpation or enucleation has been successful; but the surgery of malignant tumors has been, upon the whole, extremely disappointing. This, of course, applies to attempts to do radical operations. It must be remembered, however, that a good deal may be done in some cases by palliative operation. In some cases the obstruction of the common duct or of the duodenum can and should be relieved; most frequently the question will be whether one should do a cholecystostomy or a cholecystenterostomy. The choice should usually fall upon the latter operation, unless the patient is in such a serious condition that it seems unlikely that he can stand it. With the cholecystostomy the continual loss of the whole of the bile seems, at least in many cases, to hasten the death of the patient through malnutrition, besides necessitating troublesome dressings. On the other hand, cholecystenterostomy gives much better results, provided one chooses for the anastomosis the stomach, the duodenum, or an upper loop of the jejunum, so that the bile is preserved for whatever function it possesses in digestion. It is a mistake to use the colon for the anastomosis, both for the reason just given and also because infection of the gall-bladder is more apt to occur and to be serious. The various statistics indicate that patients survive from six to eight months on an average after a cholecystenterostomy, while with cholecystostomy they are apt to die in a few weeks.

Radical operation, that is pancreatectomy, has been of late years advised, particularly by Sauvé and Desjardins and by Kausch. Sauvé describes an elaborate technique for the resection of the pancreatic head with that portion of the duodenum immediately adjoining, and believes it is indicated in cases where the tail of the pancreas is free, where there are no serious adhesions of the pancreas to adjacent organs, and where there are no metastases of the liver. The writer does not consider it necessary in a work of this kind to give in detail the technique of such an operation. It is extremely doubtful whether in any case such an operation is justifiable. The results of resection of the head of the pancreas and the duodenum have on the whole been so poor, both as to operative mortality and as to survival, and the operation in itself is technically so difficult, that the patient's welfare will probably be best served by confining oneself to a palliative operation.

On the other hand, when the tumor is situated in the body of the pancreas, the chances are better. Here it is possible, without undue difficulty, to do a resection of the diseased portion and suture together the two stumps of the organ (Ehrhardt, Finney). Tumors of the tail of the pancreas have been extirpated with immediate success but in all these cases, whether of the tail or of the body, it appears that the chances for permanent cure are extremely bad, and the contention of Körte that total extirpation of the pancreas must be regarded as the type operation for all cases of cancer of that organ is theoretically justified. While it has hitherto been considered that total extirpation of the pancreas was not compatible with life, on account of the development of fatal glycosuria, it would seem that this need not always be the case. Franke publishes the report of a total extirpation which was successfully carried out with survival of the patient, in whom only transient glycosuria appeared. It must remain uncertain whether the extirpation was total, and in any case such isolated cases can prove nothing. It may be said that upon the whole cancer of the pancreas is best left alone. Guleke has collected twenty-four cases from the literature of radical operation. The operative mortality was fifty per cent. Of those who survived, all without exception died of metastases inside of five months, even those (three cases) in whom a total or almost total extirpation was performed. E. W. Archibald.

Pancreatinum (U. S.).—Pancreatin is a mixture of the enzymes naturally existing in the pancreas of warm-blooded animals, usually obtained from the fresh pancreas of the hog or the ox, and consisting principally of amylopsin, the starch-converting enzyme; myopsin and trypsin, the enzymes that digest albuminoids; and steapsin, the enzyme that digests fat; it should be capable of converting not less than twenty-five times its own weight of starch into water-soluble substances. It occurs in the form of a cream-colored powder almost wholly soluble in water.

Constituents.—*Amylopsin*, called also pancreatic diastase, acts energetically upon starch, even uncooked starch, converting it into dextrin, isomaltose, and maltose; its action is retarded by the alkalies and also by hydrochloric acid in large amounts, though this retarding effect is said to be counteracted by the presence of bile.

Trypsin is the chief constituent of the pancreatic juice which digests proteins. It acts in alkaline, neutral, or even faintly acid media by dissolving the protein and splitting it into amino-acids, tryptophane, etc. It differs from pepsin chiefly in that the latter digests protein in acid media, and its action is largely supplementary to that of pepsin in that it further splits the products of peptic digestion, the albumoses and peptones, into simpler bodies.

Myopsin is another proteolytic ferment similar in

its action to trypsin, the chemistry and action of which have been as yet but little studied.

Steapsin, called also lipase, is a fat-splitting ferment which emulsifies fats, and also saponifies them, reducing them to fatty acids and glycerin. These fatty acids combine with alkalies in the intestine and the soaps so formed assist further in the emulsifying of the remaining unconverted fats.

Rennin, or chymosin, is also present in pancreatin, though it has not yet been determined whether or not it is identical with the milk-curdling ferment in the stomach.

Action and Uses. Pancreatin may be given internally for intestinal indigestion in doses of gr. ii.–v. (0.13–0.3) three or four hours after meals, or may be used to predigest food—milk, beef, oysters, gruel, etc. Pancreatin is prepared in the form of tablets or in powders, with or without bicarbonate of sodium. For use as a peptonizing agent for the predigestion of food, powders are put up in so-called peptonizing tubes, the amount in each being sufficient to peptonize one pint of milk. Pancreatin is especially useful for the digestion of milk and eggs given in the form of nutrient enemata. Henry H. Rusby.

Pancreon is a proprietary preparation consisting of a combination of pancreatin with tannic acid, and said to possess the tryptic, amylolytic, and emulsifying powers of pancreatin, but to be unaffected by the gastric juice. The dose of pancreon is gr. v.–viij. (0.3–0.5) three times a day.

R. J. E. Scott.

Panum, Peter Ludwig.—Born at Roenne, on the Island of Bornholm, Denmark, Dec. 19, 1820. He studied medicine at the Universities of Kiel, in Germany, and of Copenhagen, and passed his State examination in 1845. During the following five years he practised medicine at different places, but after 1850 he devoted himself exclusively to physiological work, and more particularly to physiological chemistry. In 1851 he received the degree of Doctor of Medicine; and from that time until 1853 he traveled from one large university to another, for the purpose of getting new ideas and of making the personal acquaintance of those men who were, at that period the leaders of scientific thought. During the latter part of the trip he spent considerable time in Claude Bernard's laboratory in Paris, as his assistant. Upon his return to Copenhagen he received an invitation to fill the position of Professor Extraordinary of Physiology, Medical Chemistry, and General Pathology in the University of Kiel. He accepted the call, and in 1858 he was promoted to the regular professorship. In 1863, upon the death of Prof. Eschricht, he was chosen the Professor of Physiology in the University of Copenhagen. Very soon after he had taken possession of this office he set about having a new and suitable physiological laboratory built, and his efforts were promptly rewarded with success. During the following twenty years Panum's ability, energy, and wisdom made themselves felt not only in his own particular domain of physiology but also in that of medical education generally, of sanitary science, of public health, of medico-historical studies, etc. He died from rupture of the heart on May 2, 1885.

Pagel ranks Panum as the greatest physiologist that Denmark has yet produced. Of the latter's published writings the following two deserve to receive special mention: "Experimentellen Untersuchungen zur Physiologie und Pathologie der Embolie, Transfusion, und Blutmenge," Virchow's Archiv, 1857; and "Haandbog i Menneskets Physiologie," Kopenhagen, 1865–1872. A. H. B.

Papaver.—Poppy.—The principal products of the poppy plant will be found described under the titles of opium and its more important alkaloids. Some minor products are here considered.

Poppy Capsules (*Papaveris capsula*; *Fructus* or *Capita Papaveris immatura*) are more or less employed in medicine for the opium which they contain. Their botanical origin has been fully stated under *Opium*. For the purposes here considered, they are gathered when nearly ripe and are dried in the sun. They are more or less spheroidal, but vary in the different varieties, from strongly oblate to strongly prolate, and they range from one and one-half to three inches in diameter. The larger ones, and those of prolate form, known as the "black" variety, are by many regarded as superior. The color is pale brown, and the surface nearly smooth. At the summit there are from eight to sixteen, or occasionally twenty short, nearly sessile, recurved stigmas, indicating an equal number of placentæ, the latter projecting as sharp ridges upon the inside of the capsule. Partly concealed under the stigmas are a circle of small pores through which the mature seeds escape. The seeds are not a part of the capsule considered as a drug. Numerous constituents have been reported as occurring in these capsules, but from a medicinal point of view they may be regarded as identical with those of opium. The morphine content rarely exceeds a fourth of one per cent., notwithstanding that claims for a much larger yield have been made. The younger the pods the less morphine do they contain.

Poppy capsules were official in the United States Pharmacopœia of 1870, and in the British Pharmacopœia until the edition of 1914, but their use in the United States has almost entirely given place to that of other and more definite forms and preparations of opium. In Great Britain the syrup is probably the most largely used preparation, and is mostly administered to children, though the extract is also considerably employed. The dose of any preparation should represent from one to two drams of the capsule.

Poppy seeds possess no narcotic properties whatever though it is said that traces of morphine can be found in them. They are used purely for their fixed oil, which is an important article of commerce. The oil is quite bland and possesses only the nutritive and demulcent properties of vegetable fixed oils in general. The seeds, under the name of *maw seeds*, are largely used in bread and cake making, especially on the continent of Europe.

Poppy Petals, or *Red Poppy Petals* (*Rhœadas Petala*) are the petals of *Papaver Rhœas* L., the common red or field poppy of Europe. They resemble rose petals but are larger. The color of the fresh petals is a brilliant scarlet red, with a large black spot at the base, but the color becomes pale and dull in drying. They are used entirely for their coloring matter, for the tinting of pharmaceutical preparations, and hence are greatly preferred in the fresh condition. The coloring matter is divisible into two portions: *rhœadic acid*, which is dark red, soluble in both water and alcohol; and *papaveric acid*, which is of a brilliant red, soluble in water but not in alcohol. An alkaloid (*rheadine*) exists in very small amount, but is unimportant. It is said that a trace of morphine has been extracted, but the article can scarcely be regarded as medicinal. Henry H. Rusby.

Papaya.—*Papaw juice. Carica.* The dried milk juice obtained from the nearly ripe fruit of *Carica papaya* L. (fam. *Papayaceæ*).

This interesting plant is the well-known melon tree of tropical America, now widely introduced into other tropical countries All of its parts contain a latex or milk juice, which is more abundant and more milky in the nearly ripe fruit than elsewhere. This milk juice possesses a bitterish and very acrid taste, is

irritant to mucous membrane or to the abraded skin, and has considerable detergent power. It possesses the property of peptonizing albuminous substances, after the manner of trypsin, and of softening an additional portion which is not truly peptonized. By reason of its possessing this property, it has been largely used in its own home for application to tough meat to render it more palatable and digestible, a fact which has led to its very extensive use as a digestant, a use which is rapidly increasing. Its digestant principle has eluded isolation, as have all similar substances. It has been found possible, however, to concentrate the activity in a peculiar extract called caricin (Moncorvo), papain (Wurtz), or papayotin (Peckolt), which is extracted with water, the solution filtered and the filtrate precipitated with alcohol, and perhaps again dissolved and reprecipitated for somewhat further concentration. The fresh juice, which consists largely of water, yields also considerable resin, divisible into two portions, nearly five per cent. of a kind of caoutchouc, a little fat, malic acid, leucin, tyrosin, and other unimportant matters. The leaves, from which the papain can also be obtained, yield the crystalline alkaloid *carpaine* ($C_{14}H_{25}NO_2$), which is most abundant in the young leaves, constituting about one-fourth of one per cent. of their weight when dried. The seeds, which are pungent and which are used for their tænicidal properties, contain a resin which shares the pungency, though the latter is said to be due to a volatile principle allied to the volatile oil of mustard. These seeds have a strong flavor somewhat resembling that of mustard or horse-radish. In tropical countries, this fruit is regarded as very wholesome and its value is said to be increased when some of the seeds are eaten with the pericarp.

Preparation.—The commercial article consists chiefly of the dried milk-juice of the young fruit. The younger the fruit the larger the yield of juice and the less water does it contain. The juice congeals almost immediately upon exuding from the incisions, and is mostly scraped off, though some drips into pans placed to receive it. On some fruits it long retains its translucent whitish appearance, while on others it immediately turns to a reddish brown, and there is no apparent explanation of this difference. The congealed juice long retains its moisture, several days exposure in thin layers to a hot sun being required to dry it. In the meantime, it develops a powerful putrid odor, which fact has led to the extensive use of artificial heat and of the vacuum process, to expedite drying.

As dried papaw juice appears in market, under that name or as "Papaine." It consists of irregular friable and somewhat porous lumps mostly less than an inch in diameter, of a brown, mostly dark, dirty-brown color, of a slightly or strongly putrid odor and a sweetish, then acid taste.

Action and Uses.—Since about the year 1880, great attention has been given in Europe and America to attempts to employ papain as a digestant. Reports as to the energy, and even as to the manner of its action, vary most widely, even when presented by careful experimenters, a result that is clearly due to the use of adulterated material. Much of the information which has been supplied to physicians, and which has found its ways into professional journals and books, has been smuggled under the guise of scientific literature from interested commercial sources.

It has been definitely established that as a digestant papaya is wholly proteolytic. It disintegrates, softens, and liquefies albumen in the form of white of egg, musculin, fibrin, and casein, and considerable of the product is peptonized. This action takes place in an alkaline, acid, or neutral medium. Dr. Lafayette B. Mendel, who has made special researches in this direction, has furnished us with the following account of the products of papain digestion:

"The products of the reaction of papain with proteids consist in large part of proteoses. Peptones —*i.e.* compounds not precipitable with ammonium sulphate, but still giving the biuret reaction—are also formed. The papain proteoses resemble the related products obtained by gastric digestion. Regarding the occurrence of further products of proteolysis, such as leucin, tyrosin, tryptophan, and other characteristic derivatives of tryptic digestion the evidence is somewhat uncertain. Underhill and the writer have usually failed to find leucin, tyrosin, and tryptophan in appreciable quantities, at least under conditions in which they are readily formed in large quantities by other tryptic enzymes. Emmerling has succeeded in isolating small quantities of these substances from the products formed after very prolonged digestion, although even under such conditions proteoses predominate. Papain accordingly resembles trypsin in dissolving proteids in media of various reactions, thus differing from pepsin; its resemblance to the latter lies in the similarity of the products formed by the two enzymes. Harlay has made comparable observations with the enzyme of the related *Carica hastifolia*. Kurajeff has found that commercial preparations of papain induce the formation of peculiar protein precipitates in solutions of proteoses such as the widely used "Wittepepton".

The reaction corresponds with that described for rennin as 'plastein formation,' by Danilewski and his co-workers. The importance of this proteid-clotting or precipitating function of enzymes can only be conjectured at present. Thus it may play a rôle in proteid synthesis and regeneration; and the significance of such an enzyme in plants at once becomes apparent. On milk papain preparations exercise a clotting or curdling action. Whether these properties are all due to the same enzyme, or whether more than one unorganized ferment is present in the plant, are questions which have not yet been settled."

The custom of adulterating it with tapioca or rice starch has prevailed enormously. In 1914, the U. S. Department of Agriculture took up this subject and rejected nearly all that was offered for import, with the result of almost completely stopping the practice. Sometimes toasted rice bread or cassava bread crumbs were used for this purpose. Another form of superior quality occurs in extremely porous and friable whitish flakes, resembling dried froth. This is undoubtedly prepared and concentrated in some way. There are also other forms or products, prepared by secret processes.

Riedel, who in 1894 made a very elaborate series of experiments to determine the most favorable conditions for the activity of papain, concluded that the most favorable temperature was about that of the body; that one part of papain to one hundred of albumin was the most favorable proportion; that the more concentrated the papain solution the greater the activity; and that the capacity of papain for digesting egg albumen was about one hundred times its own weight. The answer to the last question depends naturally upon the degree of concentration of the papain; yet it has been found impossible to carry this concentration more than a little way. The activity of a definite portion of the dried papaw juice itself is much greater than that of the papain extracted from it; a single instance is recorded in which such a juice, very carefully prepared, digested one thousand times its own weight.

As a general statement, it may be said that a good average sample of papain is capable of digesting from fifty to one hundred times its own weight of albumen, under favorable conditions. It is also very noteworthy that it loses its power rapidly upon being kept. If kept with ordinary care in well-stoppered vials it will ordinarily have but little value at the end of a year.

As to whether papain possesses any diastasic action in the conversion of starch, we have also discordant reports, but are obliged to conclude that it has none. As to its milk-curdling power, it certainly possesses a small and variable degree; but this is of a peculiar character, the process and the coagulum differing distinctly from those resulting from the use of rennet.

Papaya is a powerful irritant to denuded tissues and to mucous membrane. So powerful is this action that if a large amount be taken into the stomach in concentrated form it acts as an irritant, or even as an emetico-cathartic poison. Applied to a raw surface it acts as an escharotic, and is very apt to be followed by putrefactive processes. Papain, prepared as above described, is less active in this direction, though still irritant. Desjardins states that the irritant property is almost completely destroyed by boiling, which also produces a new substance, having a powerful lumbricidal action, similar to that of the seeds.

The principal native use of papaya has been stated above. Owing to its locally stimulant action, it has also been used as a cosmetic, to remove pimples and similar roughnesses from the skin, and to produce a smooth, healthy surface. Its irritant properties have been utilized in the form of caustic applications to cancerous and other morbid tissues, but the practice cannot be considered good. Its dissolving action upon albuminous substances has been utilized by applying it to diphtheritic membranes. For this purpose a five per cent. solution, preferably made alkaline with 0.5 per cent. of bicarbonate of soda or potash, is applied at short intervals with a brush, or in the form of a spray. The results appear to be highly irregular and uncertain. A similar solution, but twice as strong, is applied to warts, corns, and other cutaneous indurations. Almost its entire use in Europe and America is for internal administration as a digestant, either alone or combined with other ferments. Owing to its irritant effect it should be administered when the stomach is full of food, and dilution with milk-sugar or other neutral substance is desirable. Opinions differ widely as to the dose, but the best evidence is in favor of the use of a considerably larger dose than that of official pepsin. Where there is an irritable condition of stomach or bowels, the dose should be reduced, and the drug should not be used in case of an ulcerated condition of those organs.

Allied Drugs.—The juice of the fruit and leaves of the pineapple has similar properties and uses, already referred to under *Bromeliaceæ*. Henry H. Rusby.

Pappataci Fever.—*Synonyms*: Three days' fever; Phlebotomus fever. An acute febrile disease conveyed by *Phlebotomus papatasii* and some other species of the genus. It is characterized by sudden onset, rather high temperature with severe symptoms, rapidly developed leucopenia, a duration of only three days, and no mortality.

History and Distribution.—The disease was differentiated clinically in the Mediterranean by Pym in 1804. Taussig in 1905 suggested its conveyance by *P. papatasii*. The disease has been found to prevail at certain seasons in many tropical and subtropical regions in Europe, Asia, Africa, Central and South America. The first exhaustive study of it was made in Herzegovina and adjacent provinces along the Adriatic by Doerr, Franz and Taussig who published the result of their work in 1908. Birt,[1] in 1910, by experimental studies in Malta and Crete, established the following facts:

(1) The blood of a person suffering from phlebotomus fever is virulent during the first day; (2) the virus can pass through a Pasteur Chamberland candle *F*; (3) *P. papatasii* can convey the infection; (4) the incubation period varies from 3 days 16 hours to 7 days; (5) *P. papatasii* are infective 7 to 10 days after sucking virulent blood; (6) the virus retains its activity for a week *in vitro*.

Etiology.—The nature of the virus is not known. At present it seems reasonable to assume that it is an ultramicroscopic protozoon parasite. The patient is infective to the biting female phlebotomus during the first day and a part of the second. By the end of the second day of the fever the patient is no longer infective for the fly. The fly, after biting the infective patient, does not become infective to another person bitten until seven days later. The phlebotomus seldom lives more than ten days in captivity, but during a longer free life she probably remains infective indefinitely, and possibly transmits the infection through her eggs to the following generation of flies. In the person infected by her bite the disease has an incubation period of three and a half to seven days.

Pathology.—In the absence of preëxisting complications the disease is not fatal; its morbid anatomy is therefore unknown. Studies of the blood by Doerr and Russ[2] have shown that antibodies are developed; the serum from convalescents neutralizes infective serum, an attack confers immunity, reinfections appear never to occur, and natives of an endemic region appear to be immune, probably because of previous attacks in childhood.

Symptoms.—The onset is sudden, with sharp rise of temperature to 104° or more and the usual febrile symptoms, headache, flushed skin, coated tongue, anorexia, etc. The eyes are injected, sensitive to light, painful on movement. The patient is irritable and intolerant to sounds, complains of pain in bones, joints and muscles, is sometimes delirious. There is no enlargement of liver or spleen. Occasionally there is a slight erythematous or roseolar rash. The pulse is relatively slow, seldom above 120. The blood is normal except for a distinct leucopenia, the white cells falling to about 4,000 on the first day and still lower on the second, the reduction being mainly in the polymorphonuclears. In thirty-six to forty-eight hours the temperature falls slowly to normal, frequently with epistaxis, more rarely with sweating or diarrhea; the symptoms subside and the patient enters upon a slow convalescence lasting two weeks or more.

Diagnosis and Prognosis.—The diagnosis rests upon the clinical signs, chiefly the sudden onset with high temperature, slow pulse, leucopenia, and short duration. The shorter course and the absence of any definite eruption or desquamation distinguish it from dengue, the absence of catarrhal symptoms from influenza, and the absence of plasmodia from malaria.

The *treatment* is symptomatic and expectant. Aspirin may be administered for the diffuse pains and a bromide for the headache. Quinine is harmful. It is to be remembered that convalescence is slow.

J. F. Leys.

References.

1. Birt: Journ. Royal Army Med. Corps, 1910.
2. Russ: Archiv f. Schiffs u. Tropen Hygiene, 1909, xiii, 22.

Paracelsus.—The real name of Paracelsus was Theophrastus Bombastus von Hohenheim. It does not appear how the latter name came to be changed into the less bombastic and more practical one by which he is now universally known. He is believed to have been born near Einsiedeln in the canton Schwyz, Switzerland, about the year 1491. At a very early stage of his education he became dissatisfied with the routine methods of teaching chemistry then in vogue, and started for the mines in Tirol owned by the wealthy Augsburg family of the Fuggers. "The sort of knowledge he got there pleased him much more. There at least he was in contact with reality. . . . . He had proof that positive knowledge of nature was not to be got in schools and universities, but only by going to nature

herself, and to those who were constantly engaged with her. Hence came Paracelsus's peculiar mode of study. He attached no value to mere scholarship; scholastic disputations he utterly ignored and despised—and especially the discussions on medical topics, which turned more upon theories and definitions than upon actual practice. He therefore went wandering over a great part of Europe to learn all that he could. In so doing he was one of the first physicians of modern times to profit by a mode of study which is now reckoned indispensable. The book of nature, he affirmed, is that which the physician must read, and to do so he must walk over the leaves. The humors and passions and diseases of different nations are different, and the physician must go among the nations if he will be master of his art; the more he knows of other nations, the better he will understand his own. . . . . In this new school discovered by Paracelsus, and since attended with the happiest results by many others, he remained for about ten years. . . . . In 1526 or 1527, on his return to Basel, he was appointed town physician, and shortly afterward he gave a course of lectures on medicine in the university. Unfortunately for him, the lectures broke away from tradition. They were in German, not in Latin; they were expositions of his own experience, of his own views, of his own methods of curing, adapted to the diseases that afflicted the Germans in the year 1527, and they were not commentaries on the text of Galen or of Avicenna. . . . . They criticized in no measured terms the current medicine of the time, and exposed the practical ignorance, the pomposity, and the greed of those who practised it. The truth of Paracelsus's doctrines was apparently confirmed by his success in curing or mitigating diseases for which the regular physicians could do nothing. For about a couple of years his reputation and practice increased to a surprising extent. But at the end of that time people began to recover themselves. . . . . His enemies watched for slips and failures; the physicians maintained that he had no degree, and insisted that he should give proof of his qualifications. (Encyclop. Brit., edition of 1911.) Thus it came about that Paracelsus was forced to flee from Basel. He went first to Esslingen, where he remained only a few months, and then continued his wanderings to Colmar, Nuremberg, Augsburg, Meran, etc. His death occurred at Salzburg on September 24, 1541.

Strange as it may appear, there can be no reasonable doubt that Paracelsus, notwithstanding his quarrelsomeness and his leanings to charlatanism and to extravagances of every kind, conferred a great and lasting benefit upon medical science. He succeeded in lifting it out of the deep rut into which it had fallen and in imparting to it that restless eagerness to ascertain the truth which characterized the work of physicians during the sixteenth century, and even long afterward. Then, in addition, he should be credited with certain specific improvements in the treatment of disease and in the preparation of remedial drugs. It was he, for example, who first established the infallibility of mercury in the treatment of venereal diseases; and he also called the attention of the medical world to a number of other medicaments; and he demonstrated, by the better results which he obtained, that it was possible materially to enhance the therapeutic value of certain drugs by bestowing greater care upon their preparation.

Of his published writings only a very few may here be mentioned: "Astronomia et astrologia," Cologne, 1567; "Philosophica mystica," Neustadt, 1618; "De præsagiis, vaticiniis, et divinationibus," Basel, 1569; and "Bücher und Schriften [des Paracelsus], jetzt aufs Neue aus den Originalien an Tag gegeben durch J. Huserum," Basel, 1589-1590, 11 volumes. Quite recently the city of Basel has erected a monument in honor of Paracelsus. A. H. B.

Paracentesis.—(G. παρά, beside, + κέντησις, puncture.) Tapping, the passage into a cavity of a trocar and cannula or other hollow instrument for the purpose of removing fluid (Stedman). The operation is variously designated, according to the cavity punctured: p. abdominis, of the abdomen; p. capitis, of the head or skull, cephalocentesis; p. cordis, of the heart, cardiocentesis; p. corneæ, of the cornea; p. intestini, of the bowel, enterocentesis; p. pericardii, of the pericardium, pericardiocentesis; p. pulmonis, of the lung, pneumocentesis; p. spinalis, of the subarachnoid space of the spinal membranes; p. thoracis, of the chest, thoracentesis; p. tunicæ vaginalis, of the tunica vaginalis; p. tympani, of the middle ear; p. vesicæ, of the bladder.

Paracentesis Abdominis.—The peritoneal cavity is punctured for diagnostic purposes, or for evacuation of fluid, "tapping." Any collection of fluid within the peritoneal cavity, whether encysted or free, may be thus removed for bacteriological, chemical, and cytological examinations. The most frequent indication, however, is the removal of ascitic fluid, typically in cirrhosis of the liver, and even this is being superseded by omentoplasty (Talma) and autodrainage of the fluid into the subcutaneous tissues.

The patient is prepared as for a formal abdominal operation. He is placed in the upright position in a chair or upon the edge of the bed. To prevent splanchnic apoplexy from too sudden withdrawal of the fluid, a Scultetus bandage or a towel is placed around the abdomen, and gradually tightened by an assistant, who stands behind the patient, as the fluid is withdrawn. There is a hole in the fabric opposite the site of paracentesis. The latter is located usually in the linea alba, midway between the navel and the symphysis, although the linea semilunaris may also be elected. The skin is anesthetized by ethyl chloride spray, or by the subdermal injection of a novocain-suprarenin solution. It is better technically to make a small incision through the skin with a scalpel, and enter with the trocar as soon as the subcutaneous tissue is exposed, rather than use the trocar from the beginning, owing to the chance of carrying infection to the peritoneum from the skin. When the peritoneal cavity is reached the trocar is withdrawn, and the fluid is permitted *slowly* to escape through the cannula, the binder being tightened *pari passu*. Obstructions to the flow may be dislodged by a sterile probe. When the fluid has been removed the cannula is withdrawn. Leakage is prevented by making the mural tract oblique in the first instance, thus forming a valve, or by temporary compression of the puncture wound. For exploratory purposes a needle of smaller caliber may be employed. The latter should not be so small that viscid fluid cannot be removed by the suction of the syringe. If the skin has been incised, a stitch is taken. With good apposition of the edges, it may suffice to paint the wound with iodine, or a cotton-cocoon-collodion dressing may be applied.

Paracentesis Capitis (Cephalocentesis).—This operation for hydrocephalus is ancient, having been first performed by Le Cat, in 1744, and repeated by Remmet, of England, in 1778. It is indicated in acute, or even in chronic, hydrocephalus when death threatens from the high intracranial pressure. A very delicate trocar or an aspirating needle is introduced through the anterior fontanelle wide of the superior sagittal sinus, and the point directed downward and a little backward. Only a small quantity, about two ounces or approximately one-fourth of the total amount, of the fluid should be withdrawn, the sides of the skull being compressed by an assistant. The wound is sealed with gauze, and adhesive plaster applied to support the skull and prevent syncope. In cases of internal hydrocephalus the needle is thrust through the coronal suture on either side, the point

being directed inward and backward so as to penetrate the lateral ventricle. The operation should be repeated at intervals of from a few days to a few weeks, according to the condition of the patient, and the rate at which the fluid is reaccumulating. If the fontanelle is closed or the sutures are ossified it is necessary to use a trephine.

Anton and von Bramann, in 1913, suggested puncture of the corpus callosum in congenital hydrocephalus due to irremovable obstruction blocking the passage of cerebrospinal fluid from the ventricles into the subarachnoid space. Their technique is as follows: At a point 1.5 to 2 centimeters behind the coronal suture and the same distance lateral to the median line an opening is made in the skull with a Hudson burr and a small slit made in the dura, care being taken not to injure the cortical veins. A curved cannula, which should be hollow and beak shaped, is then introduced through this opening, passing between the brain and the dura down to the falx cerebri, and following the falx down to the corpus callosum, which forms the roof of the body of the lateral ventricle. The corpus is then easily perforated and the fluid should at once flow from the cannula. After the necessary amount has been withdrawn the opening in the corpus callosum may be enlarged by gently moving the cannula backward and forward.

Paracentesis Cordis (Cardiocentesis).—In cases of engorgement of the right side of the heart from pulmonary congestion relief may be obtained by puncturing either chamber and aspirating the blood. In the case of the auricle—and this lends itself more readily to puncture—the needle is entered in the right third intercostal space close to the sternal margin and thrust directly backward until blood flows freely into the syringe. Owing to the low pressure in the auricle the blood must be withdrawn by suction. The wound is sealed by a cotton-cocoon-collodion dressing.

In the case of the ventricle the needle is entered in the right fourth intercostal space about an inch from the sternal margin. It is directed *inward* as well as backward. Owing to the higher pressure the blood flows without the necessity of suction.

Paracentesis Corneæ.—In case of a corneal ulcer threatening to perforate, of hypopyon, or for the relief of glaucoma (Sperino), or high intraocular tension in iritis or uveitis, this operation is indicated and is performed as follows: Local anesthesia is usually sufficient but in nervous subjects and young children general may be necessary. The cornea is punctured near its lower margin, or in the case of an ulcer through its floor, with a paracentesis needle constructed with a shoulder to prevent an undue depth of entrance, and inserted at an angle of forty-five degrees with the point of contact; or with a broad needle held flatwise, the point being kept well forward so as to avoid wounding the lens. By rotating the needle slightly on its long axis the lips of the opening are separated and the contents of the aqueous chamber more readily escape. The needle must be withdrawn slowly lest a sudden gush of aqueous cause prolapse of the iris. The eyeball may be steadied with a spring speculum or fixation forceps, provided the former does not put too much pressure on the globe, or the lids may be separated by the surgeon's fingers. If it is necessary to reopen the wound the probe end of the instrument should be used (de Schweinitz).

Paracentesis Intestini (Enterocentesis).—This operation is indicated in cases of intestinal obstruction with great distention from gas and feces. It consists of puncturing one or more coils with a fine trocar and cannula, or with the hollow needle of an aspirator. It is *not* to be performed through the unopened abdominal wall, as was formerly the practice. Under the name of "enterocentesis" a French writer, Dr. Larguier des Bancels, recommends puncturing the bowel with a large trocar and cannula, the latter being retained in position for several days (Ashhurst). Analogous to this is the use of the tube recommended by Paul, of England, in 1892. It is made of glass, is bent to a right angle, and has a rim near each end. The large tube is used in the colon, the small tube in the small intestine. A small opening is made in the intestine, the tube is introduced and is tied in place by a silk suture which surrounds all the coats of the bowel, the gush of feces is caught in a basin, a rubber tube is fastened to the glass tube, and fluid feces are collected in a bottle and beneath an antiseptic fluid. In from three or four days to a week the tube becomes loose and can be removed (DaCosta).

Paracentesis Pericardii (Pericardiocentesis).—This operation was originally proposed by Riolanus in 1653; was first successfully executed by Romero, of Barcelona, in 1819; and first performed in this country by Dr. John C. Warren in 1852. For effusion, the result of a wound, it was first performed by Larrey who entered the fifth intercostal space. Trousseau was the greatest exponent of the operation. It is now performed when life is threatened by an effusion, but, owing to the danger of injuring the heart, should be abandoned in favor of the safer but more radical procedure of pericardiotomy.

The left fifth intercostal space is the site usually chosen as the width is greater near the sternal border. It is preferable to puncture between the internal mammary artery and the sternum, and near the upper border of the sixth costal cartilage. The needle is passed backward, then inward, then downward, and enters the pericardium about an inch from the surface.

Paracentesis Pulmonis (Pneumocentesis).—Puncture of the lung for the purpose of evacuating the contents of a cavity is usually performed, when the lung is exposed, to locate a suspected collection of fluid. When such a collection has been found, or is evident without exploration, pneumotomy is indicated to afford sufficient drainage.

Paracentesis Spinalis.—Under this heading may be placed puncture of the spinal meninges, or lumbar puncture, which was devised by Heinrich Quincke. It is the operation for withdrawing cerebrospinal fluid from the subarachnoid space of the spinal meninges. It is employed as a means of diminishing cerebral pressure in hydrocephalus, cerebral tumor, uremia, and tuberculous meningitis. It may be of some service in cerebrospinal meningitis. The condition of a patient with a fracture of the case of the skull is sometimes temporarily improved by the operation. In the performance of a brain operation the brain may bulge so that the dura cannot be sutured and lumbar puncture makes suturing possible (DaCosta).

Examination of the fluid removed may be of great diagnostic value, and is now an established procedure in determining luetic involvement of the spine. Paracentesis spinalis is the preliminary step of spinal anesthesia, and of the introduction of curative agents, such as antitetanic and antimeningitis sera, and salvarsanized serum.

The best position is with the patient sitting upright upon the edge of the table with feet upon a chair and leaning forward, thereby increasing the height of the intervertebral spaces by as much as five-eighths of an inch. If he is unable to sit up the Sims position may be employed. The skin is painted with iodine. Local anesthesia, obtained by either the ethyl chloride spray or intradermal infiltration of a few drops of novocain-suprarenin solution, may be employed. A line connecting the highest points of the iliac crests, with the back straight, crosses the tip of the spinous process of the fourth lumbar vertebra, and the puncture may be made in the intervertebral space above or below this vertebra. In any case a small incision through the skin should pave the way for the needle lest bacteria

be carried to the meninges. A Pravaz syringe, with a needle at least three inches in length, is employed. The point enters one-half inch to the right of this spinous process and just below or above its tip. It is passed slowly forward, inward, and slightly upward, so as to enter the canal in the median line. Its penetration of the subarachnoid space is indicated by lessening of the resistance. In a child the depth is generally about one inch, and in an adult about three inches. The fluid is allowed to flow out spontaneously drop after drop. Care must be taken not to evacuate too much lest compression of the cerebellum arise. One-half ounce is a safe limit for the average adult. The medicament is now introduced into the subarachnoid space but never in greater amount than that of the cerebrospinal fluid that was withdrawn. After proper attention to the wound the patient should remain recumbent for a number of hours.

Paracentesis Thoracis (Thoracentesis).—This operation was first prominently advocated in America by Dr. Henry I. Bowditch, of Boston, and is now one of the most commonly performed of the paracentesis operations. It consists in penetration of the chest-wall to reach the pleural cavity for the evacuation of fluid or air or for exploratory purposes. The trocar and cannula method is to be employed only in an early stage of non-traumatic pneumothorax; otherwise aspiration by some form of vacuum bottle is the proper procedure. Unless the fluid is encapsulated and limited to a definite region the sixth intercostal space in the midaxillary line is the site most commonly selected.

The skin is painted with iodine. A solution of novocain is injected into the skin, beneath it, and into the pleura, so as to obtain anesthesia and block impulses of shock. The intercostal spaces are widened by position. The arm is elevated and the skin drawn slightly upward, so as subsequently to form a valve. A limited incision is made through the skin. The point of the needle enters just above the upper margin of the rib, so as to avoid the intercostal vessels and nerve, which run along the lower border. It is passed inward and slightly upward. As soon as it is felt to be in the pleural cavity, the aspirating tube is attached and the contents are withdrawn. The operation is concluded by proper treatment of the wound.

Paracentesis Tunicæ Vaginalis.—This operation affords a means of dealing with hydrocele. The scrotum is grasped behind so as to make tense the anterior aspect of the swelling. The sac is punctured at its anteroinferior aspect, and the needle or trocar is passed directly backward and then upward, the depth to which it penetrates being controlled by the index-finger. The testicle usually lies posterior to the sac, but may lie below or even in front, and its site may be determined by palpation, unless the sac be very rigid when tapping is contraindicated. After withdrawal of the fluid intended injections may be made, the instrument is withdrawn and the puncture sealed with a cotton-cocoon-collodion dressing. The testicles should be supported by a suspensory.

Paracentesis Tympani.—This operation, performed by every practitioner, is to relieve the tension and evacuate the pus in otitis media. The ear drum may be rendered insensitive by blocking of the auriculotemporal nerve, as proposed by P. G. Skillern, Jr., in 1913, or by instilling into the canal a few drops of a mixture of novocain, alcohol, and anilin oil. With proper illumination the membrane is incised in its posterior half. This incision should be kept close to the posterior margin and should extend from the level of the stapes to the lowest portion of the drumhead (Grayson).

Paracentesis Vesicæ.—For retention of urine that cannot be overcome by other means the bladder may be tapped suprapubically. The rectal avenue has been abandoned.

The skin is painted with iodine and local anesthesia is employed. The instrument enters in the median line, just above the symphysis pubis, and is directed backward and downward into the bladder. The trocar is withdrawn. It is dangerous to evacuate the total quantity of urine at one time. The cannula is removed and the puncture sealed by a cotton-cocoon-collodion dressing.

Paracentesis may also be employed to evacuate fluid contents of a joint, as well as to locate cysts and abscesses in the brain. Morris Booth Miller.

Paracholia.—The term used by Pick to designate the hypothetical secretion anomaly by which the bile leaves its accustomed channels and passes into the blood, giving rise to icterus. By a number of recent writers icterus is regarded as due to a diseased condition of the liver cells, the process being analogous to the secretion of albumin in diseased conditions of the kidney cells. Normal liver cells should secrete bile into the bile vessels, and urea and sugar into the blood capillaries. According to Minkowski it is, therefore, not without analogy that the liver cells in diseased conditions should give off the bile into the blood-vessels. Such a process is designated by him as *parapedesis*. Liebermeister and Pick also explain many forms of icterus as due to functional disturbances of the liver cells, either with or without evident anatomical changes, the former designating such a disturbance as *diffusion* or *akathectic icterus*, the latter as *paracholia*. Pick believes that the pathogenesis of the obscure forms of icterus may be explained by this hypothesis. He accordingly distinguishes three cases: *nervous paracholia, toxic paracholia*, and *infectious paracholia*. Aldred Scott Warthin.

Paraffin.—See *Petrolatum*.

Paraform—paraformaldehyde, triformal, trioxymethylene $(HCOH)_3$—is a polymeric form of formaldehyde, occurring as a white, insoluble, crystalline powder. It tends to decompose slowly with the production of formaldehyde gas, and, when acted upon by heat, as in some of the formaldehyde generators, may evolve the gas rapidly and in large quantities. It is employed to disinfect rooms, and for this purpose about twenty grams of paraform should be used for each 1,000 cubic feet of enclosed space. On account of its slow and steady evolution of formaldehyde, it is used by physicians as an intestinal antiseptic and by dentists for disinfecting cavities. The dose is gr. viij.–xv. (0.5–1.0). Unna prescribes: ℞ Paraform gr. xxx., ether ♏xxx., and flexible collodion ʒss. as the best application for pityriasis versicolor, erythrasma, and other saprophytic skin diseases. Paraform collodion in twenty-five per cent. strength is efficacious as a caustic for warts.

Paraform enters into the composition of ekaiodoform. W. A. Bastedo.
R. J. E. Scott.

Paragonimus.—A genus of trematode worms. *P. westermani* is the lung fluke found in many parts of the world. It has been reported from the tiger, cats, dogs, hogs, and man. It is not always found in the lungs but sometimes infects the brain or other parts of the body. See *Trematoda*. A. S. P.

Paraiso Hot Springs.—Monterey County, California.

Post-office.—Paraiso Springs. New Cottages.

Access.—Take 8:05 A.M. Southern Pacific train from the corner of Third and Townsend streets, San Francisco, reaching Soledad station at 12 M. Thence by automobile a drive of one-half hour to the springs.

"Paraiso Springs," says Mr. E. S. Harrison in his history of Monterey County, "were the property of the Mission Soledad, which lies about five miles northeast of the springs. The title of the present owner was obtained from the Church of Rome, to which a patent was granted by the Mexican Government in 1778. In the records of the Mission Soledad the healing and invigorating qualities of these waters are duly set forth." The springs are situated in a picturesque alcove of the Santa Lucia Mountains on the western border of the Salinas Valley, about 150 miles south of San Francisco. The altitude of the location, being 1,400 feet above the valley, renders the atmosphere dry, bracing, and invigorating. Below the resort, and for miles beyond, the eye scans the fertile valley, traversed by the grand Salinas River and Arroyo Seco, and the far-away Gabilan Mountains, forming a picture of great charm and glory. The commodious cottages are most comfortable. The table is supplied by the Springs' garden and dairy. On the premises are several valuable springs flowing about 2,000 gallons of water per hour, and consisting of sulphur, soda, arsenic, and iron waters. The temperature of the springs varies from 70° to 118° F. We give below the analyses of the waters of the two principal springs, the Paraiso Sulphur Spring and the Great Paraiso Hot Soda Spring.

The Paraiso Sulphur Hot Springs.

	Grains per Gallon.
Sodium chloride	2.76
Sodium carbonate	1.15
Sodium sulphate	37.10
Potassium sulphate	0.83
Magnesium carbonate	6.09
Magnesium sulphate	2.19
Calcium carbonate	0.89
Calcium sulphate	4.40
Organic matter	7.35
Total	62.76

Temperature 102° F.

This is said to be one of the best bathing waters on the coast.

The Great Paraiso Hot Soda Spring

	Grains per Gallon.
Sodium chloride	3.50
Sodium carbonate	4.23
Sodium sulphate	35.50
Calcium carbonate	1.43
Calcium sulphate	4.32
Potassium chloride	0.35
Alumina and iron	1.60
Silica	2.62
Organic matter	5.25
Total	58.80

Temperature 118° F.

Qualitatively this water closely resembles the famous Carlsbad Sprudel water, but is less highly mineralized.

Quail, dove, and deer abound in the surrounding hills. Fish are plentiful in the Arroyo Seco, a beautiful stream just over the hills.

Sufferers from malaria, rheumatic affections, gout, neuralgia, insomnia, asthma, bronchitis, and disorders of the liver, kidney, and stomach, find almost immediate relief.

Bowling alleys, box-ball alleys, croquet grounds, tennis courts, a gymnasium, and a large outdoor mineral swimming pool are at the service of the guests.

Many visitors, invalids, and pleasure-seekers visit Paraiso Springs yearly, and the excellence of the mineral waters, the salubrity of the climate, and the picturesqueness of the location make Paraiso one of the most delightful health resorts in California.

Emma E. Walker.

Paraldehyde.—Parethylaldehyde: $3(C_2H_4O) = C_6H_{12}O_3$. Paraldehyde is a polymeric form of common ethylic aldehyde ($CH_3.CHO$), and is produced by the action of a considerable number of substances upon such aldehyde. Paraldehyde is, at ordinary temperatures, a liquid, colorless, of a burning taste and powerful and penetrating ethereal odor. It dissolves in 8.5 parts of cold water and in 16.5 parts of boiling water. It mixes in all proportions with alcohol, ether, and fixed or volatile oils. At 0° C. (32° F.) paraldehyde solidifies to an ice-like crystalline mass, or may crystallize in distinct prisms. It should be kept in well-stoppered, dark amber-colored bottles, in a cool place. Paraldehyde is peculiar among ethereal bodies for possession of the property of determining *sleep*, with a minimum of by-effects. The sleep produced by the medicine seems a quite perfect imitation of natural slumber, since the subject under the influence of the hypnotic is as easily awakened as from ordinary sleep. No worse derangements occur from the medicine than a little dryness of the throat and thirst, and a trifling reduction of pulse rate and arterial tension. The most disagreeable circumstance attending the use of paraldehyde is a persistence of the taste of the drug upon the palate, and of the odor in the breath, often for a number of hours after the taking. It may also give rise to an erythematous rash, and upset the stomach. The sleep produced by a perfectly legitimate dose of paraldehyde may begin within fifteen minutes after the swallowing, and last five, six, or seven hours. The medicine is used exclusively for the procurement of sleep, and is applicable, without special contraindication, for any case in which a hypnotic is indicated. A quantity of from ♏ xxx. to lx. (2.0–4.0) is the average dose, and the same is best given dissolved in fl. ʒ i. (30.0) of an aromatic water, sweetened.

Edward Curtis.
R. J. E. Scott.

Paralysis, Acute Ascending.—Under the name of "acute ascending paralysis," Landry in 1859 described a disease characterized by weakness beginning in the legs, proceeding to complete paralysis, extending usually within a few days to the body muscles and to the arms and terminating fatally in the majority of instances by involvement of the respiratory muscles, though some few cases slowly recovered.

Landry and the earlier observers found no lesions, but more recent studies have shown that the phenomena described can occur as a result of a number of different pathological conditions, and to-day the name is used to designate a symptom-complex rather than a disease.

The prevailing conception as to the etiology of Landry's paralysis is that its symptoms are due to the action upon the nervous system of some poison, organic or inorganic, probably most frequently a toxin produced by some microorganism, as in a number of cases there have been found such evidences of infection as fever, enlargement of the liver and spleen, jaundice, vomiting, diarrhea, and acute nephritis.

The Landry symptom-complex has been observed in connection with a number of infectious diseases such as diphtheria, typhoid fever, variola, anthrax, influenza, pertussis, septicemia, in the puerperium, in chronic cystitis, in rabies, particularly after the Pasteur treatment, in parotitis, syphilis, and tuberculosis, while cases have been seen in which intestinal symptoms, with indol and skatol in the urine were present, giving rise to the idea of an autointoxication from the intestine.

In the central nervous system, in the cerebrospinal fluid, and in the blood, there have been found various cocci and bacilli, such as staphylococci and streptococci, the organisms of anthrax, typhoid fever, pneumonia, and a variety of proteus, which upon inoculation into animals produced a bulbar paralysis. In other cases again, bacteriological examination has given entirely negative results.

Fleischmann has reported a case apparently due to salvarsan intoxication.

In the epidemics of poliomyelitis which have occurred in different countries, during the last two decades, there have been observed quite a number of cases which have taken the course of acute ascending paralysis while those of neuritic type have also been seen; hence it may be suspected that many cases of Landry's paralysis are really manifestations of infection by the poliomyelitic virus.

Pathological Anatomy.—Even with the improved histological methods of to-day, in many cases the pathological findings have been negative or at least very indefinite. In some instances there have been disseminated foci of inflammation in the medulla oblongata, particularly in the pyramidal tracts, or exudation, capillary hemorrhages, etc., in the spinal cord. Wappenschmidt has laid particular stress upon the finding of hyaline thrombi, since Recklinghausen and Klebs consider these a result of the action of toxins produced by bacteria. In some cases there has been swelling of the axis cylinders in the motor tracts, again the anterior horns of the gray matter of the spinal cord have been affected (poliomyelitis). In one case neuritis of the anterior nerve roots was the only finding, while changes in the posterior spinal ganglia have also been observed. Since attention has been directed to the peripheral nerves, a number of cases in which an ascending neuritis appeared to be the sole anatomical change have been reported, while again the neuritis has been combined with myelitic or poliomyelitic changes. Some authors are of the opinion that the Landry symptom-complex is due to the extension of the neuritic process to the spinal cord, Raymond even classing together polyneuritis, acute poliomyelitis and Landry's paralysis as one disease, under the name "acute anterior celluloneuritis."

The newer investigations have in the great majority of instances showed changes, preponderantly in the spinal cord, such as disease of the vessels, hemorrhages, exudations, thrombosis, softening, infiltration and frequent alterations of the nerve cells, though only exceptionally have these undergone complete atrophy.

It would hence appear that this symptom-complex may be due to a number of different lesions, but that those of neuritis and poliomyelitis greatly predominate. However, attempts to differentiate spinal and peripheral varieties of Landry's paralysis have not been successful.

Symptoms.—The affection begins in the great majority of instances in the lower extremities, frequently first in one of them and in a day or two there is complete paraplegia. The paralysis is flaccid and is accompanied by loss of reflexes, both skin and tendon. There may be paresthesia, but pain is either absent or is only elicited on pressure upon the nerves and muscles of the affected extremities. The paralysis tends to spread within a few days to the muscles of the pelvic girdle, the trunk, shoulder girdle, and arms, and eventually to involve those supplied by the nerves originating in the bulb, so that movements of the lips, tongue, palate, and respiration are impaired and death closes the scene under symptoms of asphyxia, with simple acceleration of the breathing or respiration of the Cheyne-Stokes type. The fatal issue usually occurs in from three or four days to a week, though it is sometimes postponed for two or three weeks. In some cases, the paralysis may begin with bulbar symptoms or in the arms, and death may occur before the legs are much involved. It would seem difficult, however, to identify such cases with those described by Landry.

While there is in most cases no gross loss of sensation, there is not infrequently some blunting of the sensibility which may affect all or only some of the qualities of sensation and is usually most marked toward the ends of the extremities.

The muscles, as a rule, preserve their normal volume and react promptly to the electric current, though in those cases which live long enough there may be muscular atrophy with reaction of degeneration.

The functions of the bladder and rectum have in most cases remained unimpaired, but in exceptional instances there has been sphincter paralysis.

The sensorium remains as a rule free, though in cases in which there has been high fever and signs of sepsis clouding of consciousness has been observed. In probably the majority of instances, however, the temperature has remained normal.

Diagnosis.—Since we have to do with a symptom-complex and not with a definite disease, our endeavor should be to determine in each case, if possible, with what pathological condition we have to deal. While in probably the majority of cases, there is either a multiple neuritis or an acute poliomyelitis, the symptom-complex has also been observed in myelitis, meningomyelitis and even in disseminated encephalitis. In this connection, the bacteriological and serological examination of the blood and spinal fluid, the Wassermann reaction and the cytological examination with the Noguchi test of the latter, may furnish important indications. This symptom-complex has occasionally been observed in syphilis of the central nervous system. Also investigation as to any possible factors capable of setting up a multiple neuritis should be made.

Prognosis.—The prognosis of Landry's paralysis is always grave, particularly so in those cases which are marked by rapid extension of the paralysis to the respiratory muscles in which a fatal outcome is to be expected. Even after several weeks death may occur. In some cases, however, there is gradual regression of the symptoms with ultimate recovery. Oppenheim saw complete restoration to health in four cases out of eleven coming under his care. It is fortunately a comparatively rare condition.

Treatment.—Unless some definite and accessible etiological factor can be made out, treatment is unfortunately not very promising. In some cases in which there had been a preceding syphilitic infection, mercurial therapy, and in one case, salvarsan seem to have led to recovery (Soltmann, Nonne). When there is neuritis or poliomyelitis the treatment should be that appropriate for the one of these diseases present. Bolten has reported a case in which repeated lumbar punctures, with replacement of the spinal fluid removed by sterile normal salt solution seemed to have contributed to the ultimate recovery. In a case of Vollhard's artificial respiration carried on for several days apparently tided the patient over a period of threatened respiratory failure. Ergotin administered internally—ergotin, 1.25 (gr. xx.); aq. cinnamomi 60 (℥ii.), a teaspoonful every hour—has been recommended. Hexamethylenamine, gr. v. to gr. xv. every three or four hours, might be tried. In general a diaphoretic and antiphlogistic treatment would seem particularly indicated, when the etiology is obscure. In cases which have passed through the acute stage and are on the road to recovery, massage and galvanic applications to the affected muscles, suitable hydrotherapeutic procedures, and such tonics as iron, arsenic, and strychnine may contribute to a favorable result. Charles Lewis Allen.

Paralysis Agitans.—*Synonyms:* Shaking Palsy, Parkinson's Disease.

Etiology.—Paralysis agitans is essentially a disease of advancing years. It rarely occurs before forty years of age and mostly after fifty. It is sometimes diagnosed in the very young, but these early cases ofttimes are not so distinctly outlined that the diagnosis can be accepted without hesitation.

Heredity seems to play but a small part in etiology. Often the disease appears in members of long-lived families. Occasionally several members of the same family have been subject to the disease. I have under observation a case in which the disease occurred in both husband and wife. If this is more than a coincidence it is probable that the husband's distressful condition—his disease antedates his wife's by several years—was a causative agency through the anxiety and the worry it produced.

It is usually impossible to assign a direct cause for the disease, but in some instances emotional conditions, for instance worry, grief, and especially fright; in others overwork, hardship, exposure or acute disease appear to be the exciting cause. Not very rarely injury of some kind, injury of the head, of the extremities and especially of the nerves, is followed by the manifestations of the disease, which, then, is likely to begin in the injured part of the body.

Symptomatology.—The characteristic symptoms are tremor, muscular rigidity or hypertonicity, a peculiar posture, and the gait.

In most instances tremor is the first symptom of the disease. It begins usually in the small muscles of the hand, those of the thumb and index-finger, producing movements likened to those of rolling pills. Gradually it extends to other muscles of the hand and arm, then to another extremity—the leg of the same side or the other arm—and later to all the extremities and sometimes to the head. In some instances it appears in the tongue, jaw, chin, lips, and even eyelids. It rarely occurs in the muscles of the chest and abdomen. There is none in the muscles of the eyeballs—there is no nystagmus.

The tremor consists of symmetrical movements of slow rythm, about four to six vibrations to the second. The movements are mostly coarse, though quite variable in intensity. Those of the fingers consist of flexion and extension, abduction and adduction; those of the forearm of flexion and extension, pronation and supination. The movements of the legs, which are effected to a less extent and less frequently than the arms, consist of flexion and extension. The movements of the head are mostly merely those transmitted by the shaking elsewhere, but sometimes there is genuine tremor of the head, consisting of flexion and extension or rotary movements.

The tremor is continuous, with spontaneous variations, and occasional short periods of rest. It usually disappears in sleep. Often, especially in the earlier stages of the disease, it is controlled to some extent by active exercise. It ceases, or is lessened, for a short time in the active member. At a later period, when the tremor is very strong, active movements may have very little noticeable effect. Or, while the tremor is lessened for a short time in the active part, it becomes more violent in some other limb or limbs.

Continuous effort is likely to increase the tremor. A noticeable instance of this is the characteristic tremulous hand writing. Any excitement will increase the tremor. It is usually worse at bed time possibly due to fear of the night. Not rarely the patient is more comfortable walking than sitting or lying down. He sometimes seeks relief by pressing the fingers together or grasping an object or changing the position of the limbs. The vibration of a railway may lessen the tremor and afford some comfort. I have a patient who spends the day in a swing and finds relief only when that is in motion.

The next prominent and characteristic symptom of paralysis agitans is muscular rigidity or hypertonicity. As a rule, it is first observed later than the tremor, it may be years later, but in some instances it is the first symptom of the disease. It appears first, and is most marked, in the muscles of the neck and spine, later in those of the extremities and face, and may finally be manifest in all the muscles of the body. It causes a characteristic posture and facial expression. The trunk is bent forward; the head is usually flexed, rarely bent backward or to one side; the arms are pressed against the body, the elbows flexed, the wrists extended and the fingers usually flexed at the metacarpo-phalangeal and extended at the other joints. The legs are usually flexed and adducted. The face is expressionless. It has a stolid, mask-like appearance. Sometimes it is only the expression of the eyes that give to the face the appearance of life.

In the beginning the muscular rigidity is slight, only perceptible to the examiner because of a degree of resistance to passive movements. But it is already a source of disability to the patient. It hampers his active movements. They are less agile, more sluggish. This is especially noticeable in complex movements, such as dressing. Later, it is very noticeable in his efforts to arise from his chair which he may be unable to do without assistance. The muscular rigidity finally becomes so great that it impedes all movements and practically paralyzes the patient.

The muscular rigidity and the acquired bodily posture lead to the characteristic gait. It is a slow shuffling or festinating gait. The patient rises with difficulty from his seat, pauses for a while, perhaps to regain his power, perhaps to accommodate himself to his position, with the body and center of gravity far forward, then advances with slow short steps. This may change into a forward running gait—propulsion. Then the patient may keep on until he runs against something or seizes upon some support to stop him. This running, "festinating," gait may be produced by giving the patient a forward push. In rare instances one sees the opposite gait, a running backward—retropulsion. This may be brought on through the patient's trying to reach an object above his head, or leaning backward, or being pulled or pushed backward.

In still rarer instances lateropulsion is observed, that is, the patient runs sideward.

Though the rigidity may become extreme and there may even be contractures of the hands and feet in the later stages of the disease, there is no evidence of pathological changes in the muscles, that is no atrophy except from disuse, and no alterations in the electrical reactions. Also the superficial and deep reflexes are usually normal. There may be exaggeration or diminution of the deep reflexes or some differences between the two sides, but all in all the changes are not notable. Any definite symptom of this order, for instance the presence of the Babinski sign or absence of the knee jerks, would probably point to a complication.

The speech is often altered in this disease. Most frequently it is very monotonous. Occasionally it is explosive or slow or piping or weak or tremulous.

Hyperidrosis is often present. Other symptoms occasionally observed are difficulty of swallowing, troublesome salivation, and thickening of the skin.

Many other symptoms sometimes reported in these cases are very likely due to some complicating disease.

The subjective symptoms are often very distressing. Sometimes there is pain or aching. More frequently there are paresthesiæ, especially a burning sensation which may be accompanied by increased heat of the skin and also excessive perspiration. Many patients suffer much from flashes of heat. Probably the greatest source of distress is the incessant shaking or the muscular rigidity and fixity of the

limbs. The patient becomes very restless, wishes to move the limbs frequently, and the distress may become the greater because of his inability to do so himself. The suffering is likely to be greater at night. For this reason there is much insomnia which again intensifies the patient's suffering.

Usually the intelligence is not impaired but the impatience, irritability or depression, as the result of the suffering, may become extreme. There is sometimes definite mental disease most commonly marked by delusions of persecution and hypochondriacal ideas. But, probably in the majority of instances the mental disease is merely a complicating one.

The disease is a very chronic one, its course gradually and slowly progressive. In rare instances it sets in somewhat abruptly but commonly it begins with a just noticeable tremor of the fingers which gradually increases in its extent and its intensity. It may be a year or more before another limb—the leg of the same side or the other arm—is affected, and a number of years before the four extremities and finally the head are involved. Occasionally a case is seen where the tremor commences in a leg or where it is more marked in the lower than in the upper extremities. The muscular rigidity usually sets in some time after the tremor and slowly increases until the characteristic facial expression, posture, and gait becomes manifest or—in the later stage—there is complete disability and the patient is confined to his chair or bed.

It is not a very rare occurrence that the muscular rigidity is the first symptom, that it appears before the tremor. Sometimes the disease takes its course without any manifestation of tremor. In these cases there is the same gradual progress, with the impairment and retardation of active movement and the appearance of the characteristic attitude and gait.

It sometimes occurs, though not frequently, that there are remissions of the symptoms, or improvement as the result of treatment. But usually the disease slowly progresses with an increasingly lamentable condition of the patient. But in itself, it scarcely shortens life.

Pathology.—The true nature of the disease is still unknown. Among the theories that have been advanced are, that it is a neurosis, that it is primarily a disease of the muscles, that it is a disease of the cerebral cortex, that it is a disease of the vascular system of the spinal cord, and that it is due to changes in the thyroids or parathyroids. In most cases examined no lesions were found, but there have been reports of gross lesions in various parts of the nervous system, such as, degeneration of motor cells in the cerebral cortex; degeneration of motor cells in the cord; sclerosis in the finer vessels and the neighboring connective tissue of the posterior and lateral columns and gray matter of the cord; and also of pathological changes in the muscle fibers and spindles.

In a disease of such long standing it is not unlikely that some of these lesions were merely accidental complications. The changes in the muscles may have been due to their ceaseless activity. Many of the changes found may be merely those of senility. The view has been expressed that the disease is simply an exaggerated senile degeneration, but it is one that has met with much opposition.

Leriche believes the symptoms due to increased, but ignored, sensory excitation, keeping the muscles on a strain. In a case of the disease he cut the roots of the fifth, sixth, and eighth cervical nerves on both sides with subsequent improvement of the symptoms.

Wilson (*Brain*, March, 1912) believes that he has thrown light on the pathogenesis of this disease in an article termed "Progressive Lenticular Degeneration" which has attracted much attention. In the cases reported four seen by himself, eight by others—there is "involuntary movement, nearly always a bilateral tremor of both upper and lower extremities, the head and trunk being also sometimes involved—a tremor, usually rhythmical but occasionally irregular, and increased with volitional movements; there is pronounced spasticity of the limbs and of the face, the latter being usually set in a spastic smile, while in the later stages contractures of the limbs develop; there is dysphagia and dysarthria, the latter eventually terminating in complete anarthria; there is sometimes spasmodic laughing and emotionalism."

The similarity of this clinical picture to that of paralysis agitans is very striking, not the less so when it is added that the tremor ceases in sleep, that the reflexes are unaffected and that, even when the disease has progressed to the stage of complete helplessness there is no true paralysis.

The chief pathological feature in these cases was bilateral symmetrical degeneration of the corpora striata, due, Wilson believes, to a toxin possibly from disease of the liver, for there was nearly always advanced cirrhosis of the liver, which had given rise to no symptoms during life.

In explanation of the symptoms in these cases Wilson says, "The corpus striatum exercises a steadying effect on the action of the corticospinal system. This is effected either by the lenticulo-rubrospinal system or more indirectly viâ the optic thalamus and its cortical connections. When this influence is impaired pyramidal function is affected in its turn and is seen in hypertonicity or rigidity as well as in tremor on voluntary movements. Tremor is due more particularly to failure of function of the lenticulo-rubrospinal system. Hypertonicity or rigidity of the musculature, due to defect of the 'inhibitory' action of the corpus striatum, is possibly connected with impairment of impulses from the body viâ the optic thalamus to the cerebral cortex." The anarthria and dysphagia are supposed to be due to the muscular rigidity. Wilson believes that we may thus interpret the symptoms of paralysis agitans, that like in progressive lenticular degeneration they are due to disturbance in the extrapyramidal path, either the direct, that is the lenticulo-rubrospinal path, or the indirect path, that viâ the striothalmic fibers in the external part of the thalamus and thence to the intermedio-precentral and precentral cortex. He believes that we need not look for gross anatomical lesions in paralysis agitans—though such have been found affecting these parts—that dynamic modifications of function may be produced without much anatomical change.

Diagnosis.—A well-marked case of paralysis agitans is one of the easiest of all diseases to diagnose. It can be diagnosed at a glance. The mask-like face, the posture, the gait, the tendency to festination, the tremor are almost unmistakable. The larger number of cases are easily recognized but sometimes the diagnosis is difficult and it may even be impossible.

The disease is distinguished from multiple sclerosis by the character of the tremor—in multiple sclerosis it is a "volitional" tremor, increased by effort and absent during rest—by the absence of nystagmus, of changes in the reflexes and of paralysis. The speech disturbance is different in the two diseases; in multiple sclerosis it is "scanning"; in paralysis agitans mostly monotonous or tremulous. Furthermore, multiple sclerosis usually occurs in the young, paralysis agitans in the aged.

The tremor of paresis is finer than that of paralysis agitans, and also absent when the parts are at rest.

Senile tremor is brought on or increased by active movements, begins in the head, and while it may occur in the hands is not found in the lower extremities. Furthermore, there is no muscular rigidity.

Hereditary or family tremor is distinguished by its appearance in several members of the family, by its non-progressive character and the absence of other symptoms of paralysis agitans.

Hysteria may simulate the tremor and the propulsion or retropulsion of paralysis agitans but can usually be diagnosed by the presence of other stigmata of the disease. The same statement applies to some cases following injury, cases of traumatic neurosis, or rather traumatic hysteria.

Cases of paralysis agitans without tremor are recognized by the muscular rigidity and characteristic attitude of the head, trunk, and extremities. In the early stages of the disease before these characteristic features appear the diagnosis may be difficult. If only one side of the body is affected it may have the appearance of spastic paralysis but the rigidity is to be distinguished from that of the latter condition in that it is constant, not produced or increased by passive movements, and that slow passive movements will encounter the same amount of resistance as will quick passive movements. In addition, there are not the bulbar or other paralytic symptoms, the Babinski phenomenon, the ankle clonus, etc., found in spastic paralysis. Most cases of gradually progressing one-sided stiffness and weakness in elderly individuals are those of paralysis agitans.

Cases occur which are very difficult to classify, cases in the young or where the tremor has an intentional character, or where there are symptoms of focal brain lesions, of tabes or of some other disease. Sometimes there is, doubtless, a combination of diseases present.

Wilson's "progressive lenticular degeneration" as described above appears so like paralysis agitans that they might be difficult to distinguish. But probably this is not so. The former is a rare disease. It has been found only in young individuals. The cases ran a fatal course in a period varying from a few months to four or five years. At times there was pronounced variability in the manifestation of symptoms.

Prognosis.—The disease is of slow progress and may be of many years' duration. Death is usually due to an intercurrent disease.

Treatment.—The patient should be made as comfortable as possible. Disturbing influences, annoyances, excitement, too much company and the like, should be avoided. Unless it does him harm it is usually advisable for the patient to continue at his usual occupation as that rather adds to his mental peace and comfort, which is no small matter. It is very important to do all possible to lessen the tendency to depression and despondency.

A warm climate is likely to be more favorable than a cold one. Travelling to secure a favorable climate or a desirable resort may be very agreeable to the patient as he feels better on the moving train.

Warm baths often afford some relief especially in the way of lessening the muscular rigidity, while cold baths tend to increase the suffering. Some patients have found benefit from massage and vibration treatment.

Electricity has not usually proven to be of value in treatment, but Camp speaks favorably of the galvanic current applied in this way: a large cathode is placed at some indifferent point, while the anode is slowly moved over the rigid muscles with a fairly strong current and with care not to have any sudden change in the current strength.

Probably the best results of mechanical treatment are those obtained from passive movements, frequent gentle movements of all the joints. Friedlander's exercises, a combination of passive and active movements, are given in this way. Begin with only passive movements of all the joints of the parts affected, at first of small degree, each joint flexed and extended five to ten times, the patient endeavoring to relax the parts as completely as possible. This is followed by active exercises directed chiefly to the extensors. Care must be taken not to fatigue the patient. The exercises should be given daily or several times a day.

Patients often feel better for walking when they can do so. Here, too, overfatigue must be avoided. In the later stages of the disease the patient wishes constant changes of the position of the limbs. This is especially true at night.

Drug treatment is not very satisfactory though it must often be resorted to for the relief of symptoms. In recent years organotherapy has frequently been applied to this disease, extracts of the thyroid, parathyroid and of the pituitary body. One case in my hands improved markedly while taking extract of the parathyroid in one-sixth grain doses three times a day. In other cases no results were obtained from the same treatment.

Arsenic is frequently given to cases of this disease, but is of doubtful value. Tincture of veratrum viride in from two to four drop doses several times daily and tincture of gelsemium sometimes lessen the tremor.

The drugs most commonly administered for the relief of the tremor are the mydriatics, belladonna, atropine, hyoscyamine, hyoscine, and duboisine sulphate. They must be given carefully as large doses are poisonous, though it may require large doses to afford marked relief. Also it may be necessary to give the drug hypodermatically to secure the desired result. A patient of mine to whom I had given belladonna in small doses for many months developed glaucoma in both eyes. I feared the ocular trouble was brought on by the medicine, though it may have been a mere coincidence. The patient usually suffers most at night and may not be able to sleep without a hypnotic, paraldehyde, veronal, or whatever it may be. If the suffering be considerable and relief is not otherwise afforded injections of morphia may be demanded. Sometimes small doses of codein given in connection with hyoscyamine or other mydriatic will bring the necessary relief.

The bromides may help to give the patient comfort, especially in those cases that are extremely worried and restless.

Philip Zenner.

Paralysis, Diphtheritic.—As a sequel to an attack of diphtheria, occasionally even during the attack, a paralysis of certain muscles is not infrequent.

It has been shown quite clearly that toxin produced by the Klebs-Loeffler bacillus can produce inflammatory and destructive changes in many organs affecting in the nervous system both the cells and the nerve fibers. The changes in the latter are, however, far more uniformly present than those of the former and are usually of the nature of a parenchymatous neuritis, the medullary sheath undergoing swelling, segmentation, and fatty degeneration and eventually disappearing. The nerve cells of both brain and spinal cord as well as those of the spinal ganglia may undergo various degrees of chromatolysis and some may disappear. In a few cases multiple foci of degeneration have been found throughout the nervous system, giving a picture somewhat resembling that of multiple sclerosis.

The muscles may also undergo degenerative changes which can account for at least part of the weakness, particularly that sometimes evident in the heart muscle.

In practice, however, the paralysis is nearly always due to a neuritis, the diphtheria toxin being one of the common causes of multiple neuritis; hence in general, diphtheritic paralysis is considered as one of the varieties of this disease and is described under that heading (See *Neuritis*).

The muscles in immediate proximity to the seat of the disease, namely, those of the throat are usually the first to show the effect of the toxin, and the idea that its action spreads by contiguity derives some support from the report of a case of diphtheria of the umbilicus in a young infant, in which the primary involvement was of the abdominal muscles. On the other hand,

however, Oppenheim saw paralysis of accommodation of the eye develop as the primary affection in diphtheria of a wound of the forearm.

The weakness of the throat muscles is sometimes observed even while the throat is still inflamed; the patient experiences difficulty in swallowing, fluids run out of the nose, the voice becomes nasal, the palate may be noticed to hang down on phonation, and an anesthesia of the pharynx is occasionally observed. The eye muscles are usually next affected. The patient complains of impaired or double vision and sometimes a squint develops. Though the ciliary muscle is generally most involved, reaction of the pupil for light and accommodation is preserved. The other cranial nerves are much more rarely affected. In the milder cases the paralysis does not extend beyond the throat muscles and perhaps those of the eyes, but in the more severe cases after from two to six weeks the affection spreads to the extremities. Even in cases which never become paralyzed the knee-jerk is often lost, showing a great susceptibility of the anterior crural nerves to the action of the diphtheria toxin. The relative involvement of motor and sensory fibers varies in different cases, though in the more severe forms loss of power is very great. The paralysis is of flaccid type involving particularly the extensors of the foot and hand so that foot-drop and wrist-drop are not infrequent. The tendon reflexes are generally lost, the skin reflexes may persist. Bladder or rectal involvement is very rare. There is considerable pain in the affected regions but the nerve trunks are said to be less tender than in other forms of neuritis. Loss of sensation is most marked in the peripheral portions of the limbs. In some cases the fibers conveying muscle-sense are chiefly affected so that ataxia is the main symptom. The trunk muscles are occasionally affected.

The *diagnosis* of diphtheritic paralysis is in general that of multiple neuritis and presents little difficulty where there is a history of an attack of diphtheria. The ataxic form may, however, be readily confused with tabes. Pupillary rigidity is absent in neuritis, bladder symptoms and girdle sensation are excessively rare; while on the one hand there is generally a history of sore throat, on the other one of syphilis or a positive Wassermann reaction.

As to *prognosis* in the cases of throat and eye muscle involvement alone, it is favorable, complete recovery being the rule. Where the affection has spread to the muscles of the extremities it is more doubtful since some patients die, though probably the majority recover after a longer or shorter period. In the fatal cases death usually occurs early and it is stated by Oppenheim that in those who survive the first six weeks the danger of death is slight. The most dangerous complications are paralysis of the vagus or of the heart muscle; also paralysis of the muscles of deglutition may lead to aspiration pneumonia or to inanition, while the occasional paralysis of the phrenic nerve or of the respiratory muscles is an ominous symptom. A myocarditis or nephritis also will cloud the prognosis. Among thirty-two cases presenting some complication of this kind Oppenheim saw but five deaths.

Symptoms of heart involvement—first slow, later rapid pulse, arrhythmia—and rapid respiration are always alarming, while sudden attacks of vomiting occurring late in the disease without discoverable cause are said to indicate vagus involvement and to presage a fatal issue.

As a *prophylactic* of diphtheritic paralysis the experiments of Rosenau and Anderson would indicate the early and free use of diphtheria antitoxin. That this therapeutic agent has an effect after the paralysis has once appeared seems doubtful. It has even been accused of causing this complication, which, however, seems very improbable, and it has been pointed out that any apparent increase in the number of cases of paralysis may well be due to the fact, that since antitoxin has come into general use many patients who formerly died now live to develop the sequelæ of the disease.

In general the *treatment* of diphtheritic paralysis is the same as that of multiple neuritis from other causes, consisting after the acute stage has passed of full diet with plenty of fats, tonics, especially strychnine and cod-liver oil, a long course of galvanism and massage of the affected muscles with eventually orthopedic measures if needed. CHARLES LEWIS ALLEN.

Paralysis, General of the Insane.—See *Paresis.*

Paralysis, Infantile.—See *Poliomyelitis Anterior.*

Paralytic Saliva.—See *Saliva.*

Paramœba.—A protozoan genus of somewhat doubtful relationships. *P. hominis* is a rare parasite found in Filipinos, usually associated with severe diarrhea. See *Protozoa.* A. S. P.

Paramphistomidæ.—A family of digenetic flukes in which the ventral sucker is at the posterior end and the excretory pore opens on the dorsal surface. The only genera occurring as human parasites are *Cladorchis* and *Gastrodiscus.* See *Trematoda.* A. S. P.

Paramucin.—Mitjukoff has obtained from the mucoid contents of ovarian cysts a mucin-like substance, which differs from *pseudo-mucin* and *mucin,* chiefly in the fact that without previous boiling with dilute mineral acids it will reduce an alkaline solution of copper. ALDRED SCOTT WARTHIN.

Paramyoclonus Multiplex.—*Synonyms:* Myoclonus multiplex, Myoclonia, Polyclonia.

Originally described by Friedreich[1] in 1881, this disorder has been recognized by clinicians in Germany, France, Italy, England, and America. Its existence as a disease has been questioned, some asserting it to be a variety of hysteria, others of chorea. Still others cut the Gordian knot by claiming that both a true form and a hysterical form of the disease exist. However, the preponderance of authority as well as of evidence at the present day appears to favor its validity as a clinical entity.

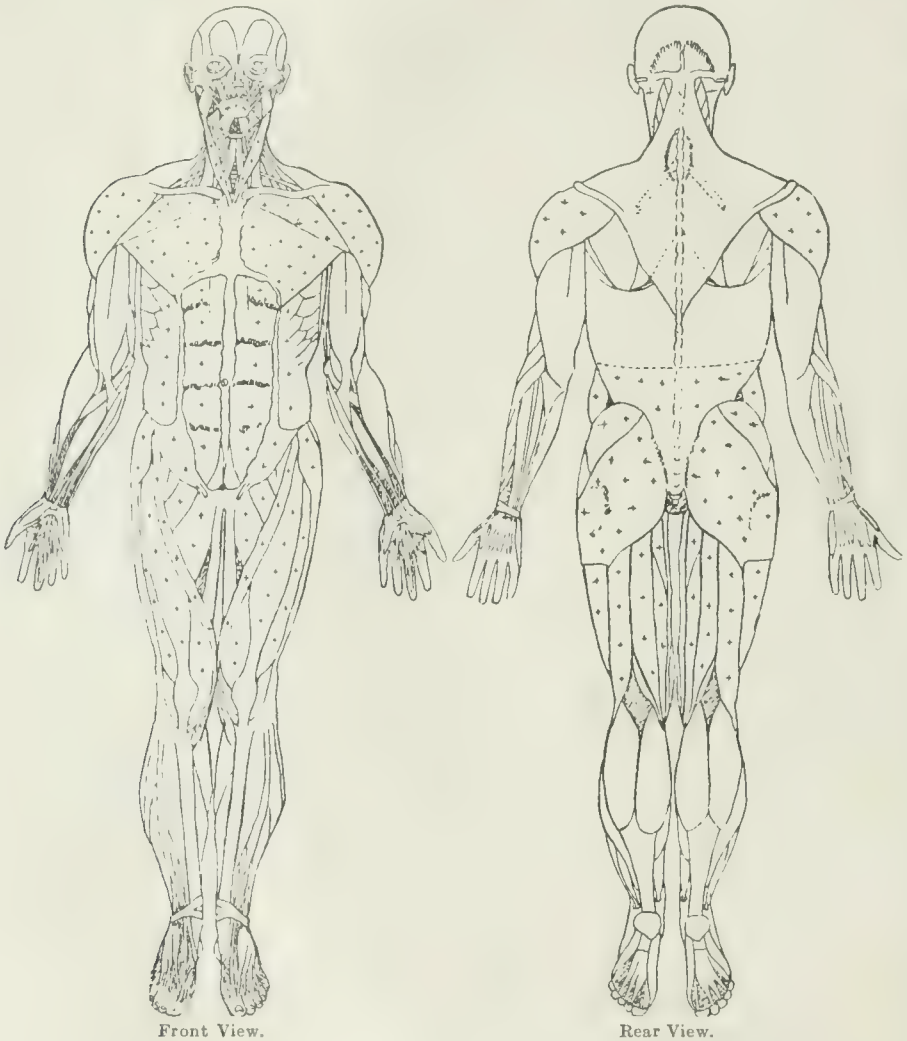
It is a rare disease. Gowers[2] states that he was able to collect but fifty-two cases in the literature up to July, 1895, of which only thirteen were considered by him true examples. One of the best accounts of the disease accessible to American readers is that of Starr.[3]

The disease is characterized by paroxysms of clonic muscular contractions, shock-like, bilateral, and symmetrical as regards the two sides of the body. The individual contractions are frequent, varying in rate from thirty to one hundred or more per minute. The duration of the paroxysms may vary between five or ten minutes and some hours. Likewise the frequency of paroxysms in a day may vary from one or two to twenty or more. The muscles affected in typical cases are the intrinsic truncal muscles and those connecting the trunk and extremities; those moving the face, hands, and feet being seldom, if ever, affected (see Fig. 4225). In one case observed by the writer,[5] the diaphragm and laryngeal muscles were involved at times, causing short, sharp, involuntary exclamatory sounds.

Negative characteristics are: consciousness is not affected; mental defects are absent as a rule, but, if present, are transient; voluntary movements of the face, hands, and feet are not abolished, even during a paroxysm, though the muscular power is much reduced; electrical changes of degenerative significance are

absent, as is fibrillary twitching. Sensation is not diminished or lost, but a decided hypersensibility to sound and touch has been observed by the writer in one case.[2] A profound sense of fatigue was also noted in that case. The convulsive movements cease during sleep, and are brought on, or, if present, increased in violence, by emotional excitement, by irritation of the skin, by cold, and by manipulative procedures generally.

Oppenheim[4] recognized an hysterical type as distinguished from the true form, but admits the difficulty of separation. Unverricht, Weiss, Kreiver, and Sepilli (quoted by Oppenheim) describe cases of a familial type and associated with epilepsy.



Front View. Rear View.

Fig. 4225.—Paramyoclonus Multiplex. Distribution of myoclonic spasm indicated by plus marks.

Causation.—The patients are usually neurasthenic. A majority of cases reported were of the male sex. The ages of patients have varied between thirteen and forty-eight. Mental worry, fright, injury, and physical strain are accredited causes. Of two cases reported by the writer one was attributable to mental worry combined with la grippe. The other was distinctly due to fright. A third case, observed by the writer through the kindness of Sir William Gowers, followed a fall from a considerable height without palpable injury. Fry's case[6] was due to overexertion, Starr's[3] to strain in lifting. Removal of the thyroid in dogs is said sometimes to cause symptoms of this disease.

The pathology is unknown. Autopsy in one case (Schultze) revealed no nervous changes. Friedreich, who was the first to describe the disease, believed it to be based on overexcitability of the spinal motor elements. Some have surmised that the cause of the faulty action lies in the muscles themselves or in an abnormal state of the nerve endings. To the writer its psychic antecedents, marked hemiplegic preponderance at times (in one case); its aggravation by mental and emotional states; the marked, though transient, mental changes in two cases; and the heightened muscle reflexes, would all suggest that the disease is to be viewed as the visible expression of a state of "*inhibitory insufficiency*," probably cortical in seat.

Diagnosis.—This is to be based on "the sudden shock-like character of the muscular contractions, their bilateral symmetry, and the comparative freedom of the extremities." (Gowers.[7]) This view is also concurred in by Walton[8] in a recent paper on the myospasms in general. Hysteria is ruled out by the absence of the stigmata and of the characteristic emotional state. There appears to be no tendency to simulation or desire for sympathy in paramyoclonus. Chorea is excluded by the non-involvement of the face and hands. Dubini's "electrical chorea," a disease endemic in a certain locality in Italy, is to be separated by its unilateral beginning, nerve and muscle degeneration, and a fatal termination in a few months.

Prognosis.—This is variable, according to different authors. Friedreich reported that some of his patients recovered. Oppenheim considers the prognosis grave. In all the American cases reported to date the patients have recovered. Relapse may occur, but does not preclude ultimate recovery.

The duration may vary from three or four months to a year or more. In one of the writer's cases the convulsions ceased on the one hundred and second day, but recurred in twenty-four hours, to disappear again in eight days. There has been no recurrence to date (four months). In the case reported by Starr the patient recovered in about a year, as did also the patient in the first case reported by the writer.[5]

Treatment.—The drug treatment followed has been so diverse as to suggest that it has had little to do with the recovery. Chloral, bromides, hyoscine, and

other sedatives, arsenic, quinine, thyroids, and galvanism have all been followed by improvement and recovery. The factors of rest, feeding, and time would appear to be the important ones. Sedatives may be used to mitigate the severity of the spasms and promote the patient's comfort. Parathyroid therapy would seem indicated to some.

Nutrient medication, in the form of glycerinophosphates, iron preparations when indicated, and supporting measures generally, are advisable.

F. W. Langdon.

1. Friedreich: Virchow's Archiv, Bd. lxxvi., 421.
2. W. R. Gowers: Clinical Lecture; National Hospital for the Paralyzed and Epileptic, London, 1895 (unpublished).
3. M. A. Starr: Familiar Forms of Nervous Disease. New York, William Wood and Company, 1891, 244; also Journ. Nervous and Mental Disease, 1887, 416 (the same case); with bibliography.
4. Oppenheim: Diseases of the Nervous System. American edition (Mayer), Lippincott, Philadelphia, 1900.
5. F. W. Langdon: Paramyoclonus Multiplex. Cincinnati Lancet and Clinic, 1896, 145; Journal Nervous and Mental Dis., 1902, 541.
6. F. R. Fry: A Case of Paramyoclonus Multiplex. Journal Nervous and Mental Disease, 1888, 397.
7. W. R. Gowers: Manual of Diseases of the Nervous System, 1893, ii., 630.
8. G. L. Walton: Contribution to the Study of the Myospasms, etc. Journal Nervous and Mental Disease, 1902, 403.

Paramyosinogen.—It has been assumed that the protein constituents of muscle are different in the living than in the dead state. According to Halliburton one-quarter of the living muscle protein consists of a globulin designated by him paramyosinogen and called musculin by Nasse and myosin by v. Fürth. The remaining three-quarters of the muscle protein consists of a second globulin called myosinogen by Halliburton. In *rigor mortis* it is assumed that these two proteins which are soluble in muscle during life are transformed into an insoluble modification—myosin—characteristic of dead muscle.

Frank P. Underhill.

Paranoia.—*Synonyms:* Chronic delusional insanity; Monomania; Reasoning mania; Progressive systematized insanity; Paranoic and paranoid states.

History.—This term has by no means been accepted by every psychiatrist. It was used by the best Greek writers to denote insanity, without regard to a definite classification. It was generic and not special. Its first apparent use as a specific collective name occurred in 1764, when Vogel applied it to *nine* different forms of mental disease. Its first application in its modern sense is due to Mendel (1881). The next most important contributions to its elucidation came from French, German, and, later, Italian, and, still later, American observers. The term has thus far found little favor in England, and it has not yet been universally accepted in this country. Its application by different writers in different lands has shown wide variations, and the varieties have been as numerous; many being based on the age at onset, the character of the hallucinations and delusions, or some other particular feature.

To-day many hospitals, notably in New York and New England, have included all varieties of paranoia, as well as many of the paranoid forms of dementia precox (Kraepelin), under the appellation of "Paranoic Condition" (Wernicke's Paranoid States?). Hence a certain confusion has arisen, since learned alienists do not always agree. This is unfortunate, especially in *medicolegal practice*, as it tends to bewilder juries and even judges. After a careful study of over one hundred cases, and consulting all available foreign and American literature, the writer, after a personal experience of over thirty years, has accepted the classification of Kraepelin as the clearest and most comprehensive exposition of the subject.

There are unquestionably cases of pure paranoia, as will be seen further on, which present a clinical picture and course as typical as typhoid. Then we find a larger group of cases, which are as clearly defined, but which show decided deterioration sooner or later. In both the delusion formation is largely of a persecutory content. This content, however, is not absolutely confined to the paranoid groups or "conditions," as single persecutory delusions may appear in any psychosis, as general paresis or the alcoholic psychoses. Hence in any given case one must take into account the heredity and other etiological factors, the development, environment, and endowment of the patient, and the course of the disease, and correlate these with the physical condition.

For a very full and interesting account of the evolution of the disease picture, from the "partial insanity" of Boerhaave, Rush, and Kant; the "monomanie intellectuelle" of Esquirol; Lasègues "mania of persecution;" the "Verrücktheit" of Griesinger, and so on, see Magnan's lectures on "Chronic Delusional Insanity;" Jelliffe's article on "Present-day Trends of the Paranoia Concept" (*Medical Record*, vol. lxxxiii., No. 14); and Meyer's article on the Treatment of Paranoia and Paranoic States in White and Jelliffe's "Modern Treatment of Nervous and Mental Diseases."

Adolf Meyer says: "Fixed and systematized delusions are the essence of the paranoic and paranoid states. They are by reputation and common experience a type of mental disorder baffling all *direct* efforts at cure. *Paranoic states* are transformations of the personality in which *reason* appears preserved but side-tracked, and no longer fitting into the natural and real work of the world and the individual, but active along set lines. The personality appears warped by the existence or evolution of central convictions which direct the thinking and activity of the individual more or less away from the normal interests and methods, and which play havoc with correct mental working by distorting its applications. *Paranoid states* are those resembling the paranoic transformations, but differing in one of more points from the full-fledged type and its causal and prognostic implications."

Meyer then goes on to discuss delusion formation and its genesis (causal interpretation); the paranoic type of constitution; principal types; and finally gives his own formulations of the paranoic type of constitution. After summarizing briefly the "recent views on paranoia" he declares that a "psychology of paranoia in the sense of a complete understanding of all the factors which conspire in its formation and development is well-nigh a utopia." He gives full credit to the many psychiatrists here and abroad, who are patiently and persistently working in this field.

Says Jelliffe in his Presidential address before the New York Neurological Society, February 4, 1913 (*Medical Record*, April, 5, 1913): "*Nearly all* of the hallucinatory types (paranoia) have gone over to the dementia precox groups. The disease *pictures* of mankind have not changed. It is not the real underlying psychotic picture that has changed—it is only the hypothesis used to explain it, or describe it, namely, the symbol that has changed. Or the symbol is retained and arbitrarily utilized to envisage an analytical or synthetic revision of previous concepts. One shifts one's point of view and reassembles the material in a different way for purely practical purposes—namely, one by which society will be the gainer in its practical problems. The term paranoia is (now) restricted to smaller and smaller groups of individuals, following Kraepelin in large measure, who is inclined to retain it as symbolizing those delusion-forming psychoses originating from internal causes, with an extremely chronic development of an intellectually produced, unassailable delusion, in

common with complete 'retention of the integrity' of the personality."

The modern expansion of views on paranoia leads a recent writer (Abbott) to ask "What is paranoia," and to answer his own question by saying, "It is a psychosis, but not a disease process."

Hence the writer will aim to present his own views, enforced by a long hospital experience, with special purpose to present to the average doctor something clear and practical, inasmuch as he, above all other men, can and should help us in securing all necessary data of the life history and endowment of patients—including their ancestry—prior to commitment. Therefore he will define paranoia as a psychosis of insidious onset; developing gradually on a defective basis; and clinically characterized by the progressive evolution of a permanent system of persecutory and expansive delusions, which lead to an immense increase of the ego, and in many cases to a distinct change of personality; retrospective falsifications of memory; explanations; hallucinations in some cases; but without clouding of consciousness, incoherence, or deterioration except in judgment, which is biased by the delusions. It is a distinct entity—a continuous process. Remissions are possible, but no intermissions, although the temporarily apparent subsidence of aggressive symptoms may be mistaken for such.

While the new researches into the nature and genesis of all the psychoses are unquestionably of great value, nevertheless the writer feels that the general picture of pure paranoia is sufficiently established, and in all essential respects will remain, whatever changes in nomenclature and groupings may occur. Brief summaries of some of his own cases, watched and studied for many years, confirm his opinion. The literature of paranoia is vast, and in our allotted space even a summary is impossible. Great difficulty lies in the inability or indisposition to agree on any definite picture of paranoia which would be *universally* accepted. Not only is there disagreement, but some foreign writers manifest almost aggressiveness or even an air of superiority in their criticisms of each other. "Hence the grouping together of those forms which have certain common and distinguishing characteristics must necessarily be modified by, and to a large extent depend upon, each author's conception of what does and what does not constitute insanity" (Paton). The Index Medicus contains in each issue the titles of all noteworthy articles on paranoia and allied conditions.

Etiology.—Cases of pure paranoia comprise about 2 per cent. of admissions to hospitals. Of 6,732 cases admitted to the Connecticut Hospital for the Insane, from Oct. 1, 1898, to Oct. 1, 1914, 119 were diagnosed as paranoia. Sixty-eight cases, or 1.1 per cent. were men, and 0.7 per cent. were females, a total of 1.8 per cent., thus confirming Kraepelin's statement that more men are affected than women. All the 119 cases were worked up as thoroughly as possible, and all were presented, demonstrated, and discussed at the regular daily staff meetings.

Paranoia develops on a defective basis or constitutional neuropathic groundwork. The word *defective* is here used in the sense of lacking, from birth up to full development, of some one or more important or essential faculties and functions, either mental or physical or both. By deterioration or degeneracy we mean a partial or increasing loss of either innate or acquired equipment. This loss may sometimes be apparently limited to memory, volition, or other faculties, but the limitation is more apparent than real, although in different degrees in different individuals. In most cases of paranoia, where complete histories can be obtained, the defective basis is very evident. It may appear in the so-called "stigmata of degeneration," in hereditary influences, and propensities and susceptibilities; in antenatal traumas, alcoholism, neuroses, psychoses, etc., in progenitors, and so on. There may be a lack of development and power in the cortical cells. Hoch, in some cases where the facts were really accessible, clearly traced the pyschogenesis. "They did not get square with their difficulties. They did not acquire balancing, healthy habits, such as a healthy turning away from difficulties to outside interests, or a habit of unburdening or a certain aggressiveness and the like. Hence in this way there developed a growing disharmony, which gradually, or sometimes under the influences of acute causes, physical or mental, may suddenly lead to an unbalancing of the mind." (*Journal of Nervous and Mental Diseases*, vol. xxxiv., p. 668.)

Berkley says: "I have never seen a paranoiac, in whose case a full and complete history could be obtained, that did not have an hereditary history of drunkenness, family neuroses, or actual insanity." Tanzi and Riva found heredity in 77 per cent. of cases, disturbances of development in 9.6 per cent., while in the remaining 14 per cent. hereditary influences were not demonstrated, but neither were they excluded. In the present condition of psychiatry, we cannot establish the etiology of paranoia on an exact, all-inclusive basis. The full development of the psychosis usually occurs between the ages of twenty-five and forty, but *may* take place in youth or even in advanced life. *Alleged* exciting causes are acute diseases, anemia, gastrointestinal affections with accompanying autointoxication, uterine diseases, puberty and menopause, trauma, excessive mental stress, shock, excesses, business reverses, deprivation, and disappointment.

Pathology.—Thus far, as in many other psychoses, no absolutely definite anatomical basis has been discovered. In persons found dead, without any history or identification, one could ascertain from the cerebrospinal conditions whether or not the case was one of general paresis, senile degeneration, or idiocy, just as in case of typhoid, cancer, pneumonia, etc., a correct diagnosis could be made. Not so here. Hence present students are devoting much attention to the psychopathology of paranoia and paranoiac states, but thus far without any universally accepted findings. This method promises great and definite results, however, but in a probably distant future.

Many physicians are now evincing interest in psychiatry. Says Dr. Lewellys F. Barker: "Contemporary psychiatry does not limit itself to the mere study of the insane or the manifestations of insanity. It desires to investigate the cerebral events underlying the abnormal mental states. It is not satisfied with normal psychology or with brain anatomy and brain physiology as they exist to-day. It does not stop at the local changes in the brain; it studies also the changes in other organs of the body, seeking abnormal processes there which can account for abnormal brain processes. Then it tries to discover in a faulty heredity or in environmental influences, explanations of these abnormal processes. Psychiatry studies also the evolution of mind in the individual and in the animal series in comparative anatomy and physiology. It does not try to escape from the borderlands of philosophy and metaphysics. The methods of a whole series of subsidiary sciences must be drawn upon. The work is cut out for the aggregate of the world's psychiatrists." (Relations of Internal Medicine to Psychiatry, *American Journal of Insanity*, July, 1914.)

My own experience and study have convinced me that in this life mind, body, "soul and spirit," whatever these last may be, are each and all interdependent and inseparable. All our mental activities depend for proper and normal functioning on the integrity of the physical system. We know that our

sight and hearing, etc., are not absolutely accurate, even in health, and hence we must make due allowances. Therefore we must thoroughly study the individual patient, first in relation to himself, and secondly in relation to his neighbor, environment, education, occupation, etc. Nothing human should be foreign.

Symptomatology.—The principal feature is the insidious evolution of a "stable system" of delusions of persecution, often requiring years. "Candidates for paranoia" early manifest abnormalities of character, as reserve, suspicion, egotism, unrestrained imagination, or instability, and are often considered "peculiar." Many present stigmata of degeneration. On this premorbid personality appear distorted perceptions, falsified impressions of the outer world, exaggeration of trifles, vague suspicions, and distrust.

Delusions.—The transition to completely developed delusions is slow. Jokes, smiles, newspaper items, sermons, or plays contain hostile references. Everything seems altered; things are misplaced. Patients begin to review their past life in the light of present troubles. They may experience unpleasant bodily sensations which are correlated with their false ideas, and complain of illness, slights, or abuses. They brood over these until their number and intensity increase, and vague suspicions of an intentional persecution become absolute certainty. People watch them, and the most innocent actions are construed into evidences of persecution.

A real wrong may form the premise of false interpretations which contradict rational experience. Eventually the delusions become fixed and dominate the entire psychic life. Their content corresponds to the endowment, attainments, and social position of the patients. Some are controlled by witches, or are possessed, others are molested for their religion, political influence, or high station; they are poisoned, tortured, driven from business, etc. The causes assigned are as varied as the delusions, but whatever their nature, all are eventually combined into a perfect mosaic, which neither argument nor opposition can destroy.

With the transition from vague suspicions to "subjective analysis" the soil is prepared for the advent of expansive ideas, and a resultant transformation of personality, the seed germinating in an attempt at "explanation." Systematization and explanation weave events of the environment into the delusions, aided by hallucinations and retrospective falsifications of their previous life. Patients now seek to establish a cause for their persecutions. Why are they abused and tortured, their plans thwarted, their business ruined, their health and even life endangered? Are they different from others, chosen of God, of exalted lineage, destined for lofty station? Their enemies must have some object. Insignificant occurrences of earlier life are magnified and brought into logical relation to their present condition. In one patient typhoid delirium foreboded a new birth as the "Immaculate Concept." Whisperings in adjoining rooms, mysterious disguised visitors, and casual resemblances led a man to believe himself the son of Napoleon Second, and to assume the name of Eagle.

To some their future greatness was foreboded by events apparently trivial, but whose real importance should have been recognized at the time, when they might have assumed their proper rank, and thwarted the machinations of their enemies. Patients consider themselves president, commander-in-chief, statesmen, saints, millionaires, inventors, poets, prophets, or at any rate vastly superior to their acquaintances, and exalted above them.

Hallucinations.—In a limited number of cases hallucinations are present, but are not as a rule as numerous or prominent as the delusions. Notwithstanding the present trend toward relegating these to some other paranoid forms, this does not seem desirable. We should judge a given case by the entire complex and course, and not on this one symptom; the more so, as hallucinations may and do appear in many other psychoses—general paresis, manic-depressive, epilepsy, etc.—without thereby upsetting the diagnosis.

Auditory hallucinations are the most common. At first there are only indefinite noises, which are gradually resolved into distinct voices. These may be heard in one ear only, sometimes in both, and sometimes only "inwardly." The language is generally indigenous, but in cultured patients foreign or dead languages may appear. There may be one or many voices, which may or may not be recognized (God, the Virgin Mary, Christ, saints, devils, relatives, male or female, "the man with the mournful voice," etc.). The words may be denunciatory, threatening, taunting, reviling, profane, and obscene, or encouraging, consoling, and calming. People are overheard plotting all sorts of crime and violence, even to sexual attacks, poisoning, or murder, and often give the patient no rest. Or the Almighty may cheer them with promises of final victory, boundless power and wealth, exalted station, etc. The content corresponds to the character and endowment of the individual, and the varieties are too numerous to describe. The hallucinations intensify the delusions, and both react not only to each other, but also to new interpretations of current events.

Hallucinations of general feeling, taste, smell, and sight follow auditory hallucinations in order of frequency. Patients may express all sorts of perverted, unpleasant, and painful sensations, from "electricity, magnetism, vibrations, acid sprays, bullets, knives, poisonous powders, etc." Taste may be perverted: there is poison in the food, arsenic in the coffee. Some paranoiacs always prepare their own food, and will not drink except from a common supply. Others smell poisonous or noxious vapors, chloroform, fecal odors. The rarity of visual hallucinations is fortunate, as it diminishes the probability of assaults. In a few cases innumerable hallucinations may persist for many years. One of my patients, a refined and cultivated woman, has been troubled for twenty-five years by auditory and olfactory hallucinations, without perceptible deterioration.

Train of Thought.—This is well-ordered, and educated patients in particular display great acumen in their arguments, appeals for redress, statements, and letters. Their premises may be real or imaginary, but in either case the resultant deductions are perfectly coherent, although a morbid transformation of constantly surging percepts and concepts essentially influence their elaboration. What Prof. Dodge of Wesleyan calls the "interplay of present with past experience" is never abolished, and Dr. Charles W. Page states that "the evidences of the senses are sifted and scanned, but as the result of some original distortion of mental power, the conclusions drawn therefrom are abnormal. Consequently the system or experience which is built up is in harmony only with the vicious constitutional obliquity of the paranoiac, who will note discrepancies in his statements, and yet be entirely satisfied with fabricated explanations, which convince none but the author." In other words, the progression of ideas is logical, but the standpoints are displaced, the ethical sense is defective, patients see no incongruity between actual and assumed facts, and their delusions persist though their empirical supports collapse. "With all their misconceptions and misconstructions paranoiacs retain for many years the power of thinking logically and clearly upon subjects other than those which touch their own false impressions" (Berkley).

Judgment shows considerable weakness, since it is biased by the delusions, and there is marked inaccessibility to arguments. With the emergence of expansive ideas false premises constantly arise which

cannot be criticized or corrected, but are accepted and utilized indiscriminately. Perception is usually keen but often distorted; orientation is always normal, and consciousness clear. Attention is largely directed to matters concerning the ego, and often wanders from matters outside the delusions. Paranoiacs have no genuine insight into their disease, but may present numerous hypochondriacal complaints for which they seek treatment, and defend with great ingenuity. They display a monstrous overestimation of self, a heightened self-feeling, and an exaggerated self-consciousness, as well as a lively feeling of independence.

Memory is good except for false interpretations of past events, which fortify their delusions (retrospective falsifications of memory). At times patients are under a vehement emotional stress, but show no independent emotional disturbances. They know well how to control themselves, and often dissimulate their apprehensions. At first they are despondent, later shy, morose, and irritable, then fearful, and finally angry and vengeful, although a few are resigned or even cheerful. Ultimately most are apt to become consequential, intolerant, or haughty. Many show a remarkable indifference in describing their criminal acts, whose nature and consequences they fully recognize.

Conduct.—This may be so well-ordered that for a long time no suspicion of insanity is entertained. The early seclusiveness of paranoiacs, their suspicions, peculiarities of dress and manner, are regarded as only "eccentricities," even when they begin to complain of abuses. This is partly due to their keen reasoning and partly to their plausible interpretations. A teacher engaged in controversies with scholars' parents and committees for fifteen years before her disease was recognized. An excellent artisan left place after place in various towns because he could get no redress for his "wrongs." During this time he was imprisoned several times for assaults. One patient airs his grievances in the press; another frequently appeals to the authorities for protection; others write to dignitaries, politicians, actresses, and so on, before their sanity is questioned. One woman kept a record of several changes of residence for two years prior to her admission to the hospital, "to escape operations performed on her at night." Many adopt disguises for self-protection, one patient wearing a "Buffalo Bill wig." But disguises or removals give no permanent security. Wherever they go—on land or sea, even "to the uttermost parts of the earth"—they cannot elude their enemies. If they should slay some, others will take their places; their trouble will end only at death.

With the advent of expansive ideas patients may apply for important offices, propose marriage to exalted personages, write books, promote inventions, etc. They neglect business and family, alienate friends, and become callous to all but their own concerns. Some, however, are capable of varied productive work for years, although their activity is often retarded and purely mechanical. Everything centers in the ego. They will not, indeed cannot take advice, meet all objections with an incredulous, superior air, and their convictions remain unshaken. When finally they succeed in an "explanation" they become very dangerous to the community, since they are almost sure to attempt a murderous assault. Since legal redress is impossible they take the law into their own hands. A paranoiac shot at a milkman because "he had poisoned his cattle and bewitched his sister." Another nearly killed an innocent man whom he deemed a secret agent of a hostile government. Presidents, kings, bankers, scientists, physicians, husbands, wives, children, acquaintances, or a casual passer, are numbered among the victims of this dangerous class. Often, indeed, the first revelations of paranoia come from a homicidal attack.

When the disease is legally as well as clinically recognized and patients are committed to a hospital, they may at first conceal their delusions, sometimes for a long time, but sooner or later they "are discovered by their enemies," and finally they may regard the physicians, attendants, or even fellow patients as "accomplices." Sometimes they bear their "imprisonment" with a certain dignity, and again consider it the culmination of their troubles. As a rule, they keep to their rooms and form no associations with others. Their pockets are often stuffed with documents substantiating their claims, copies of legal records, memoranda, and bulky letters. Their correspondence is usually voluminous. Residence in a hospital does not render them less dangerous, and they are always liable to make unexpected and treacherous attacks, especially during exacerbations. More than one physician or attendant has lost his life through careless disregard of this propensity.

Course.—The course of paranoia, when fully established is progressive, and prolonged throughout life. Several stages have been described, to which there is no objection if we bear in mind that there are many variations from the type, that the boundaries are not sharp, and the transitions are often imperceptible.

The *typical* course is as follows. On a defective constitutional basis, evidenced in childhood, youth, or even up to the period of involution, by various "peculiarities" already described, sooner or later there arise vague doubts, suspicions, fears, erroneous interpretations, or broodings over matters, often trivial, which a healthy mind would overlook or soon dismiss. Hypochondriacal complaints are apt to occur. Add to these a certain amount of introspection, and we may fittingly call the whole the stage of incubation. This may, and often does last for months or even years, and during its continuance patients are never supposed to be more than eccentric or "cranky," unless they come under the observation of a trained physician.

Having gradually passed the border line of sanity, paranoiacs enter on the second stage—of delusions and hallucinations. Here the doubts and suspicions are compacted into a delusional structure, which gradually acquires symmetry—one false idea fitting into, or leading to another—until a stable system of persecutory delusions is evolved. This is aided by the hallucinations which make their first appearance in this stage. These are of central origin, and are largely auditory (first vague noises, then voices), and increasingly torment the patients. The character of the delusions and hallucinations has already been described, and needs no further recapitulation.

The third stage may be styled that of "delusional explanation and subjective analysis" with either exaltation or change of personality. While heretofore paranoiacs have partially analyzed and arranged their delusions, perhaps instinctively, they now give them a more complete and logical interpretation. They require a reason for their persecutions, which are so numerous and constant that they must be different from ordinary individuals. They review their whole past and discover in many occurrence indications that should have convinced them that they were set apart from and superior to their fellows. Their mental ability was greater, their morals more lofty, their religion purer, their productive capacity larger; they had often received special attentions and positions; they recall mysterious and significant visitors; others' trials were due to ordinary causes—theirs to special causes. These retrospective falsifications may be confirmed by the voices, which may now be consoling or prophetic. The question arises: Am I persecuted because I am superior, or am I exalted on account of my persecutions? Whatever the answer, by an ingenious train of reasoning the past and present, delusions and hallucinations, per-

secutions and exaltation—in short, everything assists in establishing their new or rather "rightful" personality. The previous intense mental stress is now resolved into a calm assurance, and the "world savior," the "chosen one," the "Immaculate Concept," the "prophet, priest, or king," the president, statesman, scientist, poet, and so on, appear in their true light and demand recognition. The seeming equability of the patients does not prevent them from forming plans to secure and maintain ruthlessly their "rights," but rather favors them, and they are even more dangerous than in the second stage. While less obtrusive, they are more treacherous.

The fourth stage is called by Berkley the "stage of quietude, in which a degree of weak-mindedness is apparent on close examination, but in which there is nothing approaching dementia except in a minor number of instances." These latter cases the writer would include under the head of Paranoid Dementia. Impressions from the external world often fail to reach the patients, whose attention is directed exclusively to their own concerns, or reaching them, fail to impress. If allowed to go home they should be carefully watched.

Authors have described several forms of paranoia—early, late, querulant, erotic, religious, alcoholic, hallucinatory, acute, and chronic—some of which merit a brief notice. There has been a tendency to overdo this subdivision, thus obscuring the general picture. In all forms the fundamental symptom—persistent systematized delusions of persecution—is practically the same, but the picture is colored by various factors. According to my view paranoia is always chronic, and the age at onset immaterial, except that querulancy appears later than the other forms, and leads more rapidly to deterioration.

In *querulancy*, first described by Hitzig in 1895, a few cases present sufficient peculiarities to merit description. The psychosis is of gradual onset, the conduct of patients is due to an actual delusion, and the ideas of legal injury are associated with a single, very definite standpoint to which they always recur. The exciting cause is usually some real event, possibly a legal injustice, an unfair decision or adjustment of claims, or an editorial, all of which are delusionally explained. Hence the patients enter a suit in either civil or criminal courts, or both, and when the decision is adverse carry the case to the highest tribunals, and failing satisfaction or a "just verdict" from these appeals, apply in person or by letter to magistrates, legislators, cabinet officers, and even the president or king. To confirm their claims they carry about copies of court decisions, voluminous documents, newspaper clippings, etc.

However amenable at first, they soon reach a point where they cannot give any credit or attach any importance to the opinions of others, and in this respect their judgment is entirely biased or obscured. Their memory is unusually retentive, and they delight to air their legal lore on all occasions. Their conversation and letters teem with legal phrases and quotations. Consciousness is clear and thought coherent, but they show limited ideation by constant and tiresome recurrence to their delusions. While there is usually no change of personality, patients display a heightened self-feeling, a certain optimistic superiority, and an overestimation of self. At the same time they are easily irritated and shower scurrilous abuse and accusations of injustice, venality, and perjury on all opponents.

There is an increasing enlargement of the delusions, which are deeply rooted in the mental personality, and worked up into a system. Hallucinations are rare. A striking feature is the senseless way in which patients neglect their family and business, squander their money on and devote themselves to a cause which does not merit the attention bestowed on it. Froward, litigious, and even weak-minded persons may sometimes pester the courts in a way similar to that of querulants, but proof of actual delusions on which litigation is based, the complete inaccessibility to instruction or argument, the injudicious conduct, and the persistence of symptoms for years, facilitate the differentiation. The limitation of thought may explain the mental deterioration, which occurs earlier and is more marked than in other forms of paranoia, but never comes to complete dementia.

In *erotic paranoia* patients imagine themselves admired or loved by persons of the opposite sex, and usually of higher rank. Their love is romantic and platonic, and may last for years before it is divulged, except by casual meetings or occasional remarks. The most trifling things, such as a nod, smile, rosebud, costume, flight of birds, etc., are mystic or symbolic. The loved one appears at the window as they pass, attends the same church, and gives "significant looks." All know it, but say nothing directly. The delusions may exist for years before they are betrayed by actions, or their affinities are annoyed by attempts at interviews or threats. In all cases the love is believed to be mutual. Where sexual excitement exists it usually assumes the form of perversion or onanism, and is specially intense at night. Hallucinations are infrequent and transitory. When the delusions become fixed and patients obtrusive by interviews, indecent letters, etc., their conduct leads to arrest and commitment to a hospital.

In *religious paranoia* patients begin to manifest morbid religious tendencies during adolescence. Prolonged abstinence from food, protracted meetings, excessive study of the Bible eventually upset a weak personality. Texts are misapplied or rigidly construed, practice is swamped by theory, works by misdirected faith, and eventually delusions of inspiration and exaltation arise and develop logically into a system, which gradually assumes a fantastic garb. More women are affected than men. Patients become Messiahs, saints, prophets, or parents of a new and greater Christ. Many have mystical intercourse with Christ, the Virgin, or angels. Some indulge in sexual perversions, and all are more or less erotic. They are the plagues of clergymen and unendurable to the community, which eventually demands their seclusion. They are not very dangerous unless opposed, but occasionally one attempts to sacrifice one or more members of his family by "direct command of God." All are absolutely inaccessible to reasoning.

Alcoholic paranoia is characterized by partially systematized delusions of infidelity, irritability, occasional violence, and homicidal or even suicidal tendencies. Delusions are concealed or denied during hospital residence, but reappear on discharge.

Illustrative Cases.—Case I.—E. E., Polish Jew, Male. Aged sixty. Occupation, peddler. This man was arrested for shooting a man without apparent cause or reason. On trial he was acquitted on the sole ground of insanity and duly committed. An acquaintance writes: "For several years this man had traveled around the southwestern part of Connecticut as a peddler. He carried a small pack of goods and all he seemed to care for was to make enough to pay his way. Every minute of his spare time he was reading or studying, and he seemed to have a very good education. He used to talk about his enemies; they were following him around, when he was a boy he was kidnapped, his father was an eminent Frenchman; and he went by his present name and occupation for fear his enemies would find him. He never would wear anything black, and the way he dressed made him conspicuous. (He always wore a most fantastic wig, which he called a "Buffalo Bill wig.")

At all times patient opposed any direct efforts at examination, but he finally consented to write such an account as he [illegible] Handwriting was exceptionally good, and his style [illegible]. A few statements will illustrate his mental [illegible]. "I have known only since I discovered the existence of the Secret Room, to which I was kidnapped when a child. . . . I [illegible] men are always following me. I was [illegible] myself a Polish Jew. My name was given as Anzel. [illegible] I

retained it up to 1877. My real name, however, is Charles Francis Joseph Napoleon Bonaparte, the same borne by my father, Napoleon Second. . . . In 1853 I was told to go to America to escape military service. On the North Sea, on each side of our vessel, was a large ship, which accompanied us all the voyage. I *afterward* discovered that all three carried the Secret Police that was to hound and oppress me here in the United States. In New York my "relatives" sent me out to make a living with a basket containing fifty cents' worth of matches." Here he describes the "red-headed men" who have followed him ever since. "The outrages against me ceased entirely—that is *openly*, but the enemy resorted to secret tactics. Now commenced an epoch of teeth-destroying and hair-pulling. I retired at night with sound teeth; I awoke in the morning with holes in my best molars, or with gums fearfully swollen and teeth dreadfully aching. I also one morning found a bald spot where the day before there was an abundance of hair. In my simplicity I supposed it to be nothing more than the wear and tear of life. It was not until the year 1875 that I began to perceive that I was being *murdered* by *degrees*. . . . No matter where I was, I was never permitted to save much money. No sooner did I have a little money saved, when something was sure to happen to throw me out of employment. . . . My "friends" keep an army of detectives to look after me. . . . I afterward learned that the Duke of Cambridge himself came to New Haven—and ousted me from Yale College. Large lumps of sulphur were mixed with the coal I used, and my head felt as though it were a block of wood. I rolled from side to side all night and could not sleep. . . . There must have been a good deal of chloroform used on me. . . . I was very ambitious. Obscure Polish Jew as I then supposed myself to be, I yet dreamed of becoming a great United States Senator, the constitution of the United States alone forbidding me to aspire to the presidency. I dreamed even of becoming a great general and leading the Jews back to Jerusalem. . . . . The idea took possession of me that it must be the Inquisition who was oppressing me. I came to England (one of the innumerable places he wandered to) a youth of seventeen or eighteen. Seventeen months later I left it an old man of sixty in appearance. . . . Many times I heard them speak the name of Napoleon (1896). A Frenchman told me I looked exactly like him. "You are just so high; you have his figure, his face, his manners; you are the very picture of the Great Napoleon." These remarks kept coming from many sources. One day, when I was wondering that people should make so much fuss, take such great pains, and go to such enormous expense, all to persecute an obscure Polish Jew . . . the idea came to me like a *flash*. "Ha! I am a grandson of the Great Napoleon! This then accounts for all my troubles. But how did it happen? Why am I all alone? Why does not somebody take my part? What has become of my father? Who was my mother? Where are all my relations? Why does not France come to my assistance? The answers to these questions I have never been able to get." Patient gradually reasoned out the answers, and his suspicions were verified for him through misinterpretations and exaggerations of various events." "His father, Napoleon Second, did not die on date given, but was isolated or confined in some secret place. French and English authorities increased their espionage and brutalities. "A police force of 800,000 people and an army of 9,000,000 of troops are employed for that purpose. . . I have been told that thousands of American citizens were sacrificed because they wanted to protect me. Large sums of money were sent me, yet not one of them was allowed to reach me. The Post-office is full of letters. . . . Not only have they robbed and oppressed me, but they would not allow me to make a living at even the humblest occupations. . . . According to my enemies, I have been a crazy man for thirty years. . . . I have nevertheless managed to live; have invented an umbrella which will revolutionize the business, and have made several important discoveries in science. . . . Several years ago four British Men-of-War were watching for an opportunity to capture me. They made their first attempt some sixteen months ago near Katonah, N. Y., but got a shot for their pains." (Patient had carried a pistol for years.) "The last time they tried it at Round Hill, Conn. When I shot a man in the neck, in self-defense, they accused me of murder, and later of insanity." Then patient gives a minute and prolix account of the affair, too long for insertion here.

This case is characterized by a gradual onset twenty years before admission to the hospital, and presents the following mental symptoms; a slowly progressing stable *system* of delusions of persecution, firmly held and defended, and finally resulting in a change of personality; very prominent retrospective falsifications of memory; morbid suspicions and delusions of reference, resulting in a wandering life, and finally culminating in a homicidal attack on an innocent man, in imagined self-defense. With the above symptoms, consciousness is clear, perception and apprehension keen, orientation normal, memory excellent; the train of thought coherent, logical, and compact, and judgment deteriorated only as biased by the delusions. The patient presents various stigmata of degeneration, but hereditary predisposition is unascertained from inability to secure satisfactory family history. We are justified in assuming its existence as a causative factor in this case.

The prognosis is absolutely unfavorable. This patient is a very dangerous man, and the safety of the community demands his detention in a hospital for the remainder of his life.

Case II.—C. E. E. Female. Duration of psychosis, thirty-two years. Heredity denied. Up to ten days before death, at seventy-two, patient had shown no deterioration, except in judgment, and her capacity for estimation of values was remarkably good in any subject dissociated from her delusions. For example, she was an omniverous reader, was a woman of unusual culture, in art as well as literature, and her retentive memory enabled her at all times to discourse intimately on many topics, some of which naturally attract or would interest only a small and select audience. She was also very proficient in art needlework. She always wore black, set off unassumingly by white lace, and she was immaculate both in dress and person. She never presented a change of personality, but her egoism and self-consciousness were evidenced in all she said or did, but always in an unobtrusive way. In short, she impressed all visitors to the hospital with a sense of her great dignity and versatility. No one would have thought her insane, except on long observation. And yet she had a host of systematized persecutory delusions and *hallucinations*, which dominated her whole life. People read her thoughts; came from far and near to attempt assaults on her honor and chastity. Poisonous vapors were injected into her room at night. "The man with the mournful voice" was continually reviling and threatening her, using the most profane and obscene language. She indirectly accused her mother and sister, as well as writer, who had the care of her for twenty-two years, of at least tolerating, if not directly fomenting her persecutions. At the same time she would daily, by word and letter, appeal to writer for protection and redress. On three separate occasions she was allowed to inspect minutely every portion of the wing where she lived, to demonstrate the impossibility of an attempt at poisoning by gases, etc., but this was of no avail. Patient died of angina pectoris, clear to the last.

Case III.—E. B. Female. Married. Aged thirty-six. Six children. Well educated. Intellect above average. Husband poor, and environment unsuitable to a high-spirited woman, who yearned vainly after social prestige.

Before admission, patient for some time pestered priests with unreasonable complaints and demands; several times made a scene during religious ceremonies; and finally became jealous of husband. On admission to hospital the most marked symptom was a deep depression, with frequent loud wailings and weeping, and a general idea of persecution. There were visions also—"an arched bower of roses and foliage, and an angel with a little tea rose in her hand which she reached to me." "My eyes and head became dazzled." At the end of two years patient ceased her lamentations except on rare occasions, and gradually developed delusions of both expansive and depressive nature, all of them of a marked religious content, which eventually led to a change of personality. "My children, the *religious darlings of Bethlehem*—the fruit of my holy womb—are being maltreated (starving, cruelty, etc.); Father K. is putting bad words on my lips, and reading my thoughts, although he now knows I am the *immaculate St. Elizabeth*. The angels have erected a beautiful chapel here for me. There are many beautiful and holy bells, which ring messages to me. This *holy mother* cries out to you (writer) for protection, and release that I may care for my darling holy children, and so on." The hallucinations followed the delusions, and are apparently based on them. In every other respect patient has shown no deterioration, except in judgment, for several years. Thought is coherent; memory, apart from retrospective falsifications, is remarkably good; the affect, while in general accord with delusions, is not continuous, and patient enjoys her walks, the dances, and other entertainments. She is very fond of dress, and many of our nurses, who, like writer, are charmed by her agreeable and lovable personality—a charm tempered by sympathy and pity—bestow on her many clothes, ornaments, etc., with which she attires herself in a very becoming and dignified manner. "As I am the Immaculate and Holy Saint, I must look well." She daily writes long letters to her husband, addressed "To Doctor D. B. from Holy St. Elizabeth." On the reverse side she often writes phrases of a religious or exalted content.

Case IV.—F. G. Female. Age at onset forty-one. Married. In the two years prior to admission to hospital, in 1899, she had changed her residence *eight* times "to avoid persecutors." Her various delusions always centered about the idea that various "doctors in B. frequently operated on her at night, turning her

womb around, etc." She heard and recognized voices, especially by one man who goes by the name of Henry or John L. She had "communicated" her psychosis to her husband, but he completely recovered shortly after she was committed. A letter from a noted alienist of New York, whom she consulted one month previous to admission is interesting: "On October 13, 1899, Mr. and Mrs. G. of B., called on me. Mrs. G. stated that she had a great deal of trouble in B.; had been misused there; had been operated on against her will; could obtain no justice, and therefore had come to New York for an examination, and a certificate as to the extent of her physical injuries.

She said that she was certain that various operations were performed upon her by the local physicians, because she heard their voices, heard the doors open and close, and smelled chloroform in her room, although she admits that she saw no one. These operations, she said, were performed at various times at night.

At this juncture her husband interrupted her statement to corroborate all she said, and became intensely excited at the outrages performed on his wife. He said that the doors were opened magnetically, and he also perceived the odor of chloroform. They brought along two bottles of medicine to be analyzed, because they knew that they contained poison, and wished to obtain a certificate to that effect. In conclusion the husband fumed and railed against the doctors, and insisted that the State would, of necessity, have to furnish him with a lawyer, free of charge, to prosecute their persecutors. The demonstration of their systematized hallucinations and delusions of persecution is further borne out by the fact that, notwithstanding that I purposely refrained from subjecting Mrs. G. to a physical examination, she claims to you that I have operated upon her."

This patient died of tuberculosis on July 14, 1914. She was clear to the last, and never deteriorated. While she had no change of personality, she displayed marked exaltation of the ego. Notwithstanding the prominence of delusions, she was very active in the usual ward work, and was especially efficient in helping nurses care for the sick and feeble. While at times she would weep and bemoan her sad condition, and again excitedly demand protection, on the whole her emotional affect seemed perfectly natural and normal. She was fond of her nurses, and when working with or for them, she was pleasant, amiable, and congenial.

Case V.—W. N. Insurance agent. Aged forty-nine. Onset, 1908. Committed by Superior Court, May 20, 1910. Only a few details can be given, chiefly from patient's "history of his life." Parents poor, and died early. Attended district school. "Those were the days of the hickory and spellin' book." "I felt one and learned the other." At fourteen went to work, trying *various occupations*, but finally succeeded as an insurance agent, and accumulated several thousands. Was married twice (progeny from both) and in each case was divorced by his wives; they "were always in the wrong." His second wife engaged a lawyer (A. B.) to secure more alimony. After brooding over his troubles, he bought a horsewhip, carried a revolver also, and sought out A. B. After an acrimonious dispute, patient states that A. B. threw him to the floor, and the pistol exploded in his pocket, wounding A. B. At his trial he was declared insane, and committed to hospital for five years. He has never had any hallucinations, consciousness has always been clear; memory remarkably good, except for falsifications generated by or based upon his delusions, which are all of a persecutory character; he is always right, except for a few "petty mistakes," and has never given any excuse for the "cruelties and indignities inflicted on him;" he never intended to commit a crime, but "should have been imprisoned when convicted, and not sent to an asylum. Judges, lawyers on both sides, even in divorce suits, and the physicians who examined him by order of court, as well as many of his supposed friends, showed spite or recklessness or indifference toward his interests, and he has been mulcted out of large sums of money by grossly exaggerated professional charges, etc. His train of thought is coherent but absolutely self-centered, and he reasons logically from his false or distorted premises. Judgment is biased by delusions, but in business matters is excellent. Patient shows an increasing emotional irritability, and has now involved his present environment. He calls this hospital a "House of Dissimulation and a Sink of Iniquity," where he is "daily subjected to indignities," and "domineered over by degenerate attendants, prevaricating physicians, and the too high officials who show their victims little recognition." Patient's vocabulary is very large, and especially rich in non-profane expletives, rivalling in scope some political hucksters. He is gradually developing a complete "system."

Case VI.—G. B., in 1900 entered a large business office and shot four men, without any warning. One was killed instantly; one died shortly after; one has been a wreck ever since; and one recovered entirely. On examination, after his arrest, it was found that he had reacted to delusions of pesecution, in consequence of which he had since 1875 changed his residence over *twenty-five times*, migrating from the Atlantic to the Pacific, in the hope of "eluding his enemies." He acted normally before the above murderous act, was a skilled mechanic, and none of his associates had recognized in him any trace of mental obliquity.

Case VII.—W. T., a man of seventy, unusually cultured, highly educated, an ardent churchman, for thirty years was continually annoyed by aural hallucinations. Voices reviled and threatened him, using the most profane and obscene language, which "everyone near him could hear." This did not lead him to violent acts, but induced him to keep his room day and night. He had a large library, and was the best informed man I ever knew. From him I learned much, as he looked on me as his only friend. He never deteriorated up to his death, his memory and judgment, apart from his delusions, remaining keen.

Diagnosis.—This rests, in the first place, on the evidence of defective endowment. Hence, while a fully developed case can readily be diagnosed, there are cases which might be considered doubtful, unless we can obtain a *complete* and satisfactory family and personal history. The salient symptoms are early peculiarities of conduct and manner; a gradual onset; a stable system of persecutory delusions; retrospective falsifications of memory; explanations; exaltation or change of personality; coherent train of thought; clear judgment except when biased by delusions; emotional effect in correspondence with delusions; clear consciousness, and absence of any marked deterioration. Hallucinations may, and often do appear, but they are not essential. Persecutory delusions may appear in other psychoses, but often are purely episodal.

A few cases of dementia paralytica, dementia senilis, and melancholia of involution may present a transitory resemblance to paranoia, but can be differentiated reasonably soon by the absence of gradually developed and logically elaborated *system* of delusions, which dominate the entire psychic life, and the presence of characteristic physical symptoms. Similar reasons will exclude Hoch's paranoid form of manic-depressive.

Since Kraepelin and others have been enlarging and qualifying the views of dementia precox, and forming new groups or transforming or splitting up old groups, and since thus far there has been no general acceptance of these modifications and rearrangements, we shall not attempt to differentiate from the heretofore paranoid forms of dementia precox, but will refer the reader to the article on that subject. It is unfortunate that we cannot adopt a universal working classification that would hold good for one generation, at least. Of making new classifications there seems to be no end, and much grouping is a weariness to the would-be diagnostician.

Prognosis.—This is, in the light of present actual experience, unfavorable. No genuine recoveries occur, although remissions are possible, which are more apparent than real. In one case of "relative" recovery at the end of three years, the patient, who is still at large, is "occasionally troubled with ideas of persecution, concerning which she has written to the hospital for advice." (Meyer.) The writer has found reports of a few recoveries, but can gain no information of the after-care. Patients, however, are never reduced to a condition of dementia, although a few may after many years display a moderate blunting of the higher faculties and finer feelings, a moral anergy, and a gradual limitation of the spheres of interest, which are sometimes mistaken for intellectual defect. Some writers state that "involution occurs earlier in paranoiacs," and senility may color their last years by its characteristic anatomical and physiological degenerations. There are a few "mild" cases, which can get along fairly well at home, under proper conditions of care and treatment. Often much improvement can be effected in hospital cases, by personal attention, helpful suggestions, attempts at reeducation, suitable occupation, etc.

Treatment.—In clear cases hospital treatment is imperative, and as early as possible, since very many

paranoiacs develop a homicidal tendency, and all, in some respects, are a menace to their families and the community. There the regular hours, suitable occupation, other than the regular avocation, preferably manual, such as farm and garden work, appropriate diet, frequent agreeable diversions, and "wholesome muscular fatigue" (Meyer) with skilled and kindly supervision, apparently to some extent indirect, are available. It must be insisted on that each case demands special study and management, involving interminable patience and tact and perseverance.

It seems needless to remark that every patient should receive a thorough physical examination on admission, as well as at regular intervals thereafter. *All* deviations from the normal, whether of special or general senses, the vital organs, the nervous system, the circulation should be noted and remedied if possible. The stomach cannot say to the teeth—"I have no need of thee." Hence the dentist is as necessary as the oculist. The sounder the body, the healthier the mind. If we cannot make the bodies temples, we may at least patch them up as well as possible.

In the "spiritual" line, if we use that generally accepted term, we must try to eliminate the selfishness, the ego-centrism, which is specially marked in paranoia. The "two great commandments" must naturally underlie all our efforts here. Let us *try* to instill first of all love, then hope, then faith, and finally courage. Encourage the patient to do some one thing for somebody else—to-day—now. To-morrow he will perhaps do this on his own initiative.

The newer methods, such as psychanalysis, give reason to hope for good results, in improving patient's morale and conduct, and, in some cases effecting at least a partial cure. But these demand unlimited time, and every hospital known to writer is extremely overcrowded. Hence a very large staff, including several physicians specially trained in these modern methods, is essential. The severe nature of the work deserves adequate compensation, in order to induce valuable men to make psychiatry their life work. And legislatures are not overeager to appropriate money, and therefore we should educate them.

After all, the most essential work in the future must be in the line of prevention and early recognition. We must begin with the grandparents. We must study every child. We must instruct parents, teachers, preachers, lawyers, and certainly doctors, who have the best and most favorable opportunities to study children from birth to puberty, and thence to early manhood. Work in this direction has begun. Psychopathic hospitals are already established in some places, and many more are needed. The State and National Societies of Mental Hygiene have for several years been at work. A few Mental Hygiene Clinics have been organized, and more will be, similar to those in New York. A clinic has just been established, and in October, 1913, the writer assisted in opening one at the New Haven Dispensary. Popular educational lectures are now being given on the care of the mind. Let us hope we may lessen the number of paranoiacs by diminishing the source of supply. Genuine, sane eugenics will prevent many premartial and pre- as well as postnatal factors. If all defectives and predisposed persons should be kept from very early childhood in a suitable environment, with proper scientific training, mental, moral, and physical, much may be done.

James Mortimer Keniston.

Paraplegia.—By paraplegia is meant a paralysis affecting the lower extremities. If the paralysis is incomplete, we speak of a paraparesis, if the reflexes and the muscular tonus are increased, the paralysis is spastic, if they are diminished or lost, it is flaccid.

Etiology and Pathology.—Paraplegia is a symptom only, not a definite disease and can be caused by a number of pathological conditions.

It will be remembered, that the motor impulses for the lower extremities, originating in the cortical cells about the upper part of the fissure of Rolando and in the paracentral lobule, pass down through the corona radiata, the anterior part of the posterior limb of the internal capsule, the crusta of the crura cerebri, the anterior portion of the pons varolii, the pyramids of the medulla and the greater portion of them decussating at the lower end of the medulla, pass over, each to the opposite lateral pyramidal tract in which they descend to the lumbar and sacral regions of the spinal cord, where turning forward, each fiber breaks up into its end brush about a motor cell of the anterior horn, while from each such motor cell there originates an axone which passing out of the cord by an anterior nerve root enters a peripheral nerve and goes to innervate a muscular fiber.

Now paraplegia can be produced by interruption of conduction on both sides anywhere in this long path between the brain and the muscles of the lower extremities.

The cerebral palsies of infancy due to the pouring out of blood upon the surface of the brain, usually as a result of long-continued pressure upon the head in difficult labors, may take the form of paraplegia when the hemorrhage is limited to the central region immediately adjoining the superior longitudinal fissure, but in the adult such an occurrence is very rare. Theoretically paraplegia may be due to bilateral lesions in the internal capsule, the pons and the medulla, but in practice we rarely encounter cases of such etiology since the arm and leg fibers run so close together that one set can hardly suffer without involvement of the other. The same remark applies to lesions occurring in the upper portion of the spinal cord and in the great majority of instances the trouble causing paraplegia is located below the cervical enlargement.

The spinal cord may be involved in its whole cross-section—transverse lesion—certain fiber systems may alone be affected or the disease may be limited to the anterior horns—poliomyelitis. Pathological processes of the first category are crushing of the cord by injury or its compression in diseases of the vertebræ (Pott's disease), tumors, vascular disease (endarteritis), hemorrhage, embolism, or thrombosis, cavity formation (syringomyelia), myelitis, and meningomyelitis.

The systemic degeneration of the lateral columns produces a typical spastic paraplegia, while that of the posterior columns is the basis of locomotor ataxia, though in this latter disease inability to use the legs is due to ataxia and there is not a true paralysis; hence it is not generally classed as a paraplegia, although the patient ultimately becomes bedridden. The simultaneous affection of both lateral and posterior columns causes the "ataxic paraplegia" of Gowers, while Friedreich's ataxia is generally held to be due to a similar combined sclerosis with additional involvement of the direct cerebellar tracts and the columns of Clarke. The lateral pyramidal tracts also degenerate in case of a lesion higher up in the motor tract and are practically always affected in compression of the cord or in lesions of its cross-section. The anterior horns are affected in poliomyelitis also in a transverse lesion, and if either of these involve the cord in the lumbosacral region a flaccid paraplegia will result. In multiple neuritis there is nearly always more or less symmetrical involvement of the leg muscles, hence a paralysis of paraplegic type. Finally certain varieties of progressive muscular atrophies and dystrophies affect the legs and lead to bilateral weakness.

To recapitulate, paraplegia may occur as a symptom in any of the following conditions: injury, hemorrhage,

tumor, etc., affecting the upper portion of the central region of the brain cortex of both sides; bilateral lesion of the motor tract anywhere between the cortex and the lumbosacral cord; lesions of the cauda equina; such diseases as lateral sclerosis, amyotrophic lateral sclerosis, tabes, combined sclerosis (ataxic paraplegia), multiple sclerosis, Friedreich's and heredoataxia; meningitis and myelitis; endarteritis of the vessels of the spinal cord; hemorrhage, embolism, and thrombosis; tumors of the spinal cord; syringomyelia; the caisson disease; pernicious anemia; in pellagra; poisoning by ergot and similar drugs; poliomyelitis; multiple neuritis; muscular atrophies, and dystrophies; and as a functional disturbance in hysteria. (See further "*Spinal Cord, Diagnosis of Local Lesions of the,*" and articles on the above-mentioned diseases.)

Symptoms.—The character of paraplegia will depend upon the seat of the lesion and the nature of the underlying cause. When conduction is interrupted above the lumbar region, the paraplegia is always spastic except when the spinal cord is completely severed, in which case it is flaccid and the reflexes are lost. Lesion of the anterior horns of the spinal cord, of the anterior roots of the spinal nerves and of the peripheral nerves, always cause flaccid paraplegia.

In spastic paraplegia there is gradually increasing heaviness and stiffness of the legs with increase of the muscular tonus and exaggeration of the reflexes, so that locomotion becomes more and more difficult and there is a tendency to painful spasm of the muscles particularly in bed at night. The gait is characteristic, the patient has difficulty in raising the feet from the ground so that they are dragged along and the shoes are worn out on the toes and along the inner side of the sole. On account of the spasm of the adductor muscles, the legs cannot be separated well and there is a tendency to cross-legged progression, particularly in children. The steps become short; on account of the increase in reflexes there is a foot clonus at each step and finally locomotion becomes impossible. In the terminal stages, there may occur contractures which draw up the legs upon the thighs and the thighs upon the body. The muscles may then undergo atrophy from disuse. The reflexes are greatly exaggerated, the knee-jerks are excessive, there may be a knee clonus, there is ankle clonus and the Babinski, Oppenheim, and Gordon reflexes may be present. When the lateral pyramidal tracts are alone involved, there is no loss of sensation but hypoesthesia or anesthesia may be a feature in transverse lesions. In flaccid paraplegia, on the other hand, the reflexes and muscular tonus are diminished or lost and if the patient can walk at all, the gait may be ataxic.

In anterior horn and peripheral nerve lesions, the affected muscles undergo atrophy and may show reaction of degeneration on electric examination.

Compression of the spinal cord from whatever cause, usually affects the lateral pyramidal tracts, and manifests itself in spastic paraplegia. This is often an early symptom in Pott's disease. It is particularly characteristic of syphilis of the spinal cord which usually takes the form of a meningomyelitis or that of endarteritis of the vessels of the cord.

Senile paraplegia usually occurs in elderly people who are the victims of vascular disease, and as the lateral columns are more poorly supplied with blood than the other parts of the cord, it usually takes the form of spastic paraplegia though a flaccid ataxic form is occasionally observed.

By paraplegia dolorosa is meant a variety of paralysis, in which in spite of complete loss of sensation and motion in the lower extremities, they are still the seat of excruciating pains. It usually occurs in cancer of the spinal column in which the posterior roots above the segments of the spinal cord already destroyed are compressed by the cancerous mass and the resulting irritation is referred as pain to the periphery.

Urinary paraplegia occurs in connection with disease of the urinary organs. Its origin is obscure, but it is probably due to a myelitis arising from infection from the above source.

Further descriptions of the paraplegias occurring as symptoms in different diseases will be found under the appropriate headings.

Diagnosis.—Since paraplegia is a symptom only, it is of particular importance, both for prognosis and for treatment, to decide what is the underlying condition. Syphilitic spinal paralysis most frequently manifests itself as spastic paraplegia, though the posterior column type of the disease, syphilitic "pseudo-tabes," also occurs. As syphilitic paralysis in its earlier stages is the form most amenable to treatment, its prompt diagnosis is of the greatest importance. The history of the case, the presence of other evidences of syphilis, the Wassermann test upon the blood and the spinal fluid, with the Noguchi and Nonne-Appelt tests and the cell count upon the latter should clear up the matter.

In tumor formation there is usually a long history of root symptoms, particularly of pains radiating into the corresponding segmental nerve distribution, while in Pott's disease the bony deformity will be apparent or should show in the *x*-ray picture.

In myelitis, the discovery of a possible etiological factor and the segmental distribution of the motor and sensory symptoms should indicate the nature of the case.

Hemorrhage and vascular plugging come on suddenly.

Paraplegia from brain disease is accompanied, as a rule, by some other localizing symptoms dependent upon what part of the motor tract is involved (localized spasm, convulsions, cranial nerve paralyses, etc.). It is rare except in children.

Each of the diseases of the spinal cord mentioned above has its own particular symptomatology of which paraplegia is only a part.

In hysterical paraplegia, there is nearly always the history of a trauma or shock of some sort, the limbs often show anesthesia in band-like distribution not segmental, the reflexes are not disturbed or slightly exaggerated, there is no bladder trouble and the electrical reactions of the muscles remain normal. When there is loss of knee-jerk or, on the other hand, the Babinski or Oppenheim signs are present, the paralysis is in all probability organic in origin and not hysterical.

Prognosis.—The outlook in paraplegia depends entirely upon the underlying cause. Cases due to brain disease once established are susceptible of but limited improvement. In Pott's disease, if the pressure upon the spinal cord can be removed early enough, and the bone lesion heals, there may be complete recovery. In the case of tumors compressing the spinal cord the prognosis depends entirely upon how early their presence is recognized and the possibility of their removal by surgery. Such neoplasms once removed show little or no tendency to recur.

Cases of myelitis often come to a standstill and even improve, hemorrhage may be more or less absorbed. Syphilitic meningomyelitis is most amenable to treatment of any of the causes of paraplegia and if handled early and vigorously, complete cure may be effected. Poliomyelitis improves up to a certain point, but nearly always leaves some deformity and loss of function.

In multiple neuritis power may be eventually restored though some cases are permanently crippled. The other chronic diseases of the spinal cord are usually progressive and are little influenced by treatment. Hysterical paraplegia may quickly disappear as a result of some strong suggestive influence but it sometimes persists a long time.

Treatment.—The treatment of paraplegia will depend entirely upon the underlying cause and will find consideration under the different diseases of which this is a symptom. In any given case it is most important to decide, 1. whether it is due to some cause mechanically producing compression and amenable to surgical treatment, and 2. whether syphilis of the central nervous system is present. In the latter case, treatment should be prompt and intensive, best by the injection of salvarsan or neosalvarsan, intravenously or possibly by some of the newer intraspinal methods—though these last are as yet hardly beyond the experimental stage and in some instances have been productive of very bad results—followed by a prolonged course of mercury and iodide of potassium.

In paraplegias of unknown origin also mercurial treatment has sometimes been of benefit. In any case the patient should be guarded against overfatigue and when bedridden, should be treated according to the general principles governing the care of paralyzed patients, *i.e.* with attention to the bowels and bladder, prevention of bed-sores, etc.

In cases which have come to a standstill, the residual incapacity may call for surgical and orthopedic measures. In cases with extreme spasticity, Foerster's operation, in which the posterior spinal nerve roots are cut, with the object of doing away with the excessively heightened reflexes and increased tonus by severing the reflex arc and substituting ataxia for spasticity, is finding increased application. Of late there have been attempts at dealing with paraplegias of obscure origin by laminectomy alone. In some instances compression of the spinal cord by bony exostosis has been found, in others the relief of pressure alone seems to have been of benefit. This "decompressive operation" seems worth trying in suitable cases, though the number of such operations so far reported is as yet too limited to justify definite conclusions as to the value of the procedure.

Charles Lewis Allen.

Parapsoriasis.—This is a term introduced by Brocq, which is now considered the best designation for a group of dermatoses, which while differing one from another in appearance, have at the same time certain common characteristics. These various forms of eruption have been described by Colcott Fox and Macleod under the head of resistant maculopapular scaly erythrodermias; by Brocq as érythrodermie pityriasique en plaques disséminées; by Unna as parakeratosis variegata; by Crocker as lichen variegatus; and by Jadassohn as dermatitis psoriasiformis nodularis. Brocq suggests three subtitles to the generic term parapsoriasis, namely: parapsoriasis en gouttes, en plaques, and lichenoides. He identifies Unna's parakeratosis variegata with his parapsoriasis lichenoides, Jadassohn's dermatitis psoriasiformis nodularis with parapsoriasis en gouttes, and his érythrodermie en plaques disséminées with parapsoriasis en plaques.

All of these various forms of eruption have a number of features in common, and some of their clinical aspects are suggestive of the psoriasiform type of seborrhoic dermatitis and pityriasis rosea, of fading lichen planus papules, and of the early erythematosquamous eruption of mycosis fungoides. They are characterized by an extremely slow evolution, a fine branny, scale formation, a distribution of sharply defined circumscribed patches of variable dimensions, and scattered irregularly over the body, an almost complete absence of itching, a pale pinkish-red color, little if any infiltration, and an extraordinary resistance to local treatment. The histological findings as described by Hodara, consists in the lichenoid type, of a hyperplasia of the perithelial cells of the blood-vessel walls of the cutis and of the papillæ, and swelling of the connective-tissue cells adjacent to the papillary bodies. Changes in the epidermis consist of a mild hypertrophy and hyperplasia of the prickle-cell layer. Parapsoriasis en gouttes presents the same changes, but they are more marked in character; there also exists a perivascular infiltration, with small, round lymphoid cells. Hodara did not find necrosis, epitheloid cells, or giant cells, in the connective tissue, nor were the blood-vessels engorged with polynuclear leucocytes. The author does not agree with Civatte and Milian, who believed the disease to be a form of tuberculide.

Parapsoriasis is exceedingly resistant to treatment, the eruption persists, in spite of the most energetic local treatment. Arsenic internally, and pyrogallol externally, have seemed to be the agents which have had the most favorable influence upon the disease. Hodara recommends calcium sulphide.

Paul E. Bechet.

Parathyroids.—In 1880 Sandström discovered the presence of small glandular organs on the posterior surfaces of the lateral lobes of the thyroid. He found these to be of constant occurrence, and from their structure regarded them as embryonic thyroid tissue; he accordingly named them *glandulæ parathyroideæ*. A year later, the same organs were independently discovered by Stieda in embryos of the pig, and by Baber in different animals. The former regarded them as carotid glands, the latter as embryonic thyroid tissue. But little attention was paid to these glands until 1891, when Gley asserted their importance. In the few years immediately following, his statements were supported by numerous observers. In 1895 the first careful study of the minute anatomy of the parathyroid was given by Schaper. Numerous experimental investigations followed, both in normal and thyroidectomized animals, showing the physiological importance of these structures. Various names have been proposed for them: "*epithelial bodies*," "*accessory glands*," "*accessory thyroids*," "*glandules thymiques*," etc.; the original designation *parathyroid* has the advantage, however, that the organs are not thereby confused with the accessory glands having the true thyroid structure.

Development.—The parathyroids and the thymic nodules found in connection with the thyroid arise from the third and fourth branchial clefts. On their dorsal aspects these clefts develop epithelial thickenings which retain an epithelial structure instead of developing into thymus tissue. These are the parathyroids, and are embryologically designated "parathyroid III" and "parathyroid IV."

The parathyroids occur usually in pairs; sometimes one on each side, or two on one side and one on the other. The writer has also found three upon one side. The total number observed in man has never been greater than four. Thymic nodules are often found in close association with the parathyroids, often directly continuous. Parathyroids may also be found in the cortex or medulla of the thymus. The common development of the two organs explains the close association of the two types of tissue.

In size they vary greatly, but they are usually very small; the average, as found by the writer, being about 7 millimeters long, 2 to 3 millimeters broad, and 1.5 millimeters thick. The average weight is about 0.2 to 0.3 gram. They are often almond shaped, having one end recurved; but the shape not infrequently suggests the spleen. At other times they may be flat, cylindrical, or round. Their color is usually pale brown or yellowish, but may be brownish red or bluish, so that they are easily mistaken for hemolymph glands. They usually lie behind the lower poles of the lateral lobes of the thyroid, separated from the thyroid tissue by a septum of connective tissue, their convex surfaces lying in slight depressions on the under surface of the lobes.

Not infrequently they are found below the thyroid, even as low as the level of the clavicle or in the thymus. The inferior parathyroids are much more inconstant in their position and relations. It is often very difficult to recognize the parathyroids at the autopsy; therefore all of the glandular structures in this region should be removed for microscopical examination. It is of advantage, in case the organs are not easily found, to take out the neck organs *in toto* and fix them in formalin. After fixation the dissection of the region behind and below the thyroids usually results in the determination of the exact location and relations of the parathyroids, their brown or yellow color becoming more prominent in contrast to the lighter adipose tissue about them. The color is usually lighter than that of the thyroid. By following up the branches given off from the inferior thyroid artery, just before the vessel passes into the thyroid, the parathyroids are usually easily discovered. They derive their blood supply from these branches. The parathyroid vessels may run in a stalk connecting the parathyroid to the thyroid. Their veins empty into the veins on the surface of the thyroid, or directly into the inferior thyroid vein. But little is known of the nerve supply. Sacerdotti and Anderson have traced nerve fibers along the vessels and between the epithelial cells.

The microscopical appearances are those of a gland having a delicate capsule, from which thin connective-tissue septa pass in, supporting the larger blood-vessels, and separating the imperfectly developed lobules. The general appearance of the gland may vary greatly. Often it appears as a single mass of closely placed polygonal cells, between which run numerous delicate capillaries, forming a network in the meshes of which lie the cell groups or alveoli. A very fine reticulum extends through the entire glandule, even separating individual cells especially toward the center of the organ. This reticulum stains with eosin, and slightly with orcein. In other cases the lobular arrangement is much more marked, the cells showing a more decided cord-like or alveolar arrangement. The anastomosing columns may consist of a single row or of several rows of cells, arranged upon the capillaries. In other specimens the cells may be grouped into round follicles. Not infrequently all three types are found in one gland.

The cells vary in appearance, so that three chief varieties may be distinguished. The majority are somewhat larger than those of the thyroid; the nucleus stains deeply, the protoplasm but slightly and is vacuolated. The boundaries of these cells are visible as fine lines. Besides these, there are large polygonal cells with deeply staining nucleus, very granular protoplasm which stains deeply with eosin, and with sharp cell outlines. The third type of cell is low columnar, and is arranged upon a basement membrane in such a way that the cells radiate toward the center of the group, giving it the appearance of a follicle. In the center of this a definite lumen may often be made out. It usually contains a finely granular substance, but may contain a colloid-like material. Occasionally the follicles are cystic. Between these three types of cells there are all possible transition forms. Kohn also distinguishes three different arrangements of the epithelium: (1) A compact cell mass; (2) a retiform tissue; (3) a lobular arrangement.

Many of the large polygonal cells stain heavily with eosin, resembling closely the acidophile cells of the hypophysis. These oxyphile cells are wanting in the parathyroids of young children. In others fine fat droplets are often present and the size and number of these increase with age. The follicular arrangement of the cells is always more marked when the lumen-like opening, containing granules or colloid-like material, is present. The different appearances presented by the cell indicate most probably different stages of functional activity.

The circulation of the gland is sinusoidal in character, the epithelial cells being separated from the blood by endothelium only, connective tissue as a rule not accompanying the capillaries. The secretion of the gland, as clearly shown in a hypertrophic parathyroid obtained by the writer in a case of acromegaly, is into the lymph vessels. According to Benjamins colloid is constantly present. The writer has not found this to be the case, but has found constantly in the open follicles a finely granular substance. Vincent holds that the fundamental histological features of thryoid and parathyroid are practically identical; other recent investigators also hold that the essential elements of the two organs are the same. Although entire parathyroids or portions of these organs show appearances quite different from that of thyroid parenchyma, all possible transitions may be found between the two tissues. In some cases it is very difficult to distinguish the two tissues; the absence of colloid in the parathyroid tissue may be the only difference apparent. After thyroidectomy the parathyroids left *in situ* become transformed into tissue that cannot be distinguished from that of the thyroid.

Physiology.—The majority of writers favor the belief that the thyroids and parathyroids are independent organs with distinct functions. Vincent, on the opposite side, holds that the present evidence does not warrant this assumption. From the standpoint of comparative anatomy he believes that there is a very close relationship between the two organs; and he regards the experimental evidence as unconvincing. The frequent anatomical continuity and the occurrence of transition forms must be taken as indicating the close anatomical and physiological relationship. Removal of thyroids and parathyroids gives rise to serious symptoms, and to death in some animals (dogs, cats, foxes, wolves), while in others (sheep) the effects are but slight. In other animals there may be produced a chronic cachexia, or an acute tetany, but the symptoms may disappear and the animals survive a long time. The importance of both glands in the general body economy must be great, but it is not yet shown that their functions are vitally distinct. Vincent would regard thyroid and parathyroids as constituting one apparatus, with probably the *pars intermedia* of the pituitary as a third constituent of this apparatus.

Pathology.—Variations in size, shape, and number of the glands occur. Cysts lined with columnar or flattened epithelium may be found near or in connection with the parathyroids, as congenital "rests" of the gill pouch or of a diverticulum of the same. Benjamins suggests that this is an analogue of the *ductus thyreoglossus*, and should be designated as the *ductus parathyroideus*. The writer has observed in one case in man a blind duct, lined with low columnar cells, passing into the parathyroid, its epithelium being directly continuous with that of the gland. Near the entrance of the duct into the parathyroid there were several large cystic follicles containing colloid-like material.

Circulatory Disturbances.—The most important are *hemorrhages*. These are most often caused by stasis and trauma at birth. Diffuse extravasations or small hematomas may be produced. These later become encapsulated cysts, pigmented areas of connective tissue or pigment-free scar tissue. The glands may become diminished in size and deficient in function. In *leucemia* the parathyroids may be infiltrated with white cells. Gley found in the parathyroids of the rabbit twenty-five times as much iodine as in the thyroid, and in the dog six times as much. He suggested that the parathyroids prepare the secretion which is then stored up in the thyroids.

Retrogressive Changes.—*Simple atrophy* occurs in congenital syphilis. *Pressure atrophy* may be caused

by struma of the thyroid. *Cloudy swelling* and *fatty degeneration* have been seen. *Fatty atrophy* occurs in old age and in cachexias. Benjamins has observed *hydropic degeneration* in groups of cells, occurring in two cases in which the organ was hyperemic. The writer has obtained a reaction for *mucin* in the cysts found in one case. In the parathyroids from cases of chronic pulmonary tuberculosis he has also seen *colloid-containing* follicles, portions of the glandule closely resembling thyroid tissue.

Hypertrophy.—In a case of acromegaly with adenomatous tumor of the hypophysis the writer found great enlargement of the superior parathyroids, the right parathyroid weighing 1.5 grams, the left 1.7 grams, the right one being nearly 2 centimeters long. Both were deep bluish red. The microscopical examination showed the follicles to be for the greater part cystic, and containing finely granular material staining deeply with eosin. No colloid was found. All transition stages could be observed, from the closed follicle to the cystic ones. The dilated cystic follicles could be seen to possess direct communication with the lymph vessels. The thyroid in this case showed interstitial increase of connective tissue. Adenomatous hypertrophy has also been observed in cases of osteomalacia.

Benjamins has seen an interstitial hyperplasia of the connective tissue of the parathyroids in a case of Basedow's disease associated with cirrhosis of the liver.

In struma of the thyroid, according to Benjamins, there is no increase of size in the parathyroids; on the contrary, they are often smaller, and are either normal or show retrogressive changes rather than progressive. These changes are to be referred to the pressure of the enlarged thyroid.

With the exception of the one case mentioned above, Benjamins found no changes in the parathyroids in Basedow's disease.

Benjamins describes a tumor attached to the right lobe of the thyroid, which in structure he regards as closely resembling that of the parathyroid, and regards its origin from the latter as possible. Tumors of the parathyroids have been reported by a number of observers. These were small in the majority of cases and presented the structure of "adenoma" or "compensatory hypertrophy."

Experimental Pathology.—The results obtained have been contradictory and confusing. There can be no doubt that the effects of extirpation are very different in different animals. MacCallum, Berkeley and Beebe, Biedl, and others have attempted to show that complete parathyroidectomy produces tetany, and the origin of this tetany has been ascribed to changes in the calcium metabolism, increase of ammonia in the blood, increased excitability of the nervous tissues, acidosis, etc. The results obtained in the case of sheep and goats are very different from those in the dog; and MacCallum's very positive claims based upon his experiments with the latter animal must in the light of other experimental investigations be regarded as premature. Halsted's "tetania parathyreopriva" rests on similar incomplete experimental evidence. Although the statement is made in the majority of text-books that the most obvious and remarkable effect of parathyroid insufficiency is tetany, a critical examination of the literature must convince one that it is not yet positively shown that such tetany is due to *loss of parathyroid function alone.* Likewise the attempts to show relations between the parathyroids and Graves' disease, epilepsy, paralysis agitans, myotonus, myoclonus, myasthenia, infantile atrophy, osteomalacia, rachitis, nephritis, and eclampsia rest upon little or no evidence. The therapeutic use of parathyroid in these conditions has been of no avail. Transplantation or grafting of parathyroid tissue has been employed in the treatment of postoperative tetany. ALDRED SCOTT WARTHIN.

Paratophan.—Trade name of a substance recommended as a substitute for atophan. It is methyl atophan, or 6-methyl-2 phenyl-quinoline-4-carboxylic acid ($CH_3.C_9H_4N.C_6H_5.COOH$). It comes in the form of a yellow crystalline powder, of slightly bitter taste, soluble in alcohol, ether, chloroform, and alkaline solution, but not soluble in distilled water. It is employed to meet the same indications and in the same dose as atophan. T. L. S.

Paratyphoid Fever.—Paratyphoid fever is an acute infectious disease caused by infection with the Bacillus paratyphosus. The paratyphoid bacilli belong to a group of organisms which belong between the typhoid and colon bacilli, being nearer to the typhoid bacillus as the paracolon bacillus is nearer the other end of the group. The paratyphoid bacilli were divided by Schottmüller, who first identified them, into A and B varieties which differ but slightly in their cultural characteristics. The differentiation of these organisms from the other members of the group may be a matter of extreme difficulty. The disease produced by these organisms is very similar in all ways to typhoid fever. The mode of dissemination of the infectious agent is similar and prophylactic measures are identical except that, of course, bacterial vaccines of the paratyphoid bacillus should be employed.

PATHOLOGY.—The most constant finding is the enlargement of the spleen which was present in all autopsies. The involvement of the lymphoid tissue is less constant than in typhoid fever though it may go on to ulceration and perforation in a similar fashion. The rash is a similar one. The blood shows a leucopenia and later a relative lymphocytosis with a diminution of the eosinophiles during the febrile stage.

SYMPTOMS.—These are similar to those met with in typhoid fever though generally less severe. The onset is gradual. The period of incubation is from four to six days. Headache, lassitude and a slight bronchitis are frequent manifestations, though the disease may begin with a definite gastrointestinal upset. The course of the fever is similar to that in typhoid though generally shorter. Relapse, perforation, and hemorrhage may occur. Rose spots are constant. Herpes labialis is said to be not infrequent which is a point in differentiation from typhoid in which it is rare (Jochmann). The enlarged spleen is a characteristic symptom.

DIAGNOSIS.—The diagnosis depends upon the isolation of the *Bacillus paratyphosus* A or B from the patient's blood, urine or feces or some localized lesion. The agglutination test is also of value. The serum of a patient suffering with paratyphoid fever may agglutinate the typhoid bacillus in low dilutions but should have a marked agglutinating action upon the paratyphoid. In the absence of a positive culture the diagnosis may be made upon the basis of the agglutination tests.

PROGNOSIS.—The prognosis is good, the mortality rate being about one per cent.

TREATMENT.—The treatment is identical with that of typhoid fever. RALPH G. STILLMAN.

Paré, Ambroise.—Called the Father of Modern Surgery. Edouard Nicaise ("La Chirurgie de Pierre Franco") speaks of him as one of the three greatest surgeons of the sixteenth century, Franco and Würtz being the two others. Paré was born at Laval, France, about the year 1509. Although his early education had been very incomplete, through lack of sufficient funds, he nevertheless managed to make

satisfactory headway in acquiring knowledge of the art for which he seems almost to have been born. It is narrated of him, for example, that by the year 1536 he had already been connected with Hôtel-Dieu, the great hospital at Paris, for four years, and that he had been permitted on several occasions to operate under the supervision of his superiors. Then, for the following thirty years, Paré was actively engaged in surgical work connected with the numerous military expeditions of that period of French history. Notwithstanding the fact that, during the years of warfare, a very large part of nearly every day was spent in camps, in the saddle, or in attendance upon the wounded or the sick, he managed to find the time for making good the deficiencies of his early education, and for writing treatises on surgical topics. Although by this time (he was then forty-five years old) he had become quite celebrated as a surgeon, he decided that it would protect him from troublesome interference on the part of the Medical Faculty and from the jealousy of individual physicians if he were to secure the formal authorization to practise. Accordingly, he submitted himself as a candidate at the regular examinations in August, 1554, and on the 18th of the following December he received the degree of Doctor of Surgery. Eight years later, Paré was chosen First Surgeon to the King of France, Charles IX; and, after the latter's death, he held the same position under Henry III. He died at Paris on April 25, 1592.

Paré's love of simplicity and his great ingenuity manifested themselves in all his surgical work. He completely distanced all his predecessors. He cared nothing for precedent unless it were backed by the authority of reason.

Of his published writings it will be sufficient to mention the following single collection: "Les oeuvres d'Ambroise Paré, conseiller et premier chirurgien du roi, divisées en 27 livres, avec les figures et portraits, tant de l'anatomie que des instruments de chirurgie et de plusieurs monstres, Paris, 1575. This work passed through many editions and was translated into several foreign languages—English, German, Dutch. The best modern edition is that of Malgaigne, published in Paris (3 vols.) in 1840–1841. A. H. B.

Pareira Brava.—*Pareira*, U. S. P.; *Pareiræ radix*, B. P. The root of *Chondrodendron tomentosum* Ruiz et Pavon (fam. *Menispermaceæ*).

This drug is derived from a tall woody twiner of Brazil and adjacent parts of tropical South America. It was first introduced to the notice of physicians in Europe about 200 years ago, and after a period of neglect was again brought forward in the early part of this century. It is very little used at present—at least in this country. During this period several other closely related products from allied genera have been imported as pareira brava, adding much to the botanical confusion in regard to its source.

Pareira occurs in subcylindrical, knotty, and somewhat tortuous, hard, heavy, and tough pieces, of indefinite length and one to six centimeters (½ to 2½ in.) thick; externally blackish, longitudinally wrinkled and bearing transversely elongated protuberances or incomplete annular ridges, as well as constrictions, or occasionally fine fissures; the dried transverse surfaces exhibit several equilaterally concentric circles of interrupted, porous wood wedges, projecting beyond the markedly retracted intervening tissue of the rather large medullary rays; internally pale brown or yellowish brown, when freshly cut having a waxy lustre; inodorous and bitter.

Of the several spurious pareiras, all have a gray or grayish-brown surface instead of the blackish color of the genuine, and are less, or not at all, knotty and roughened. None cuts with its waxy luster, and all are lighter in weight and less solid.

Pareira contains from two to three and a half per cent. of an alkaloid which is probably pelosine, similar to, if not identical with, buxine of box, and biberine of green-heart bark. A little tannin also exists, together with starch, gum, and about eight per cent. of ether-soluble fat.

Action and Uses.—What we know of the constituents of pareira and their actions does not support the therapeutical ideas upon which its use is based. It is known to be a fairly good bitter tonic, and slight antiperiodic properties may be reasonably assumed. Its use, however, is chiefly as a diuretic, and in inflammatory diseases of the genito-urinary organs, more especially in orchitis. While it does appear to have a slight diuretic action, the idea of its use in this way probably depends upon administering it in decoction well diluted with water. Certainly, the idea of its having the great diuretic value once ascribed to it has been completely abandoned. There is good clinical evidence of a moderate degree of usefulness in the other directions named, although such action is by no means certain or uniform.

The Pharmacopœia provides a fluid extract made with ten per cent. of glycerin, of which the dose is a fluidram. For its diuretic effects, the five per cent. decoction is best employed.

Allied Drug.—The drug which is, in the United States and England, regarded as the principal adulterant or substitute of pareira is that wholly or partly specified in some pharmacopœias, namely, the root of *Cissampelos Pareira* L., a plant of similar habit and growing in the same region, though much more widely distributed, and believed also to grow in India. The root is generally smaller than pareira and is of a brown or gray-brown color; longitudinally, much grooved and transversely fissured, and readily losing its bark when kept in stock.

The alkaloid of this drug has been proven to be pelosine. Cissampelos is believed to act much like pareira, though it is more generally used as a tonic.

A number of other tropical American drugs are locally known as "pareira," but they bear no resemblance to the genuine article. Henry H. Rusby.

Parent-du-Chatelet, Alexandre Jean Baptiste.—Born at Paris, France, Sept. 29, 1790. He received the degree of Doctor of Medicine in 1814. For a certain number of years he engaged in the practice of his profession, but after that he devoted all his energies to the cultivation of public hygiene. He died March 7, 1836, at the comparatively early age of forty-five. His published writings, of which only a few may here be mentioned by title, are accepted as standard authorities. As examples the following deserve to be named: "Mémoires sur les débardeurs de la ville de Paris, ou recherches sur l'influence que peut avoir sur la santé l'immersion longtemps prolongée des extrémités inférieures dans l'eau froide," in the Annales d'Hygiène, 1830; "Sur le battage des tapis et ses inconvéniens," in Ann. d'Hyg., 1833; and "De la prostitution dans la ville de Paris, considérée sous le rapport de l'hygiène publique, etc.," Paris et Londres, 1836. A. H. B.

Paresis, General.—General paralysis of the insane, also known as paretic dementia, dementia paralytica, and popularly as paresis (which term for convenience will be used largely in this article), is undoubtedly an old disorder, but its recognition as a distinct type dates back only to the early years of the nineteenth century. The occurrence of paralysis with insanity apart from that associated with gross organic disease of the brain had been noticed by earlier observers, but it is to Bayle (1822) and Calmeil (1826) that we owe the first definite recognition and description. Since then it has been, more than almost any other type of

mental disorder, a special study of the alienist, and its literature has surpassed in extent that of any other. It has been called a disease of modern life on the presumption that only in comparatively recent times has it become prevalent, and there is much apparent reason in this presumption. Certainly only of late years has its prevalence been so notable, and its actual increase seems to be a fact that cannot well be contested, making all due allowances for defective diagnosis which undoubtedly affected the statistics to some extent up to within a comparatively recent period.

The definition of general paresis presents some difficulties. In the first place, it is a protean disorder, and its symptoms have often in the past suggested to alienists that we have in it not one, but possibly several, distinct morbid entities. This, in fact, has been the contention of some of the French writers, who maintained that the paralysis and the dementia indicate two distinct types. The pathology of the disease has also been in dispute, so that neither on clinical nor on pathologic grounds has there been, up to a comparatively recent date, a basis for positive assertion of the unity of the disorder. The close relations, however, with tabes, with the more recently acquired facts in regard to the pathologic processes in the neurons, have of late years thrown much light on paresis. We now know that typical paresis is a usually late appearing manifestation of syphilitic infection of the nerve centers and can in a general way agree with Mott, who holds that it is a disorder essentially due to a degeneration of the neuron itself, a parenchymatous degeneration, with characteristic perivascular exudate of lymphocytes and plasma cells and (probably secondary) inflammatory changes affecting the vessels, lymphatics, and membranes, due to the active toxin of syphilis and the irritation of the products of nerve decay. Accepting this theory of the disorder, which seems, in view of all the facts, as possible as any, we may define paresis as a generally subacute inflammation of the brain, due primarily to toxic degeneration of the nerve elements, especially those of the higher cerebral centers (speech, ideation, etc.), and generally attended with a chronic progressive dementia and physical paresis with manifold other mental, sensory, and motor symptoms, and ending inevitably in death from general exhaustion or from one or other of the special cerebral complications incident to the affection—acute delirium, convulsions, apoplectic attacks, etc.—or from intercurrent complications. A more strictly pathological definition is that of A. Meyer, who limits the term "general paresis" to cases of a diffuse, progressive, parenchymatous syphilis with preponderance of the loss of tangential fibers and other nervous structures, with neuroglia overgrowth, disorganization of the lamellation of the cortex, and infiltration of the sheaths of the small and medium vessels with plasma cells and lymphoid cells, and occasional local devastations. From a fairly noteworthy number of cases we may generalize that general paresis is an invasion of the brain by spirochetes with a parenchymatous reaction, and a more or less incidental mesoblastic response (Weigert). These definitions seem to represent the present prevailing opinions of authorities on this issue. The fundamental conception of the disease is the special parenchymatous involvement as the essential lesion of paresis, the other pathological conditions being accessory. It does not necessarily follow that other pathologic conditions may not simultaneously appear and coexist with the degeneration of the neuron, but they are not the disease itself.

Etiology.—*Predisposing Causes.*—The primary and essential cause of general paresis is syphilitic infection, but this fact has been slow in gaining general acceptance by the profession. The earlier writers on the subject, as a rule, paid but little attention to luetic infection among the causes of the disease; it was only incidentally mentioned by Bayle, and Esquirol recognized it only as contributing indirectly through the overuse of mercurial treatment. Sandras, however, in 1852, called syphilis and intemperance the two great causes of general paralysis; and some years later several Danish physicians, Steenburg, Esmarch, Jessen, and Kjellberg, announced their belief in the specific nature of the disease. Most authorities, however, up to the last two or three decades have put syphilis in the background, and it is only within that period that the compilation of numerous statistics indicating its frequency as an antecedent has brought it prominently to the front. In 1886 Rieger deduced from such figures as were then available the causal relation of syphilis, showing that the liability of paresis of those infected was sixteen or seventeen times as great as that of non-syphilitics. Since then the statistical evidence has become much stronger.

It has been the custom to speak of tabes and paresis as parasyphilitic or metasyphilitic diseases, that is as derived from syphilis, but not the disease itself. Since the very recent discovery of the spirochete of syphilis in brains of paretics it is probable that these qualifying adjectives will soon pass into disuse, and these disorders be generally accepted as late luetic manifestations. The finding of Levaditi, Marie, and Bankowski of its presence in the brains in nearly ninety per cent. of the paretics examined after death in the acute convulsive exacerbations of the disorder is especially significant in this connection.

Admitting syphilis as the primary essential factor in the etiology of paresis, there still remain some questions to be answered. Syphilis is a common disease, but only a comparatively few syphilitics become paretics. Mattauschik and Pilcz found that in 4,134 officers in the Austrian army, infected with syphilis, during the years 1880 to 1900, only 198 became paretics, and 113 developed tabes, not counting those who later became paretics. Other investigators have obtained more or less similar ratios, and we can therefore estimate that at present not more than five to seven per cent. of those infected with syphilis acquire so-called parasyphilis. Just why the spirochete in most cases either fails to involve the nerve centers or confines its ravages to the meninges, and only in such a small proportion of cases insidiously attacks the deeper structures of the brain and cord, has not been demonstrated, but it is quite conceivable that it only affects the nervous structures under the provocation of certain predisposing conditions that make them specially vulnerable or when their resisting powers were originally impaired. Syphilis, like tuberculosis, is a specific germ disease, and also like tuberculosis, it may perhaps originate a predisposition and the offspring of syphilitic parents may be more liable to succumb to the later consequences of luetic infection. In this sense syphilis may be said to be a predisposing cause of paresis. The cases of juvenile paresis (and possibly of some later ones) are not altogether due to heredity in a proper sense of the word but are more likely direct effects of a prenatal infection. It is very probable that any cerebral weakness such as that claimed to exist by Naecke, would predispose to the disease in conjunction with other etiologic factors, but here we must take into account the almost infinitely numerous possibilities and protean manifestations of late syphilis of the nervous system. According to a very recent investigator (Stoll) over half the children born of syphilitic parents who survive infancy, give a positive luetin reaction. If this test is sufficiently reliable and his findings are confirmed by those of other observers, they might help to explain many cases without a personal luctic history.

Age has a certain obvious influence in the incidence of paresis. It is preëminently a disorder of the active period of life, most cases occurring between the ages of twenty-five and forty-five. This is the period of special stress upon the nervous centers, the time during which the brain is most taxed, and when overwork,

anxiety, exposure, and dissipation are making their drafts upon the nerve centers under the stress of modern civilization. After fifty, paresis is rare and while many cases have been reported in patients after sixty, the writer has never seen one that was clearly this disorder; certain cases of senile organic change in the brain cells often simulate paresis, and are probably responsible for some of the cases diagnosed in patients of advanced age. Juvenile paresis, occurring about the age of puberty or rarely earlier, is commonly, as said already, the result of congenital syphilis, and the stress of puberty may furnish the exciting cause.

Sex and occupation are also generally included among the predisposing causes of the disease. The great majority of paretics are males, but its increasing frequency among women is a common observation in more recent times. Women are less exposed to the exciting causes than men, and it is a noteworthy fact that in this country at least the majority of female paretics are married women, and a syphilitic history can sometimes be found and more often suspected in their married partners. Of the unmarried female paretics, many are prostitutes, who seem to be especially liable. Of three personally known to me, one was I believe, of this class, and one of the others had had an illegitimate child.

Certain male occupations seem to favor the occurrence of paresis, and they are the ones, as a rule, that conduce to irregular habits, sexual, alcoholic, etc. Commercial travelers, railroad men, speculators, men about town, etc., furnish a large proportion of all cases, while clergymen, Quakers, farmers, etc., furnish few or none. It is a disease of cities rather than of the country, where, though morals may not be always better, syphilis is less prevalent and life is simpler and less intense. Race in itself has probably very little to do with the etiology of paresis, though much has been made of the apparent exemption of certain peoples in the arguments against the syphilitic origin of the disease. It is not only the predisposing causes that are requisite, but also the exciting causes, and if either are lacking the disease is not likely to appear. Syphilis is common among the Egyptians, but paresis is rare; but there is little in their uneventful lives to cause the strain on the nerve elements that is required, and the fatalism of the Mohammedan is also a safeguard. While it is believed by many specialists that the Jews are less frequently affected with syphilis than those of any other race and religion, Beadles finds them in London specially liable to paresis, which he attributes largely to their trading and speculative tendencies. Many of them, moreover, come to that city from sections of Europe where syphilis is very common and one might say endemic, so that they do not necessarily escape special risks of infection.

Reviewing the predisposing causes of paresis, the first place must be given to syphilis; it is the one, indeed, essential cause. Heredity can be regarded only as a secondary and non-essential cause, and the others —age, race, occupation, etc.—are of importance only as related to the other two.

Exciting Causes.—The exciting or immediate causes of the nervous breakdown of paresis are numerous, but one stands preëminent; that is, mental overstrain and worry, including under these the stress and anxiety of business and the struggle for existence under conditions of modern civilization. The best proof of this is the fact that paresis is almost exclusively a disease of civilization and almost unknown among barbarians and populations living under simple conditions; it is a disease of cities, where the struggle for life is keenest, and rare in rural districts and away from the temptations and excitement that abound in the great centers. There are also direct evidences of the fact that mental strain is one of the chief exciting causes, if not the chiefest, in the personal history of paretics; anxiety, business worries, etc., are among the most commonly ascribed causes. As syphilis develops into paresis in only a small percentage of cases, some additional factor is required, and the last straw that breaks the back of the weakened nerve element in this disease is most often supplied by some mental strain, most commonly that of the class of which worry and anxiety are the types.

Alcoholic excess has been recognized as a cause from a very early date, and undoubtedly is an important factor in many cases. Its importance, however, has been exaggerated. Alone it seems to have been powerless in the past, when such excess was far more prevalent than in many regions where of late years paresis has made its greatest advances. In combination, however, with other factors, its influence is not to be underestimated, and it has been a precedent in a very large proportion of all the occurring cases. It is very natural to assume its action in producing the disease, since it is well known that a very similar though transitory clinical picture is sometimes produced by it alone. The chronic incurable paralysis with dementia of chronic alcoholism has in it also some suggestion of that of paresis, though the differences are wide enough to make the distinction between them easy.

Sexual excesses are another commonly attributed and no doubt an important cause. There is often a history of such excesses, but its significance is sometimes lessened by the fact that it is itself an early symptom of the disorder. Unless the history of sexual debauchery goes back over a considerable period of time, as it often does, too much weight may easily be given it as a causal factor. Mott, at least in his earlier writings, considers this element in the etiology very important; excesses of this kind, he holds, may deprive the brain cell of what is directly essential for its nutrition. By itself, however, it is ineffective. Lechery of the most abandoned and abominable type has always existed among men, and in past ages even more than in the present, but paresis is essentially a modern disease.

It was long ago noticed by Fournier and others that paretic symptoms were apt to follow the milder and neglected cases of primary syphilis; this observation has been since generally confirmed, and it has even been suggested that a florid syphilis tended to furnish an immunity to the later metasyphilitic disorders. At present, there seems to be a tendency with some syphilologists and neurologists to suspect the existence of a special strain of the spirochete of syphilis that attacks the nervous centers. The apparent long incubation and the special features of its pathology and some serologic findings somewhat support this contention, but it has not been proved as yet. The resisting power and defenses of the brain are a factor to be considered. Cases with the clinical picture of paresis occurring after recent syphilis or in connection with its secondary or tertiary manifestations are classed by some as syphilitic pseudo-paralysis, a term introduced by Fournier, but practically discarded by him in 1894. It is customary with many writers to point out diagnostic features of this type as distinguished from true paresis, some of which at least are certainly fallacious, and none according to the writer's experience absolutely reliable. It does not appear, however, to him that there is any impossibility or improbability of the genuine disorder appearing after recent luetic infection, unless we can show the impossibility or unlikelihood of the special disorder of nutrition of the nerve elements which we consider the essential lesion occurring except after a lapse of years. Cases do occur with every symptom characteristic down to the resistance to treatment and the fatal outcome, in connection with comparatively recent syphilis, and the most natural course is to recognize them as true paretic cases. It seems therefore correct to include syphilis with other commonly recognized exciting causes such as trauma and sun-

stroke, but there is generally back of these last some other well-marked factor, and usually, if the facts can be ascertained, a luetic history.

The etiology of paresis or general paralysis is one of the most important subjects in connection with the disease: hence the space here given to it. The disease, so far at least, has always been practically incurable and fatal. Prophylaxis is the only real defense, and this depends upon its etiology. It can now be said that it has always had syphilis as its essential antecedent. In most cases this seems to act very slowly and insidiously and paresis usually manifests itself as apparent effect of other active causes, usually after the lapse of years. These later factors may be various, but among them and probably cooperating in nearly every case is the element of mental stress, either as overwork, worry, or the excitement of the demands of modern civilization generally acting on the weakened nervous organization. Heredity, except as hereditary syphilis in juvenile paresis, probably plays only a subordinate part—less, indeed than in other forms of mental disease. We cannot altogether neglect, however, the possibility of all the factors together working on the heredity of the race and producing a class of more easy victims of the disease. There may be something in Naecke's supposition of a congenital brain weakness tending specially in this direction.

Symptomatology.—It has been already remarked that paresis is a protean disorder. Its beginnings are insidious; as Regis says: "There is perhaps no disease that begins more gradually than general paralysis. Except when it begins with a congestive ictus its invasion is so gradual and insensible that it is almost always impossible to fix its real commencement, and its origin is lost, so to speak, in the darkness of the past." It is unusual to find the earlier manifestations reported in the histories, and at best it is the rule to obtain only vague impressions or indistinct recollections of facts. Sometimes, as intimated in the above quotation, the first thing noticed is a maniacal, convulsive, or apoplectiform attack; but it is probable that in some of these cases there was a gradual deterioration preceding the insult, which passed unnoticed even by friends and intimates. It has been customary in text-books to describe three stages of typical paresis: the preliminary or incubatory stage, the stage of active bodily and mental symptoms, and that of final paralysis and dementia. To a certain extent this division is justified, but the cases of abnormal course in which these stages are not clearly defined are so numerous as almost to invalidate the rule. In a very large proportion, however, there is a period in which the disorder is only partially developed though it has a wide range in its symptoms. As a rule, the very earliest beginnings, as already said, are little noticed even by the patient, himself, and sometimes the fully developed stage of the disorder seems to break out without any prodromal symptoms whatever. The first symptoms are perhaps as often as not indistinguishable to the observer from those of neurasthenia. The patient feels himself somewhat incapacitated, his memory is less acute, power of sustained attention is lessened and generally his capacity for mental exertion is diminished, he complains of nervousness, sleep may be unsatisfactory, he may complain of obscure neuralgic or what he takes for rheumatic pains, headache is not uncommon, and most authorities mention it as occurring especially in the frontal and vertical regions. There is apt to be some mental depression and occasionally something like a mild melancholia which may shortly pass off in these earlier stages. Incipient paresis may perhaps account for some otherwise unexplainable suicides. The system often seems to the individual generally out of sorts, there may be dyspeptic symptoms and constipation, or other irregularities. At first the incapacity is noticed only under stress of work, but after a longer or shorter time it becomes so constant and prominent that he may give up work or have to abandon it. In some cases there are spinal symptoms resembling those of locomotor ataxia, girdle sensation, and occasionally actual ataxia and pupillary symptoms or other ocular paralyses appear at this stage, to disappear later or to become less conspicuous with the advance of the cerebral disorder. Tabo-paresis beginning with these symptoms is now a well-recognized type of the disease. Berkley specially cautions practitioners as to their diagnosis of neurasthenia in a patient in middle life who presents reflex pupillary disturbances. Anisocoria, which in the developing or developed stage of the disorder is a frequent pupillary symptom, may appear in normal individuals, so that its special significance by itself is not so great as that of some others. An absence of the light reflex, the so-called spastic myosis, is far more significant but is not so prominent to the casual observer. The pupils are small, the reaction to light is absent or sluggish, and this symptom may be one of the earliest of all to appear. The alienist or even the physician in general practice so rarely has the opportunity to observe the earliest precursory phenomena that it is well to bear this symptom in mind. Still more significant is the Argyll-Robertson pupil in which the light reflex is lost or greatly impaired, while the convergence and consensual reflexes still occur. This is characteristic of paresis and tabes and may be a very early symptom. I think it is very generally seen in tabo-paresis. Distortion of the pupils is also sometimes observed as an early symptom. Other facial signs noticed in the beginning are occasionally a peculiar lack of expression in the features, hard to describe but quickly recognized by an experienced eye. There seems to be already a partial paralysis of the muscles of expression not analyzable into defects of special muscles, but rather uniformly involving all. This becomes marked in the later stages of paresis, but sometimes may be detected early. The reflexes, tendon and cutaneous, are apt to be exaggerated in this early stage, at least in the purely cerebral phase of the disease, but this is in accordance with the neurasthenic type prevailing. A fine tremor may also exist in this preliminary stage, though it is not often remarked till later, when it becomes a prominent feature.

The earlier mental symptoms of the prodromal period are also of the neurasthenic type—inability to perform mental labor, lack of power of sustained attention, defects of memory noticeable in little things, and in recollection of recent events, etc. The intellect may be apparently clear on most things and the patient be conscious of his slips of memory and other defects, and consider himself only a victim of nervous prostration. There is marked increase of irritability as a rule at this time, and, what is of some significance, a degree of moral defect is occasionally very evident, sometimes showing itself in a neglect of the minor proprieties of life, but often also in an apparent loss of moral inhibitions in higher matters. The tastes may change, and the individual, from being refined and fastidious, may take up coarse indulgences, become careless in habits and gross in his appetite, vulgar in speech, and sometimes show a decided sexual depravity. The altruistic emotions, family affections, etc., may be noticeably impaired or lost, and a disgusting egotism be manifested in many ways. The upright honorable man of business may become utterly unreliable and tricky, and the sedate father of a family indulge in undignified and open immoralities—all this before there have been enough other symptoms of intellectual or physical derangement to cause their friends to suspect their real condition. This is, however, not always the case; the moral lapses may be slight, and only the gradually advancing general weakness or neurasthenic symptoms call attention to their disorder. Sometimes only the minute but important physical defects in manual dexterity are

the chief ones noted; we have seen a stenographer affected with incipient paresis in whom, aside from a decided emotional depression, an inability to take notes accurately and quickly from dictation was almost the only noticeable symptom of this entire stage.

The emotional depression mentioned above is a common feature in many cases, and may be, as said before, taken for a sort of neurasthenic melancholia, the depression masking the other symptoms. Sometimes the mental disturbance is hypochondriacal in type, and this may extend well into the later stages after the physical symptoms are well advanced. There is every variation in the degree of intellectual impairment; in some exceptional cases it may seem to be slight even late in the disorder, so that a general paralysis without dementia has been spoken of by some writers. As an almost universal rule, however, mental defect to a greater or less extent is detectable on careful observation even in the earlier stage, and is the characteristic feature throughout the disease. It shows itself in the fatuous business projects, the confusion of ideas, the lapses of memory and propriety. It is also seen frequently in the writings, which sometimes show characteristic traits of mental failure, not only in their substance but in dropping of words, or letters, incomplete sentences, etc. They may also give evidence of the physical breakdown in a fine tremor which is characteristic even in this early stage, as already mentioned.

The Developed Disease, First Stage.—The transition into the second stage (first of some authors) is usually gradual and the distinction between the two not always marked. We may say that a good landmark showing the full onset of paresis is to be found as much as anywhere in the alteration of speech. When this becomes noticeably or even slightly embarrassed in the pronunciation of words demanding the use of the labials and dentals, the condition is recognizable by any one with the slightest experience. It is not only the difficulty of producing certain articulations, but a general defect of coordination of speech muscles that causes a peculiar thickness of utterance noticeable in any attempt at articulation. The patient will have special difficulties with some sounds, words like "National Intelligencer," "Peter Piper picked a peck of pickled peppers," etc.; he will stammer and fail and try to repeat, but the pronunciation of all words will be also affected. There is a defect of coordination of the muscles involved, together with a partial paresis, central in its origin. This symptom varies in extent in different patients; in some the speech alteration may be comparatively slight, but it is sufficiently frequent to be characteristic, and can be detected in some degree in nearly every case.

The muscles of expression are still more involved than in the prior stage, and irregular twitchings and local paralyses, lasting or temporary, are observed. There may be ptosis, one side of the face may be more affected than the other; tremors of all the facial muscles and of the limbs are characteristic of this stage. Manual dexterity is apt to be lost or very much impaired in special acts, such as those required in a trade or in the arts, all on account of the loss of coordination of the finer cerebral mechanisms. The muscular power in itself is not so much impaired as is the controlling power. The patient may feel well, all the bodily functions may be carried out, sleep, appetite, digestion, and excretions be normal or apparently so, for a considerable period after this disorder has thus fully developed; the reflexes differ little from those of the initial stage—that is, they are variable, the neurasthenic exaggeration may continue in the deep reflexes, or they may be diminished or lost. The pupils are unequal in a very large proportion of cases at this period, and may continue so to the end; in other cases there is myosis, such as is common in the earlier stage. In some cases the Argyll-Robertson reaction is marked. There is no regular febrile movement, the temperature may be about normal, except in connection with some accident of the disease, convulsion, or apoplectiform attack.

In a few cases ataxic symptoms precede the outbreak of paresis, as already mentioned, and they may occasionally appear in this earlier period of the fully developed disease. Their early occurrence and subsequent disappearance seem not to have been noticed by the earlier writers; the tabetic type has been generally recognized only of late years. Its comparative rarity accounts in part for this, and the fact that the tabetic symptoms are probably prominent only in the earlier ante-asylum stage is sufficient for the rest. It is, in fact, not of special importance, except as showing the relationship between the two disorders, paresis and tabes. Out of nearly 250 cases under the writer's hospital observation, definite tabetic symptoms occurred only in three, though it is possible the number might have been increased had full data as to the earlier manifestations been obtainable. In this form or stage—the ascending spinal type—the knee reflex is absent.

The congestive or apoplectiform and convulsive attacks which may occur, and which as previously stated may be sometimes the earliest manifestation, are most frequently seen after the paresis has fully developed. The apoplectic insults are less frequent than the convulsions, and, as a rule, more serious. Their onset is sometimes similar to an ordinary hemiplegic attack, though the unilateral paralysis is not always complete. There may be no loss of consciousness. A more characteristic paretic type is one in which the patient becomes suddenly or gradually comatose, with hot skin, stertorous respiration, and this leaves behind it a temporary paralysis of one or more members and generally a permanently more or less deteriorated mental condition. Or there may be only a temporary coma or somnolence of varying duration without very appreciable sequels; there is no regularity in the type or the results. I have seen a patient hemiplegic on one occasion and only aphasic on another, each time for the space of a few hours, but appreciably worse mentally after each attack. Occasionally these attacks are serious, and death may occur in the first seizure both of the congestive and the convulsive types.

The epileptiform attacks may occur singly or in rapid succession; the latter is a frequent type in the later stage of the disease. In either case they are often very similar in their appearance to those of epilepsy. They may, however, be fatal, and are usually followed by an aggravation of existing mental and bodily symptoms.

The mental symptoms of the fully developed stage are a continuation of those of the later prodromal period. Usually before the physical signs of the developed disease have become well marked, the extravagances of conduct and of advanced dementia and evident delusions have made the insanity manifest to friends and the public. In fact, the mental often precede the physical symptoms. Some patients pass gradually into an active delusional insanity with comparatively slight physical symptoms, others have some of the bodily symptoms very pronounced with apparently little intellectual impairment. Most patients, however, after the speech defects have become permanent or after a period of months, or it may be of years, of the condition described as the preliminary stage, begin to exhibit an intensification of their mental symptoms. The tendency toward dementia becomes evident, and a peculiar delusional type is often developed, there are grandiose ideas of wealth, personal ability, etc. These may have existed before to some extent, but they now become conspicuous, and in the beginnings of this stage the mental state may closely resemble that of acute simple mania. With the abnormal excitation of the faculties, however, there is a more pronounced element of mental weakness and confusion than is the case with the acute maniac.

Later, as the bodily symptoms develop, the dementia is more prominent, the mental activities take on the delusional form, and the extravagance of the patient's fancies is uncontrolled by any element of reason or recognition of possibilities or probabilities. It is not usual in this stage to see fixed and consistent paranoic conceptions, though in some instances such occur. In the majority of this type of paretics the delusions are unsystematized—they are the expression of the exalted self-consciousness of the individual and the advancing incapacity to recognize the true relation of things. These patients are possessors of billions of dollars, have mines where coined double eagles are dug out by the ton, are husbands of thousands of wives, own all the railroads, are the greatest orators and authors, have converted millions by their sermons, etc., all given out as gospel truth in rapid succession it may be by the same individual. This unsystematized and extravagant character of paretic delusions is a feature of the disease in so large a proportion of the cases that it has been held and is still often considered to be the special characteristic of the disease. More frequently, however, at least of late years, other types of mental disturbance are observed. In a large proportion of cases this is of a depressed type throughout, and sometimes a hypochondriacal extension of the neurasthenic depression of the earliest phase. These patients may show a mental weakness only and a general tendency to exaggerate and invent morbid feelings; any slight ailment or injury disturbs them unduly and is sometimes the direct occasion of an outbreak of delirium. In other cases there are the self-accusatory delusions and feelings of unworthiness, as in melancholia, which is strongly suggested; and in still others only a progressive dementia from the beginning to the end of the disease. Occasionally paresis assumes a circular type of alternating excitement and depression, and there are cases in which fixed delusions resembling those of systematized delusional paranoia occur and continue throughout a considerable period. I have seen a paretic who for five years remained in a stationary condition with fixed moderately exalted delusions, pronounced visual hallucinations of angels, deities, etc., a rather prominent general dementia, speech disturbances marked, pupillary inequality, and a generally good physical state as regards nutrition, the digestive functions, etc. Then he rapidly passed into the third stage, became paralytic, and soon succumbed.

It is difficult to estimate the proportion of paretics in which the disease assumes the exalted and the depressed or demented types; but while the former is usually considered the most typical, it is certainly not the most frequent. The demented type, in which the mental symptoms are predominantly those of steadily progressive mental failure, is perhaps as frequent as any; Kraepelin estimates that it includes over forty per cent. of the cases according to his experience, while the exalted form includes only fifteen or sixteen per cent., or, taking in the more acutely maniacal cases which he classes as the agitated type, about twenty-six or twenty-seven per cent. The depressive type he finds to occur in about twenty-seven per cent. of all cases. The purely hypochondriacal and the circular cases and those with only comparatively slight intellectual disturbance even with marked physical symptoms form a still smaller contingent, but they exist as a class and may be reckoned according to the writer's observation as forming two or three per cent. of the whole. The difficulty in any classification is the large number of cases in which the symptoms are at one time of one type and at another show a quite different aspect, so that it is not easy to say in just which class they belong. In women these irregular forms are proportionately more frequently observed than in men, but the number of female paretics observed by me has been so small that a positive generalization is hardly justifiable.

Sensory symptoms may occur at all stages of the disease after it has once developed. Anesthesia and analgesia are not uncommon in advanced cases, and various paresthesias may occur in the earlier stages. Disorders of special senses are common, especially of smell or taste; depraved appetites are often observed. The sexual appetite is sometimes exalted in the excited cases, seldom so in the depressed, and rarely if ever in the progressive dementia type (Marandon de Montyel).

Hallucinations are not so prominent in paresis as in some other forms of insanity, but they occur in a considerable proportion of all cases. In the agitated type of either expansive or depressive delusion they are apt to be manifest. In the agitated depressed cases visceral hallucinations are comparatively common, the patients complaining of having cats, dogs, reptiles, etc., inside them, and in women delusions of pregnancy are aroused. Sometimes visual and auditory hallucinations are also common, but are not so strikingly frequent, except in the delirious attacks.

A not very uncommon feature in the fully developed stage and sometimes beginning it are the occasional attacks of acute maniacal excitement, usually of short duration, but sometimes prolonged over days and even weeks. They may occur suddenly in the night or in the day, and suggest the psychic equivalents of the epileptic. It is quite possible that the mechanism is the same, that they are the equivalents in a sense of the apoplectiform or convulsive attacks, symptoms of special cortical explosions, only that here the objective manifestation is psychic in its character. Like the convulsions or congestive attacks, they are likely to be followed by a usually permanent psychic deterioration —they accelerate the progress of the dementia.

Of quite a different character are the attacks of acute delirium that occasionally occur at any stage of the disorder. They are sometimes incited by apparently a trivial cause, such as a slight traumatism in the hypochondriacal cases, but they form one of the most formidable complications when they occur. The patient passes into a wild maniacal delirium, often with hallucinations, his bodily activity is incessant and violent, food is refused, insomnia is nearly absolute, sleep being only in snatches from exhaustion, the bodily temperature rises sometimes to an extraordinary height—in a case observed by the writer it was 107° F. in the axilla through the shirt several days prior to death. Toward the close of the scene it falls again as the vital powers fail and the patients succumb to exhaustion, and the rectal temperature may even be below normal some time before death. In some cases, in which the symptoms are less severe, the patient may survive, but like other forms of acute delirium it is generally fatal. When it occurs early in the disease, as it sometimes does, it may form the basis for a diagnosis of "galloping" paresis, some of the reported cases of which are probably examples of this condition. It may be said here that rapid cases of paresis are not confined to this or to any agitated type, as the convulsive or apoplectic attacks may be fatal almost in the earliest stages of the disease.

Remissions of the symptoms may occur at any time prior to the appearance of complete dementia, and last in some cases for years. Sometimes these remissions are so complete as to suggest recovery, and cases have been reported as such. More often there is a check to the progress of the disease, which still manifests itself in some ways; the patient remains in a stationary condition, and one that in itself alone might not suggest paresis. The longest continuous remission of this kind personally observed by the writer was about five years, which is much above the average, though cases of much greater duration have been reported. After the third or final stage has appeared, remissions are hardly to be looked for.

The passage from the second to the third stage of paresis may be sudden or gradual. Generally, sooner

or later, in the second stage, the mental failure becomes more marked and rapid, the paresis more pronounced. The patient becomes neglectful of the ordinary decencies with the advancing dementia, and the third or final stage may be said to have begun. The dementia and the paralysis, however, do not by any means progress *pari passu;* in some patients the dirty habits precede the physical symptoms, and *vice versa.* In the typical form this third stage is characterized by the aggravated speech defects, increased feebleness and incoordination, marked failure of mentality in all respects, as well as by the untidiness. Symptoms of cortical irritation are more frequent, the convulsive and congestive attacks become more frequent and also often more severe, with correspondingly more rapid advances in mental and physical deterioration, tremor becomes more marked, and such symptoms as grinding of the teeth, localized spasm, contractures, etc., are frequent, and the former may be almost constant, nutrition fails, trophic disorders such as bedsores, ulcerations, buttock sloughs, hematoma, arthropathies, fragility and fractures of bones, etc., make their appearance. Deglutition is embarrassed, and special care has to be taken to prevent choking from food. Any or all of these symptoms may coexist, and the final stage of all cases which are not carried off earlier by the cerebral crises, accidents incident to the condition or by intercurrent disease is a gradually failing vegetative existence, ending in death from final gradual exhaustion of nerve centers, with cardiac and respiratory failure or disease of lungs, kidneys, digestive tract, etc.

The average duration of a case of paresis is about three years from the date of first recognition of the patient's aberration, but it varies between very widely different extremes. The preliminary stage may extend over years, while long remissions or periods of non-progression may lengthen out any stage of the disorder before the final general physical breakdown.

Diagnosis.—In the fully developed stage of paresis there is little difficulty in the clinical diagnosis, particularly if the characteristic speech alterations and the peculiar facies which becomes familiar to all who have to do with these cases are present. It is in the earlier stage, when the physical symptoms are less developed, that the difficulty exists. The disorders that are then likely to be confused with it are neurasthenia—itself a protean affection—simple mania, and circular insanity. It is usually said that the moral deterioration as well as the actual mental deterioration is sufficient to distinguish the early stages of paresis from neurasthenia, but this is a hardly reliable test for all cases. There are incipient cases of paresis in which the moral and esthetic sensibilities are not so obviously impaired, and cases of neurasthenia in which there are actual defects of memory and conditions of mental incapacity that might lead to error. It is not always possible to distinguish beyond question in the earliest beginnings the symptoms of the irreparable changes in the nerve cells from those of the less serious disorder. There is usually, however, a less serious aspect to the depression symptoms and a more gradual development in neurasthenia. The prior history aids in the diagnosis; in paresis the symptoms appear in a more sudden manner and in all cases time soon reveals unmistakable distinctive characters in the earlier physical symptoms, the abnormal pupillary reactions, the tremor and changes in the facial musculature, and the usually graver nature of the mental defect. Simple melancholic depression may sometimes be simulated for a short time, but simple maniacal excitation or hypomania, or still more the excited stage of circular insanity, is liable to cause mistakes. The type of mental derangements in some cases of hypomania and circular insanity is very similar to that of the exalted phase often observed in incipient paresis, and the circular type of the latter is sometimes even still more confusing. I have in mind a noted case of circular insanity who had been pronounced a paretic several times by alienists of experience. Here also the element of time aids in the diagnosis; the circular cases do not show the progressive dementia or the physical symptoms as they do in the circular form of paresis.

The organic brain disease of arterial sclerosis or atheroma is another condition that has, in the writer's opinion, given rise to more erroneous diagnosis of paresis in the past than any other. The clinical symptoms may closely resemble those of paretic dementia, using the term in its strictest literal sense. The transient congestive or convulsive attacks, the gradually advancing mental failure, the motor symptoms, and even the peculiar speech defect may to some degree be intimated, though the latter is seldom a perfect reproduction of paretic speech. The pupillary reflexes are also less characteristic, and the age and history of the patient usually clear up the diagnosis. Many cases of paresis in individuals over sixty years of age, however, have been reported, and I am inclined to think that many of them were really cases of senile organic dementia. It is in such cases, as well as in the neurasthenic ones that the serologic tests when thoroughly applied will render the greatest service. If, with the clinical symptoms, the Wassermann, the globulin and luetin reactions, and especially the Lange gold chloride test with the spinal fluid are positive, the diagnosis of paresis can hardly be questioned. Occasionally a case of this kind takes on the galloping form of acute delirium, thus rendering the resemblance more striking, and in most cases, though not in all, the prognosis is not much better than in true paresis.

Various toxic agents, alcohol, lead, arsenic, and the toxin of pellagra now and then produce syndromes like that of paresis, and lead to mistaken diagnoses. The terminal paralysis in some cases of chronic alcoholism has sometimes a strong suggestion of the demented type of paresis, though there are characteristic differences. A temporary condition very closely resembling certain phases of paresis caused by this agent is well known. In some cases of chronic lead poisoning there is a close resemblance to paresis. Regis classes this among the pseudo-general paralyses, and finds it often only temporary and curable. It has, he says, a more rapid onset and course, and the symptoms, however severe, are apt to disappear with the elimination of the poison. Syphilis, however, must be excluded in these cases. Personally I have observed at least one case of chronic lead poisoning with some of the features of paresis, which was diagnosed as such by a skilled alienist. The patient died in a convulsive attack. The macroscopic appearances of his brain were not unlike those of paretics and there was also an interstitial nephritis. So far as the diagnosis between this and the usual form is of any importance, it can be made, as a rule, by the history and usual symptoms of plumbism.

Very much has been written in regard to the diagnosis between syphilitic brain disease and true general paralysis. It has been said that the former can be distinguished by the irregularity of its course, the character of the ocular muscle palsies, differences of speech disturbance, and character of the delusions; the sensory symptoms, headache, etc., are said to differ; optic neuritis is early and acute; and, lastly, it is claimed that the syphilitic disease yields to specific medication which is ineffective in paresis. Much importance is also attributed to the time element in the diagnosis—cerebral syphilis may occur soon after infection while paresis is claimed to be a later manifestation requiring five years and often a much longer period before it is recognizable clinically. These are only some of the differentiating points alleged to exist between them. It may be that hereafter less stress will be laid on the points of difference, distinguishing cerebral syphilis from paresis since it has

been proved that the latter is itself a form of active lues, and the spirochete has been caught in the very act, so to speak, in the cerebral crises of the disease. Plaut's law (blood Wassermann +, and spinal fluid weak or −) does not seem to be universally applicable and still more refined serologic methods also appear undecisive. Dunlap has called attention to the difficulty sometimes met with in differentiating cerebral lues from paresis and others will probably agree with him that there is no clear borderline between the two. The later appearance of paresis and the serologic tests (none of them pathognomic, unless it be the "paretic curve" of the Lange test) make a distinction practically, and one somewhat encouraging sometimes for prognostic purposes. When, after recent syphilis, we have as far as possible the complete syndrome of paresis, and as resistant to specific treatment as is paresis, it seems to me useless to venture a distinction between the two. It is not necessary or even reasonable to assume that the toxin of recent syphilis may not affect the cortical neurons under favoring conditions so as to produce the disease that the same toxin favors after a lapse of years. Bianchi claims that he has seen many such cases. True paresis may possibly have its beginnings sometimes with tertiary or even with secondary syphilis, and a gumma of the base be found simultaneously with the incipient paretic changes in the convexity. Of course there may be a diffuse, cortical, brain syphilis that will not become paresis, but when the clinical picture of the latter exists and the condition consistently follows its course, there is no reason for calling it anything else.

The other disorders commonly mentioned as liable to be confused with paresis, such as multiple sclerosis, cerebral tumor, etc., require but brief notice. In multiple sclerosis we have the intention tremor, the quite different character of the speech defect and gait, and the lack of characteristic mental symptoms of paresis. It is very rarely that a brain tumor alone presents features that would lead to a diagnosis of paresis, though a localized focal paresis (Lissauer's paralysis) may simulate brain tumor. It is in distinguishing the non-luetic conditions that the serologic tests are most valuable and they now are essential in all cases.

The importance of the diagnosis of this disease is chiefly in its earlier stages, especially in the earliest or prodromal stage. This is not so much for the possibility of successful treatment, which is remote at the best, but on account of the need of control of the patient before he can do harm by his extravagances, and occasionally this has a forensic importance. The paretic, in the incipient stage, may seriously involve himself or friends and may impose upon others to their disadvantage. It is advisable that insurance examiners, especially, should be posted on its earliest symptoms and indications.

Prognosis.—The outlook for a paretic is bad in all respects. Sooner or later, and generally within a few years after the recognition of his disorder, he succumbs either to one of the complications incident to his condition or finally to the exhaustion or marasmus of the final stage. A paretic's life is far more uncertain at any stage than is that of victims of most other forms of insanity, and there is no time when a sudden and fatal aggravation may not occur. Nevertheless, there are now and then instances of a stay or remission in the disorder, and sometimes even a marked improvement, so that the patient is able to return again for a time to his former associations and occupations. Remissions—almost complete intermissions—lasting many years, even twenty or more, are sometimes reported and there is a non-progressive type of paresis in which the disease may show no change for over thirty years and which the pathologic conditions are those of true paresis (Alzheimer). Cases of cure have even been reported, some of them probably based on these remissions. The characteristic of the disease, however, is its fatal progressiveness, and all reported cures should, as Kraepelin remarks, be looked on with suspicion. While it may be possible that cures have occurred, they are so rare as to make the probability of one in any given case altogether a negligible quantity. The disease may be set down, in the present state of our knowledge and therapeutic resources as almost inevitably fatal.

Pathological Anatomy and Pathology.—In cases of paresis in which an autopsy is afforded in the early stage of the disease by deaths occurring from convulsive or congestive attacks or other accidents, the chief macroscopic appearances are those of a chronic meningoencephalitis often modified to some extent by the immediate conditions preceding death. Thus, for example, if the patient has succumbed very early from convulsions, or specially if an attack of acute delirium has preceded death, the gross appearances of the brain may be more or less those of an acute meningoencephalitis with foci of intense congestion and hemorrhages. Ordinarily, however, the appearances are characteristic; there is marked congestion of the membranes and cortex, often localized more prominently in one hemisphere and generally most marked in the anterior and middle regions of the convexity; there are distention and tortuosity of the pial vessels, the membrane itself is thickened and opalescent or milky, and the cortical substance in certain regions, especially along the median fissure anteriorly, is apt to be adherent to the membranes and these to the cranium, so that in removing the calvarium it is sometimes almost impossible to avoid tearing away portions of the brain over the summits of the convolutions. This is almost sure to occur in separating the pia-arachnoid. The dura itself is sometimes largely adherent to the inner cranial surface, and the Pacchionian granulations are often excessively developed. There may be subdural hemorrhagic foci or cysts, especially in cases that have lasted for some time with symptoms of the developed disease, and in advanced cases a wasting of the cerebrum with atrophy of the convolutions, and the adhesions of the membranes and cortex are less noticeable. The cranium itself may be thickened in these older cases. The ventricles are liable to be dilated and often granular on the ependyma. The white matter of the centrum ovale is congested, dotted with minute bleeding vessels, the thickened walls of which can sometimes be felt like bristles on passing the finger over the freshly cut surface.

The macroscopic lesions affect particularly the frontal and central regions and the hemispheres rather than the occipital and basal portions and the cerebellum. Orton, however, finds the hippocampal region affected next in frequency to the frontal. In juvenile paretics Mott found the left hemisphere weighing less than the right, a fact which he thinks has a bearing on the theory of overuse or stress as an exciting cause of the disease. In paretics generally the region of the brain most subject to stress is that most often atrophied. Edema of the brain is another common and striking feature in some postmortems of paretics.

The microscopic alterations in this disorder involve the membranes and all the tissues, the nerve cells, the neuroglia, and the vessels of the brain, as well, as the nerve fibers of the brain and cord and even the peripheral nerves. Together with the lesions of pachymeningitis and the leptomeningeal framework of the pia-arachnoid with the various attendant vascular alterations, there are still more important changes in the brain substance itself. There are marked vascular inflammatory changes which in the acuter forms may be most intense. In the cases of galloping paresis not only the cortical, but the basal finer arteries in the pons and elsewhere reveal a very marked periarteritis, while externally the lymph spaces are extensively in-

filtrated with the so-called plasma cells (modified lymphocytes) and lymphocytes clinging to the vascular walls, and there are minute extravasations throughout the nerve substance. To a certain degree these appearances are characteristic of all comparatively recent cases of paresis, though not so marked as in the hyperacute form. In the older cases we have a decided increase of the blood-vessels, with thickened walls and occasionally minute aneurysms, relics of old microscopic hemorrhages, patches of softening, etc. In the nerve cells themselves, very marked changes are met with, though these may not be so prominent in the earliest stages of the disorder. The fibrils of the ganglion cells are degenerated especially within the cell body. "They are sometimes thickened, either from swelling or sticking together of several fibrils, or in short heavy broken pieces and fine granules disintegrated. There is no marked thinning of the intercellular fibril network and the destruction of fibrils appears to be more marked in the external layers than in the internal layers, and the very finest fibers are affected." (Alzheimer.) According to Alzheimer, the nerve cell changes are not especially characteristic; "the only changes in the fibers of the ganglion cells in general paralysis which would differentiate the disease from many others * * * * * * are a peculiar rotting of the process and disintegration of the fibrils." The degenerative changes usually localized to a large extent, and the pathologic appearances described may be apparently absent in other cortical tracts, at least until the later period when the morbid changes have involved the brain generally.

The nerve fibers also suffer with the nerve cells, and in the later stages of the disease the degeneration may involve the greater part of these in extensive cortical regions and be traced down to the basal ganglia and the medulla. A peripheral neuritis in paresis has long been observed, and the spinal implication has been studied particularly of late years, especially with reference to the relations with tabes. These relations were noticed or suspected many years ago by Türck, Horn, Spitzka, Kiernan, and others, and their recognition has recently become quite general, especially since statistical studies have made evident the common specific etiology of the two disorders. It is probable that, as Fuerstner says, there are few cases of paresis without implication of the cord, but the fact that it has not heretofore been the general custom to examine it as carefully as the brain has prevented its being so universally recognized. In the tabetic cases the lesions may be those characteristic of tabes or primary degeneration of the posterior root fibers and posterior column sclerosis, but the spinal cord tracts affected need not be and are not always the same as those in tabes.

The neuroglia is also involved, there is proliferation of the spider cells, the processes of which form a tangled mesh, and in some portions, especially the internal and external limiting layers of the cortex, this is particularly noticeable, the more so from the more or less complete disappearance of the normal nerve cells in these parts. With this sclerosed condition the cortex is sometimes reduced to half its normal thickness. Along the vessels also, with the plasma cells, appear the elongated rod cells which Alzheimer in later writings considers largely of glial origin. Their presence in large numbers in the perivascular infiltration is characteristic. It is this general perivascular infiltration with plasma cells that is the most significant picture in paresis, which can be excluded if it is not found. (Alzheimer.) It is present, though usually to a slight extent, even in the stationary type. Every portion of the nervous system is liable to be affected in this disease, the changes varying according to the situation and the function of the part. Secondarily to the nervous lesions we have the possibility of any and every other organ being affected, and some of the important viscera are, as a rule, more or less involved. The kidneys are very commonly found disordered, there may be gastric or intestinal lesions and cardiac or pulmonary complications are common. Characteristic changes have been found in the cerebellum in cases of so-called hereditary (juvenile) paresis; abnormally formed and double nucleated Purkinje cells and swellings of their processes. Developmental defects—anatomical anomalies of the cord and brain—have also been observed in these cases.

The question whether paresis is primarily a disease of the nerve cells itself or of the vascular system has been extensively argued in the past, and at the present time the weight of opinion seems to favor the view that in this disease, as in tabes, the primary lesion is in the degeneration of the neuron, that it is primarily a parenchymatous rather than an interstitial disorder, with secondary inflammatory conditions of the vessels and tissues generally. Either view, however, is consistent with the toxic origin of these disorders; it is perfectly supposable that in the more acute and rapid forms the vascular involvement may be simultaneous with or locally precede that of the nerve substance, while in other cases, especially those of the late developing type, the damage to the neurons may have been primary. Since we know the toxin is that of syphilis, we know that it may lie latent in the organism for long periods, to be finally wakened into action by various exciting causes, or it may act violently on the nervous system very soon after its introduction into the body. We know very little of the earliest changes of paresis and it is possible that we might find by thorough search of the histories in some cases facts indicating early vascular disturbances long antedating the characteristic paretic symptoms.

In tabes the process is a similar one, and the relations of the two disorders are coming to be generally recognized. Their differences are essentially due to the different portions of the nervous system primarily involved—in paresis the cerebral association system and in tabes the exogenous afferent spinal neurons are involved. The selective action of the luetic toxin is exhibited in both, and, as already noted, they not infrequently appear to be combined or to follow one another in the same individual. In each disease the parts first involved appear to be those subjected to special strains—in paresis the cortical neurons from worry, alcoholic or other excesses, overwork, etc.; in tabes the spinal sensory neurons from similar causes affecting the cord, the strain of special overwork or equilibrium, sexual excess, exposure, etc. In each we have the specific pupillary reactions, the meningeal thickening, interstitial sclerosis, and wasting of the neurons. The pathological resemblances are certainly close enough to suggest a relation between the two disorders, and, taken in connection with the known facts of their etiology and course, the belief in their essential identity is certainly strongly favored, if not absolutely confirmed.

Treatment.—Inasmuch as paresis, at least when fully developed and in asylums, is practically an incurable disease, the treatment is mainly palliative. It may be that, could it be taken in its very beginnings, there might be some hope of cure; but the opportunity is seldom afforded. Our treatment of nervous syphilis, however, is undergoing a change, new and more effective methods have been devised and it is perhaps not too much to hope that they may be more successful in this seemingly hopeless disease.

If a safe and efficient spirocheticide that can reach every part of the nerve centers is obtained, it would seem a cure might be possible. The long and approximately complete remissions that occur would suggest this. At present the autoserosal-varsan treatment of Swift and Ellis with its more recent modifications appears most promising. In any case the special treatment should be supple-

mented as far as possible by vigorous general antisyphilitic measures. A judicious use of hydrotherapy, baths, prolonged and otherwise, adapted to the case, and carefully administered and watching the effect, has been useful, and in some cases has apparently produced long remissions of the disease. Baths are of course an essential adjunct to the treatment, and strict cleanliness must be secured, especially in the demented conditions. In any case, on general principles, it is advisable to protect the patient as much as possible from any effects of intestinal intoxication. Tonics, heart stimulants, hypnotics, local remedies for bedsores, etc., all may come into play in the various stages of the disease to meet occurring conditions. Drugs usually fail to do much good in the acute delirious attacks, but sedatives should be tried with due precautions. In the paretic status epilepticus injections of chloral or hypodermic medication may be tried.

It would be well if all incipient paretics could be put under a modified restraint; often a rest cure would seem advisable. When the disease has fairly manifested itself, asylum treatment is necessary and should be continuous except during pronounced remissions. If during these the patient is able to be at home, he should still be under medical surveillance and advice. In the closing scenes of the disease, the most that can be done is to meet the symptoms as they arise and make the patient's last days as decent and comfortable as possible. It is important, it should be said, to watch the patient's eating, and give only such food as can be taken safely without danger of choking. The condition of the bowels and bladder and the trophic alterations will all require careful attention.

HENRY M. BANNISTER.

Park, Roswell.—Born at Pomfret, Connecticut, on May 4, 1852. He received his professional education at Northwestern University, the medical department of which was located in the City of Chicago. In 1877 he was appointed Demonstrator of Anatomy in the Woman's Medical College of that city; and two years later he became Adjunct Professor of Anatomy in the Chicago Medical College. In 1882 he was chosen Professor of Surgery in the Medical Department of Northwestern University, and during the following year he was called to Buffalo, N. Y., to occupy the Chair of Surgery in the University of that city. He died at his home in Buffalo on Feb. 15, 1914, after a prolonged period of poor health.

In the domain of medicine Dr. Park attained distinction in several directions. In the first place, he was a skilful and painstaking surgeon, well grounded in the knowledge of anatomy and in the principles of pathology; he took a very active part in the dissemination of a thorough knowledge of aseptic and antiseptic methods of surgical treatment; he was untiring in his efforts to acquire effective knowledge of the natural history of cancer and of the means of combating it successfully, the establishment of the State Institute for the Study of Malignant Disease at Buffalo having been brought about largely through his efforts; he was an accomplished writer, thoroughly able to express his thoughts in terse and faultless English; and, finally, he was a man who possessed a charming personality and was one of the ornaments of the medical profession.

A. H. B.

Parker, Willard.—Born in Hillsboro, New Hampshire, Sept. 2, 1800. In 1830 he received the degree of M. D. from the Harvard Medical School, and in June of the same year he was appointed to the Chair of Anatomy in the Berkshire Medical College at Pittsfield, Mass., at that time a leading country school of medicine. Two years later, he gave two separate courses of lectures in this school —one on anatomy and one on surgery. In 1836 he accepted the Chair of Surgery in the Cincinnati Medical College, and then shortly afterward spent some time in the English and French hospitals. In 1839, soon after his return to America, he was appointed to the Chair of Surgery in the College of Physicians and Surgeons in the city of New York. He held this position for thirty years, and was then (1870) given the Chair of Clinical Surgery, a position which he continued to hold up to within a few months before his death. In 1845, when Bellevue Hospital was reorganized, Dr. Parker and Dr. James R. Wood were appointed Visiting Surgeons; and in 1856 Dr. Parker was chosen one of the Visiting Surgeons to the New York Hospital. His death occurred April 25, 1884.

Among the contributions which Dr. Parker made to the art of surgery the following may be selected as possessing decided practical value: the operation of cystotomy for the relief of chronic cystitis; the operation for the cure of abscess of the appendix vermiformis; and the operation for laceration of the perineum occurring during parturition, in which the sphincter of the rectum is divided near its coccygeal attachments and the edges of the septum divided, so as to give increased uniting surface, the strain upon the sutures being taken off by relief incisions.

Dr. Parker made relatively few contributions to medical literature; his large private practice, his hospital work, and his medical college duties allowed him very little time for anything else. "As a teacher," says Stone, "Dr. Parker enjoyed the highest reputation. With a fine personal presence and a courteous and affable manner which won the personal regard of his pupils, he also riveted their attention by his direct and lucid manner in unfolding the principles of his art, and by the unexcelled and simple and commonsense character of his operations and general treatment. The writer of the present sketch recalls to mind the introductory remarks made by Dr. Parker at the beginning of the winter course of lectures (Oct., 1864) at the College of Physicians and Surgeons, New York. Although these remarks were made nearly fifty years ago before an audience of first-year medical students, the lapse of time has not diminished their homely wisdom or their appropriateness to the conditions which exist to-day. Dr. Parker said: "Gentlemen: When you begin the practice of medicine, provide yourselves, each one, with two bags—a small one in which to put the fees that you may collect, and a large one for holding the snubs and insults which you will surely receive."

A. H. B.

Paronychia.—See *Hands and Fingers, Diseases of.*

Parovarium, Diseases of.—The term parovarium is applied to a series of from six to eight closed tubules which lie between the two layers of the broad ligament. They radiate out from the ovary toward the Fallopian tube, terminating in a large tubule which runs parallel to and beneath the Fallopian tube.

The pathological changes to which it is liable consist practically of only two varieties, viz.: cystic disease and carcinoma, the latter being secondary to similar disease elsewhere, and so rare as not to merit consideration in so short an article as this.

PAROVARIAN CYSTS.—These arise from dilatation of one of the tubules of the parovarium, and are therefore intraligamentous. Frequently they remain so, in which case their removal is an exceedingly grave proceeding, but at times they stretch the ligament to such an extent that they become abdominal with a well-formed pedicle. In the latter case they are freely movable and ovoid in shape, while in the former they are fixed in the pelvis and have often an irregular outline. When pedunculated these cysts have a

complete covering of peritoneum; while at the point where they split the layers of the broad ligament only the upper surface is covered by this membrane. This peritoneum is smooth and glistening, and the blood-vessels may be seen beneath it. These cysts are nearly always unilocular and contain, as a general thing, a very thin and limpid fluid; but in the case of older cysts this fluid may be thicker and turbid, especially if any hemorrhage has taken place into the cyst.

The inner surface of the cyst is lined by ciliated columnar epithelium which may be accompanied by some cells of the cylindrical variety. Next comes a layer of connective tissue and unstriped muscular fibers, and lastly comes the peritoneal coat.

Symptoms may be absent in the pedunculated variety until the cysts become sufficiently large to interfere with the heart and respiration, when dyspnea and palpitation, as well as the swelling of the abdomen, will be complained of. When the cyst is sessile, however, one early gets pelvic discomfort or even pain, and the action of both bladder and bowels will be interfered with.

An abdomino-pelvic examination of the patient, in a case in which the tumor is pedunculated, will give the signs of an ordinary unilocular ovarian tumor, except that the fluidity of the contents will not be so evident in the latter. When the tumor is sessile, however, a fixed and fluctuating mass is felt to one side of the uterus, which is displaced to the opposite side of the pelvis. No hard nodules are to be felt in this mass.

The tumor may rupture, and this may be followed by refilling and repeated rupture, by cure, by hemorrhage, or by sepsis and death.

The *treatment* is removal. In the case of the cyst with a pedicle this is very simple, but when the broad ligament has been split up and the tumor has reached the pelvic floor, the treatment is a difficult matter. Here there is such risk of hemorrhage when one tries to remove the tumor by itself that a clean sweep of the pelvis is advocated by most operators. Hall taps the cyst after having opened the abdominal cavity; he then ligates the ovarian arteries—that of the affected side to the outer side of the tumor, and that of the opposite side on the uterine side of the ovary if that is to be left, to its outer side if it is to be removed. The peritoneum is divided across the top of the bladder, which is separated from the uterus. The uterine artery on the healthy side is tied and divided, after which the cervix is divided across. The other uterine artery is then clamped, ligated, and cut. The tumor capsule is incised in front and behind, and the tumor is then shelled out and removed with the uterus. The peritoneal flaps are united by a continuous catgut suture.

F. A. L. Lockhart.

Parthenogenesis.—(Gr. παρθένος, a virgin, and γένεσις, production). Parthenogenesis is reproduction by means of unfertilized eggs.

Occurrence.—This means of perpetuating the species occurs normally in several widely separated groups of animals and in a few plants. It was really discovered first in the plant lice, aphids, by Bonnet through a series of experiments begun in 1740; although Albrecht had recorded a single case of parthenogenesis in the silk-moth as early as 1701. In the Aphidæ the fertilized eggs which have lasted through the winter hatch in the spring, giving rise to females known as stem-mothers, which in many species are winged, and in others are without wings. These are viviparous, producing parthenogenetic eggs which develop within the oviduct. After a number of parthenogenetic generations sexual individuals are produced, the males being winged, the females always without wings. After copulation the females lay fertilized eggs, which remain dormant during the winter. In this group parthenogenesis is thus combined with an alternation of generations. But sometimes some of the parthenogenetic individuals live through the winter, thus producing two parallel cycles of development. In some of the aphids the life history is complicated by the fact that the sexual and asexual generations inhabit different host plants.

Parthenogenesis occurs normally also among the worms—in the liver flukes, larvæ of *Fasciola hepatica*, and in the rotifers. In the Crustacea it is found in certain genera of the Entomostraca, namely, Cypris, Daphnia, Polyphemus, Artemia, Apus, Lepidurus, and Limnadia. The phenomenon is widely distributed among the insects, being especially characteristic of the Hymenoptera—saw-flies, gall-flies, ants, bees, and wasps; the Thysanoptera; and the Aphidæ and Coccidæ—plant lice and scale bugs. It is found rarely among the moths, as in the genera Apteronia, Psilura, and Solenobia; and in one genus of gnats, Chironomus.

Among plants parthenogenesis is described as occurring in *Chara nitida*, *Thalictrum fendleri* and *purpurascens*, and some fungi, as Saprolegnia.

Classification.—The forms of parthenogenesis have been classified by Geddes and Thompson, and later by Delage according to their mode of occurrence into several groups. Of these the most important are: (1) *Occasional* parthenogenesis, of which the only authentic example appears to be the silk-moth. It has been known for a long time that once in a while a female silk-moth may be found capable of laying eggs, some of which will develop without fertilization. Geddes and Thompson include in this group a form of parthenogenesis that they also call *partial* and that Delage distinguishes as (2) *facultative*. This form is characteristic of the bees, ants, and wasps. The queen bee, for example, as was first shown by Dzierzon, appears to be able at will either to fertilize the eggs as they are laid by means of spermatozoa stored in the sperm sac or else to withhold fertilization. The eggs develop equally well in either case, but fertilized eggs always develop into workers or queens, while the unfertilized eggs invariably give rise to drones. This is proved partially by the fact, noted by Hensen, that when a queen bee has been impregnated by a drone of another variety, the female offspring, workers and queens, will all be hybrids, while the young drones will show purely the characters of the maternal race. Moreover, queens that have been prevented from receiving the male, old queens whose sperm sacs have become exhausted, and the workers that occasionally can produce eggs but have no copulatory organs, all produce male offspring only. Finally, von Siebold was unable to find any spermatozoa in eggs from drone cells.

(3) *Seasonal* parthenogenesis accompanied by an alternation of generations is common with the Entomostraca and Aphidæ. In the Aphidæ the parthenogenetic young are born alive as already described. That this process is dependent upon seasonal conditions is shown by the experiment of Réaumur and Kyber, who, by maintaining artificially summer conditions in a glass case, were able to obtain fifty continuous parthenogenetic generations extending through four years. In the Entomostraca the summer eggs which develop parthenogenetically are smaller, have less yolk, and thinner shells than the fertilized winter eggs, which are well provided with food yolk and covering to withstand drying and cold. This form of parthenogenesis is also characteristic of the gall flies, but in most of these there is but a single parthenogenetic generation between two sexual ones.

(4) *Juvenile* parthenogenesis has been taken to include the summer reproduction of the aphids. But that view no longer prevails, for the parthenogenetic females appear to differ from the perfect forms chiefly in the absence of certain accessory reproduc-

tive organs. One case seems to be that of a species of the gnat, Chironomus, in which the pupa produces parthenogenetic eggs. In the gall-midges Cicidomya and Miastor, adult males and females appear in the spring and produce fertilized eggs. The larvæ that hatch from these eggs produce parthenogenetic eggs which undergo development within their bodies, so that they give birth to other larvæ. This process, known as pedogenesis, is continued throughout the year.

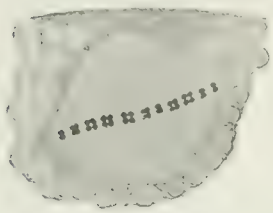


Fig. 4226.—First Maturation Spindle in Parthenogenetic Egg of *Artemia salina*. × 1060. (After Brauer.)

Finally, we have (5) total, or *exclusive*, parthenogenesis. That is, in many rotifers, some of the Entomostraca, and a few insects, no males have ever been found, and it is inferred that in these cases there is perpetual reproduction by unfertilized eggs only.

(6) *Artificial* parthenogenesis will be discussed in another paragraph below.

Fig. 4227.—Extrusion of the First Polar Body of the Maturation Spindle shown in Fig 4226. × 1060. (After Brauer.)

Another classification of the phenomena of parthenogenesis is that of Taschenberg, who distinguishes three divisions: (1) *Thelytoky*, when the unfertilized eggs give rise to females only, as in the summer generations of the aphids; (2) *Arrhenotoky*, when males only are produced, as in the case of the queen bee; and (3) *Deuterotoky*, when the offspring are of both sexes, as with the gall-flies.

Fig. 4228.—Egg Nucleus Derived from Half of the First Spindle Remaining in the Egg. The centrosome has divided. × 490. (After Brauer.)

Cytology.—It was first suggested in 1877 by Minot on theoretical grounds that parthenogenesis might be due to a failure of the egg to produce polar bodies (see articles *Ovum* and *Maturation*). Balfour in 1880 and later Van Beneden maintained that the extrusion of the polar bodies in eggs destined for fertilization is a special provision to prevent parthenogenesis. Theory also led Weismann to investigate the question of parthenogenesis, and he observed in 1885 that in the parthenogenetic eggs of Polyphemus, one of the Daphnidæ, but one polar body is formed. In 1888 Blochmann made the important discovery that in the plant-lice, aphids, parthenogenetic eggs produce but one polar body, while the fertilized eggs produce two. Weismann

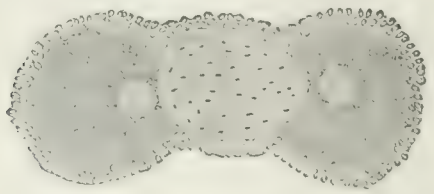


Fig. 4229.—Egg Nucleus of the First Type at the Beginning of the Formation of the Cleavage Spindle. × 490. (After Brauer.)

subsequently found this to be true of the eggs of ostracodes and rotifers, and was led to infer that the differences observed in these forms is one that distinguishes all parthenogenetic eggs from those destined for fertilization. But doubt was thrown upon this view by the observations of Blochmann (1888–89) and Platner (1889), who discovered that in the honey-bee and in the moth Psilura (Liparis) the parthenogenetic

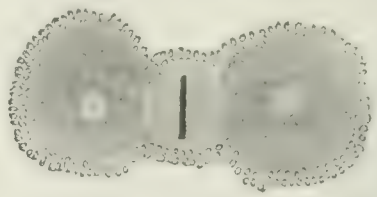


Fig. 4230.—Cleavage Spindle of the First Type. × 490. (After Brauer.)

eggs produce two polar bodies. The difficulty was supposed to have been met by Brauer's brilliant research, in which he discovered that there are two types of parthenogenesis. Both types occur in the eggs of Artemia. In the first case the first maturation spindle contains eighty-four chromosomes in the form of typical tetrads (Fig. 4226), which divide so that eighty-four dyads are removed in the first polar body and eighty-four remain in the egg (Fig. 4227). There are indications of an attempt to form a second polar spindle, but no divison takes place, and the eighty-four dyads give rise to a reticular cleavage nucleus (Fig. 4228).

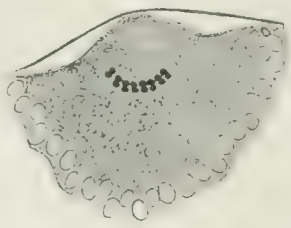


Fig. 4231.—Second Maturation Spindle of the Same. × 1060. (After Brauer.)

In the second type, which is less frequent, a second polar spindle is formed and the eighty-four dyads divide, producing two groups each containing eighty-four single chromosomes (Fig. 4231). Ordinarily these remain in the egg, producing two small reticular nuclei (Fig. 4232). Preparatory to division two centrosomes appear, whether by the division of a single one or not is not known. But, at any rate, they form a single spindle in which the 168 chromosomes arrange themselves in two distinct equatorial plates (Figs. 4233 and 4234). In rare cases, however, Brauer observed that the second polar body is actually extruded, and then its nucleus returns to the egg and presumably undergoes the changes just described.

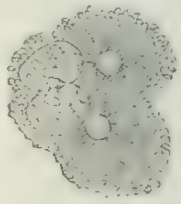


Fig. 4232.—Two Egg Nuclei Derived from Halves of the First and Second Spindles. × 490. (After Brauer.)

According to the investigations of Nachtsheim (1912) the process in the honey-bee differs from the second type in Artemia. The fertilized eggs produce two polar bodies, the process be-

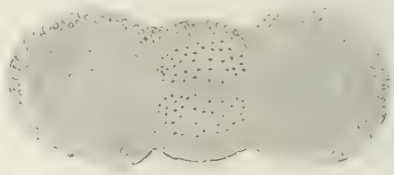


Fig. 4233.—Egg Nucleus of the Second Type at the Beginning of the Formation of the Cleavage Spindle. × 490. (After Brauer.)

ing completed after the entrance of the spermatozoon. The spermatozoa are all of one kind, and all these eggs produced females with thirty-two chromosomes in their cells. The unfertilized eggs likewise produce

two polar bodies, which remain separate, and these eggs, all of which produce males, develop with the haploid number, sixteen chromosomes.

Heredity.—We are indebted to Dr. Ernest Warren for observations upon heredity in parthenogenesis. The forms that he studied are Daphnia (1900) and an aphid, *Hyalopterus trirhodus* (1902). From twenty-three individuals of Daphnia he obtained ninety-six young, and from sixty aphids he reared 455 offspring. Measurements were made of parents and offspring of both species, and the coefficients of heredity were calculated by the methods described in another place (see article *Heredity*).

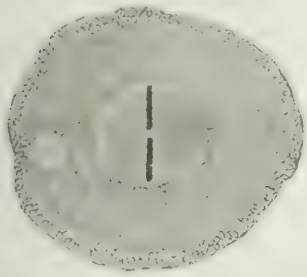


Fig. 4234.—Cleavage Spindle of the Second Type. × 490. (After Brauer.)

The results of direct inheritance were found not to differ very much from those obtained in sexual reproduction; taking the mean of Daphnia and the aphid, the coefficient for parental inheritance was found to be 0.41 and for grand-parental 0.24.

Interesting results on heredity in honey-bees have been obtained by Newell (1915). On crossing yellow Italian with gray Carnidan bees, it was found that the yellow color is dominant (see *Heredity*). The drones inherit only the color of the mother if she is homozygous. But a queen resulting from the crossing of the two varieties, and therefore heterozygous, always produces two kinds of drones, gray and yellow, and only two kinds, in equal numbers.

Artificial Parthenogenesis.—It has been known for a long time that the ova of animals that reproduce by the sexual method only will sometimes undergo an irregular segmentation. R. Bonnet (1900) has given an exhaustive review of these phenomena as observed in vertebrates, and concludes they are pathological in character. The segmentation observed is a fragmentation of the cell leading to dissolution. He places in this category the early experiments of Dewitz (1887), who found that frogs' eggs treated with corrosive sublimate would undergo segmentation. Similarly Tichomiroff (1886) was able to induce the development of unfertilized eggs of the silk-moth by treating them for a few minutes with sulphuric acid, but this is a species in which occasional parthenogenesis is known to occur.

In 1899, however, Loeb made the remarkable discovery that by the use of a solution of magnesium chloride of a certain strength (a mixture of $\frac{2.0}{8}$n $MgCl_2$ and sea-water in equal parts for two hours) he could induce development in the unfertilized eggs of a sea-urchin (Arbacea), a group in which normal parthenogenesis is unknown, so that the egg not only divided but continued through the blastula and gastrula stages, and eventually formed normal pluteus larvæ (Fig. 4235). At first he attributed this result to the specific effect of the magnesium ions. But later researches showed (1900) that other salts and such organic substances as urea and cane-sugar could produce the same result. Loeb then concluded that the cause of development was not the specific effect of certain ions, but that it was due to an increase of osmotic pressure. Especially he noted that the reagents used seemed to cause a ljquefaction of the nuclear membrane, and he regarded that as a prerequisite for cell division.

These results stimulated many investigators to try other methods, and it has been found that artificial parthenogenesis can be induced in the eggs of a considerable number of animals of various groups by a great variety of means, both chemical and mechanical. Loeb continued his study of the subject and his results have been collected in a convenient volume (1913). To start normal development in an unfertilized egg, he finds that the essential thing is the formation of a fertilization membrane, which is followed by an increase of oxidation within the egg. This may be produced by any agent that causes cytolysis. But in most cases it is necessary to arrest the process by transfer of the eggs to hypertonic sea-water or to a dilute solution of potassium cyanide for a short time. "The causation of development requires two factors, the one is the membrane-forming factor, the other the corrective factor."

F. R. Lillie (1916) offers another explanation. He finds a substance, "fertilizin," that is liberated in the egg when the germinal vesicle ruptures, and that when activated furnishes the stimulus that starts development. It is activated normally by something in the sperm (see article *Impregnation*); but the same effect is produced upon it by the agents that cause artificial parthenogenesis.

A number of zoologists have investigated the internal phenomena of artificial parthenogenesis. Three years before Loeb's first successful experiment R. Hertwig (1896), found that in unfertilized eggs of sea-urchins, Echinus and Sphærechinus, treated with dilute solutions of strychnine, the nucleus might give rise to a bipolar mitotic figure. Using mainly unfertilized eggs of Arbacea, T. H. Morgan made a series of studies (1896, 1899, 1900) upon the effects of solutions of sodium and magnesium chlorides and also dilute strychnine upon the cytoplasm, his "principal discovery being that the eggs become filled with 'artificial astrospheres' (asters) containing deeply staining centrosome-like bodies, which may become connected with the nucleus and 'seem to act as anchors for the chromosomes and move out into the egg with the chromosomes attached to them.'"

Our knowledge of the internal phenomena of artificial parthenogenesis really began with the beautiful work of E. B. Wilson (1901), soon after the

Fig. 4235.—Normal Plutei Reared from Unfertilized Eggs; treated with equal parts of a $\frac{2}{8}$n $MgCl_2$ solution and sea-water. Magnified. (After Loeb.)

publication of Loeb's first paper. He completely confirmed Loeb's general result, finding that "unfertilized eggs of Toxopneustes (a sea-urchin), when treated with a mixture of equal volumes of sea-water and twelve per cent. $MgCl_2$ and then replaced in pure sea-water, may segment, give rise to actively swimming blastulæ and gastrulæ, and in many cases to plutei." This imperfect method resulted, however, in a large number of abnormalities and mon-

strous forms, and even the best specimens were not exactly like those produced from fertilized eggs.

Serial sections showed that no sperm nuclei were present. The internal changes, while showing an interesting parallel to those occurring in fertilized eggs, were unmistakably different from the latter. During cleavage many of these eggs show but *one-half* the normal number of chromosomes, namely, eighteen instead of thirty-six, and most of the eggs failed to form any trace of a vitelline membrane, which in fertilized eggs is formed after the entrance of the spermatozoon.

Delage (1901) also investigated the internal phenomena of artificial parthenogenesis, using eggs of species of sea-urchins and starfish. He obtained development in the former after both polar bodies had been formed, and in the latter after only one polar body had been formed as is the case in normal parthenogenesis. He claims also that the number of chromosomes present is the same as in fertilized eggs. But Boveri (1902) has shown this to be an error, the number of chromosomes found by Delage in the sea-urchin being really half the normal number, thus confirming Wilson.

Lefevre (1907) was the first to use organic acids (acetic and oxalic) to induce parthenogenesis. He made a very complete study, not only of the internal phenomena in the early stages, but also of the subsequent development of the eggs of the worm, *Thalassima mellita*. In these experiments fifty to sixty per cent. of the eggs developed normally, producing a fertilization membrane and two polar bodies with a reduction of the chromosomes to the haploid number, which persisted throughout the later stages.

ROBERT PAYNE BIGELOW.

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Parvin, Theophilus.—Born at Buenos Ayres, South America, Jan. 9, 1829. He received the degree of M. D. from the University of Pennsylvania, in 1852. About one year later he removed to Indiana. In 1864 he accepted the Chair of Materia Medica and Therapeutics in the Medical College of Ohio, and in a few years he resigned this for the newly created Professorship of the Medical and Surgical Diseases of Women. During the following nineteen years he held similar chairs in three or four different medical schools. Finally, in 1883, he was chosen Professor of Obstetrics and Diseases of Women and Children in the Jefferson Medical College of Philadelphia, and this position he held up to within a few years of his death, which occurred in 1898.

Stone, writing in 1892, says of Dr. Parvin: "He ranks to-day, undoubtedly, among the very greatest obstetrical authorities in America, and these are necessarily few. As a lecturer he appears to have been eminently successful. . . . . He has written much on obstetrics, but the cream of all his writings and the work which at once placed him in the front rank of his profession, is his "Science and Art of Obstetrics." . . . . . The personal traits of Dr. Parvin are striking and in some respects, unfortunately, rare. He is cordial, helpful and sympathetic to his younger brethren, to whom these things mean much upon the threshold of their lives, but his finest trait, and the rarest, is a broad-minded capacity which enables him to appreciate the good work of his peers, and to acknowledge it open-heartedly."

A. H. B.

Pasadena.—See *Los Angeles*.

Paso de Robles Hot and Cold Sulphur Springs.—San Luis Obispo County, California.

POST-OFFICE.—Paso Robles. Hotel and cottages.

ACCESS.—Viâ the Coast Line of the Southern Pacific. These springs lie in the beautiful valley of the Salinas River, about 16 miles from the shores of the Pacific Ocean and 216 miles from San Francisco. The name of El Paso de Robles is derived from the Spanish, meaning "the pass of the oaks," from the fact that the main highway ran through this valley. For many miles this picturesque valley is covered with gigantic white oak, live oak, and cottonwood trees, and nestled in one of these cosy groves is Paso Robles. The once wild "pass in the oaks" is now transformed into a blooming resort, with cultivated grounds. When the Southern Pacific Railroad was completed a magnificent modern hotel was built. This structure is near the springs and overlooks the prosperous town. The building is of solid brick throughout. A number of cottages are also found under the umbrageous oaks in different parts of the extensive grounds. Diet is made an important feature here, the cuisine being under the direction of a physician. On each side of the resort and valley the evergreen hills covered with forests of pine, oaks, manzanita groves, and sweet-scented shrubbery, form a pleasant contrast to Paso Robles proper. The Salinas and Nacimiento rivers can be seen and the Mission San Miguel nearby, all against a background of the Santa Lucia Mountains. The climate is remarkably mild and delightful all the year round, and the atmosphere is pure, balmy, and invigorating. The waters of Paso Robles are sulphurous and alkaline and range in temperature from 59° to 122° F. They comprise the "Main Hot Sulphur" spring, the "Mud" or "Moor" spring, the "Soda," "Sand," "Cold," "White Sulphur," "Iron," and "Garden" springs. The great hot sulphureted spring is located about three hundred yards from the hotel in a southeasterly direction. Over it has been constructed one of the finest bathing establishments on the coast.

This modern bath-house, or "kurhaus," of marble and mosaic is unexcelled in the completeness of its equipment and the effectiveness of its water and mud remedies. Here under skilful medical supervision,

is given every form of hydropathic treatment known. Hot sulphur-water baths (natural heat), mud packs, vapor baths, steam baths, electric light baths, carbonic acid (effervescent) baths (Nauheim), tonic baths, salt baths, Scotch, Charcot, and other douches, Swedish exercises, and resistant movements are all available. By means of an elaborate ventilating system, the air throughout can be changed every twenty minutes.

The swimming plunge-bath pool is also fed direct from the spring—the sulphur water flowing in and out continuously. This pool is eighty by forty feet and is provided with shower baths and suites of dressing rooms. It has its own entrance. The flow of this spring is more than two million gallons per day, and it has a temperature ranging from 105° to 110° F. The following is the analysis made by Professor M. E. Jaffa and Mr. Dennis R. Hogland.

Main Sulphur Spring.

Temperature 107° F.	Parts per Million.
Lithium chloride	Trace
Potassium chloride	37.8
Sodium chloride	309.6
Potassium bromide	Trace
Potassium iodide	Trace
Sodium sulphate	45.9
Calcium phosphate	Trace
Sodium borate	Trace
Calcium bicarbonate	153 4
Silica	66.0
Ferrous bicarbonate	Trace
Magnesium bicarbonate	98.2
Sodium bicarbonate	708.5
Total	1,419.4

Gases	Cubic Inches per Gallon of Water
Hydrogen sulphide	7.85

These waters are found to be especially serviceable in subacute and chronic rheumatism and articular affections, in blood, glandular, and cutaneous affections, in autointoxication, malarial toxemia, lead and mercury poisoning, anemia, nervous exhaustion, insomnia, certain chronic affections of heart and blood-vessels, and in strumous cases. In catarrh of the nasopharynx the water, used as a hot douche, has proved beneficial. It may also be used to advantage, in the form of a hot douche, in the treatment of leucorrheal discharges and in engorgement of the female pelvic organs.

The mud springs are of benefit in rheumatic affections, gout, arthritis, stiff joints, stiff muscles, chronic swellings, sprains, synovitis, glandular enlargements, chronic cutaneous diseases, and the like. These springs cover a space of about twenty-five feet square, over which suitable bathing facilities have been established. These consist of dressing-rooms, hot sulphurous water plunges, and the mud bath. The mud springs flow collectively about six thousand gallons per hour.

Following is the analysis made by Professor M. E. Jaffa and Mr. Dennis R. Hogland.

Mud Springs—Lithia and Sulphurous

Temperature 104°–122° F.	Parts per Million.
Lithium chloride	****
Potassium chloride	20 8
Potassium bromide	***
Potassium iodide	***
Sodium chloride	1,311.6
Sodium sulphate	460.3
Sodium metaborate	22.0
Calcium phosphate	2.12
Magnesium sulphate	5.9
Calcium sulphate	315 0
Calcium bicarbonate	70.9
Ferrous bicarbonate	2 91
Silica	105.0
Total	2,316.51

Gases	Cubic Inches per Gallon of Water.
Carbon dioxide free	22.9
Carbon dioxide given off from bicarbonate by evaporation.	2.84
Hydrogen sulphide	1.08

*** Large trace.
**** Well-marked test by spectroscope.

The mud bath-house is two miles from the hotel and main bath-house, but a closed carriage is at the service of the guests who make the trip.

The mud baths are unique in that they are built down into the strong vegetable mud where hot lithia and mineral waters at a temperature from 108° to 122° F. bubble up continuously. The bather is literally standing in mud on top of the spring, and thus derives the benefits of both gas and heat.

About two hundred yards north of the mud baths is the Soda Spring. Its temperature is 77° F., and its flow is limited. The water is much used for drinking purposes. By allowing a small quantity of sulphureted hydrogen to escape the water becomes very palatable.

The analysis of this spring made at State Food and Drug Laboratory, University of California, by Professor M. E. Jaffa and Mr. Dennis R. Hogland, is as follows:

Soda Spring.

Temperature 77° F.	Parts per Million.
Lithium chloride	****
Potassium chloride	14.5
Sodium chloride	807.5
Potassium bromide	Trace
Potassium iodide	Trace
Sodium sulphate	314.8
Sodium borate	*
Calcium phosphate	Trace
Magnesium sulphate	122.1
Calcium bicarbonate	246.5
Silica	*
Iron and aluminum oxides	1.3
Magnesium bicarbonate	122.8
Calcium silicate	205.5
Total	1,835.0

Gases	Cubic Inches per Gallon of Water.
Carbon dioxide free	16.09
Carbon dioxide given off from bicarbonates	12.12
Hydrogen sulphide	0.08

* Small amount.
****Well-marked test by spectroscope.

The water has valuable antacid and aperient properties. It belongs to the alkaline-carbonated class.

The clubhouse adjoining the hotel has a large bowling alley, billiard, pool, and tea rooms.

Golf, tennis, croquet, horseback riding, motoring, swimming, and field shooting in season are among the recreations.

Emma E. Walker.

Passiflora N. F. *Passion flower.*—The dried herbage of *Passiflora incarnata* L. (fam. *Passifloraceæ*).

This plant is a soft woody vien, climbing high over shrubbery and trees in the southeastern United States, where its edible fruit is considerably used under the name May-pop.

The drug is nearly smooth. The stems are about a fourth of an inch or less in thickness, irregularly angled and hollow, pale green or brownish, occasionally purplish. The leaves are thickish, about two to four inches long and broad, exclusive of the petioles, the petioles bearing two glands near the summit, three to five lobed, the lobes broad, acutish, lightly serrate, the large purplish-white flowers solitary in the axils, three-bracted. Both odor and taste are slight and indefinite, the latter somewhat fatty and dis-

agreeable. The constituents have not been examined with any care. A trace of alkaloid has been reported.

Passion flower has been exploited by commercial interests, and most of its literature has been compiled with a view of creating a demand for it. It has been considerably employed in eclectic and homeopathic practice. These authorities attribute to it mild sedative and even hypnotic powers, while larger doses are said to be emetic. Its use by these practitioners in numerous grave conditions, as well as their minute doses, involve obvious absurdities. Whatever benefit may be derived from its use may result from the administration of fl. ʒ ss.–i. (2.0–4.0) of the fluid extract. The extract has some value as a soothing application to hemorrhoids, as well as to inflamed conditions of the skin.

HENRY H. RUSBY.

Pastæ Dermatologicæ.—Dermatological pastes are medicinal preparations intended for external use. They are not official in either the United States or British Pharmacopœia; but several of them are given in the National Formulary and British Pharmaceutical Codex. Those in the National Formulary are named for some noted dermatologist (Unna or Lassar), and are mixtures of the consistence of an ointment. They contain sulphur, dextrin, zinc oxide, resorcinol or some other substance; and their action may be antiseptic, soothing, rubefacient, or caustic. The *Pasta Dextrinata* (dextrinated paste) of the N. F. contains dextrin and glycerin, and is used as a vehicle for many of the medicated pastes used in dermatological practice.

R. J. E. SCOTT.

Pasteur, Louis.—Born at Dôle, in the Department of the Jura, France, Dec. 27, 1822. After completing his preliminary studies at Besançon (near Dôle) and at the École normale supérieure, he received the degree of Doctor of the Physical Sciences in 1847. One year later, he was chosen Professor of Physics at the Lyceum of Dijon; and then he accepted, in quick succession, the following important positions: Professor of Chemistry in the Strassburg Faculty (1848); Dean and Professor of Chemistry in the newly established Faculty of Sciences at Lille (1854); Director of the Scientific Section of the École normale supérieure (1856); Professor of Geology, Physics and Chemistry at the École des beaux arts, Paris (1863); Professor of Chemistry at the Sorbonne (1867–1889); and, in the year last named, Director of the institute which bears his name ("Institut Pasteur"). It was here that he prosecuted, on a large scale, the researches which he had already begun elsewhere, and which are now well known throughout the entire world, into the methods of protecting both men and animals from infection by rabies, anthrax (splenic fever), and hog cholera. He died at Garches, near Versailles, Sept. 28, 1895.

It is scarcely possible to overrate the magnitude of the boon which Pasteur's discoveries have conferred upon the human race, discoveries which were not stumbled upon accidentally, but were the direct result of persistent, laborious, and most precisely conducted experimentation, largely upon living animals. That a human being should have been able to achieve such remarkable results suggests the idea, and justifies the hope, that even greater achievements may be looked for at some future day from Pasteur's successors.

The various protective and curative procedures designated by the comprehensive term "serum therapeutics," and the extraordinary revolution which antiseptic and aseptic measures have effected in surgery and obstetrics, are all primarily to be credited to the labors of Pasteur.

A. H. B.

Patchouli, Oil of.—*Oleum Foliorum Patchouli.*—A volatile oil distilled from either the fresh or the dried leaves of *Pogostemon heyneanus* Benth. (*P. patchouli* Pell.; *P. suavis* Tenore. Fam. *Labiatæ*).

The Patchouli plant is native and cultivated in the East Indies, especially in the Straits Settlements, and the drug or the oil distilled from it is mostly exported from Singapore. The oil ranges from pale yellow to brownish, usually with a greenish tinge, and is occasionally of a deep brown color. Its specific gravity varies from 0.97 to 0.99, even when pure. With ninety per cent. alcohol it yields a clear solution which usually remains clear upon the addition of more alcohol (Gildemeister and Hoffman). The oil has a characteristic and very intense and persistent odor. Its composition is not well known, though it yields a peculiar camphor known as Patchouli camphor. This oil is little, if at all, used medicinally, though it has the ordinary aromatic stimulant properties of its class. It has very important uses in perfumery.

HENRY H. RUSBY.

Patella, Diseases and Injuries of.—The patella is a sesamoid bone developed in the quadriceps tendon, and is therefore a part of the extensor apparatus of the knee. Some anatomists have considered the patella homologous with the olecranon process of the ulna; but there are serious objections to this view, and it is not indorsed by Poirier and Charpy.

The first rudiments of the patella appear about the tenth week of fetal life, and ossification usually begins from one center about three years after birth; but the *x*-ray often fails to cast a shadow until the sixth year, and the bone is not fully developed until after puberty. The principal functions of the patella are to increase the leverage of the quadriceps muscle and to protect the knee-joint anteriorly. It seems to be, however, a luxury rather than a necessity, since its congenital absence may produce little or no disturbance of function. The kangaroo, which has no bony patella, is noted for its powerful posterior limbs.

Fractures and traumatic dislocations of the patella, and prepatellar bursitis are discussed in other sections of this work; there remain the congenital and developmental anomalies, and certain diseases, deformities, and painful affections which follow.

Absence or Retarded Development of the Patella.—This is a not unfrequent accompaniment of congenital deformities involving the knee, especially of absence or imperfect development of one or more bones of the leg, and of congenital flexion, hyperextension, and ankylosis of the knee. Of these conditions the one which has attracted most attention is the so-called congenital dislocation of the knee, where the child is born with one or both knees in hyperextension, and the tibia luxated forward. In a large proportion of these cases no patella is discoverable in infancy; but in many, if not most, it develops later, and may reach normal proportions. Such a case, observed by the writer,[1] had no patellæ at seven months of age, but they could be felt as very small nodules six months later, and at three years of age were well developed. At thirteen years this boy was active, and had good functional use of the knees and perfectly developed patellæ.

Many of the cases in the literature are reported too young to determine the fact of permanent absence. Rectification of the deformity and orthopedic treatment seem to exert a favorable effect on the development of the patella in these young cases. Potel[2] has collected 78 cases of congenital knee luxation, of which about half were bilateral; in 50 of these cases the condition of the patella is noted, of which 18 were normal; in 16 the patella was absent, in 10 atrophied, and in 2 anomalous. Potel reports in addition 20 cases of absent or rudimentary patella accompanying other deformities of the knee. Little[3] reports 42 cases of

absent or rudimentary patella, not including a remarkable group of 18 cases in four generations of one family, who had no patellæ and no thumb nails. Other family groups have been reported by Wirth[4] and Wolf. Many of Little's cases are on Potel's list and on the later list of Thorndike.[5] Some of the individuals in whom the patella never develops are nevertheless active and even athletic, and unconscious of any defect. While extremely rare, cases of complete absence of the patellæ, due to developmental defect, and uncomplicated by other anomalies, do exist. Joachimsthal[6] proved by *x*-ray examination that Wirth's case was indisputable. As absence of the patella is usually a syndrome rather than a pathological entity, the treatment is that of the primary affection, and in the case of congenital luxation and some other deformities it is usually effectual. The following advice, given in a recent work of reference[7], is erroneous: "When the patella is absent it is usually necessary to produce an artificial ankylosis between the femur and tibia." On the contrary, it is rarely if ever necessary to have recourse to this operation for this reason.

Split Patella.—Very rare are the cases of congenital split patella. Grüber[8] reports a case in which both patellæ were divided into a small superior external and a large inferior internal segment separated by a groove. Joachimsthal[5] reports a case of horizontal and another of vertical fissure in which fracture was excluded.

Congenital Dislocations of the Patella.—While this condition is uncommon there is a considerable literature on the subject. Steindler[9] reports sixty-one cases of outward and two of upward dislocation. This deformity is frequently combined with genu valgum, but such combinations are not always congenital; moreover, there are many cases of congenital dislocation in which no genu valgum is present. The affection seems to be usually due to imperfect development of the anterior part of the external condyle. Alsberg[10] reports three cases in one family, father, son, and daughter, in which the displacement was outward and bilateral. In two of these cases there was practically no disability.

Cases of congenital dislocation are also reported by Potel,[2] Bergmann,[11] Elliott,[12] Drehmann,[13] Gallet,[14] Cayre,[15] and McLaren.[16] The so-called congenital dislocation upward is rather an elevation than a luxation of the patella, as has been pointed out by Blencke.[17]

Pathological Displacements of the Patella.—The commonest of these is displacement upward from elongation of the ligamentum patellæ; this is rarely congenital, though a certain congenital laxity of the ligaments may predispose to this affection. Shaffer[18] has pointed out that elongation of the patellar ligament and displacement of the patella upward may be an important factor in the production of certain knee disabilities, and has[19] indicated its connection with slipping patella and displacement of the semilunar cartilages. Shaffer states that with the knee flexed at ninety degrees and the quadriceps tense, the distance from the apex of the tibial tubercle to the lower edge of the patella in an adult is normally not over two inches, and is often less. In his cases of upward displacement the patellar ligament was often three inches or more long.

In rupture of the ligament the patella is drawn upward by the quadriceps, and in rupture of the quadriceps at its insertion the patella drops downward. Schulthess[20] has shown that in congenital spastic paraplegia the ligamentum patellæ is elongated, and the patella displaced upward, probably from the continued traction of the spastic quadriceps. With the knee flexed at ninety degrees, the inferior border of the patella makes a sharp projection in front of the knee in these cases.

According to an investigation of Peltesohn[21] the patella was elevated in eleven out of fourteen congenital spastic cases.

The posterior surface of the patella is concave in these cases, owing to its abnormal relation to the end of the femur.

Slipping Patella; Intermittent Dislocation of the Patella.—In this affection, either from congenital defect, laxity of the ligaments, trauma or genu valgum, the patella becomes displaced outward, and the malposition tends to recur more and more frequently in spite of reduction; it finally may become permanent. Shaffer believes that this condition is often associated with elongation of the ligamentum patellæ, and that this is an important factor in the affection. In several cases he found an exostosis in the intercondylar groove, due, as he supposes, to the absence of the patella from its normal position. Goldthwait[10] reports eleven cases in girls and women, which developed about the age of puberty, and was usually associated with flat-foot and often with knock-knee; in all the cases the tubercle of the tibia was displaced outward and the line of pull of the quadriceps was deviated. Wiemuth[22] reports 66 cases, of which 32 were of congenital origin, 14 traumatic, and 20 pathological. Schanz,[23] Friedländer,[24] and others report cases.

In the milder cases flat-foot should be corrected, and various knee-caps and appliances may be used to hold the patella in place, or to prevent abnormal movement at the knee, but in inveterate cases one or more of the following operative procedures may be necessary:

1. Genu valgum, if present, should be corrected, though this will not always prevent the displacement. If a supracondyloid osteotomy is done the knee should be rotated inward to increase the prominence of the external condyle (Graser[41]).
2. The tibial tubercle with the ligamentum patellæ may be detached with a chisel, and sutured or nailed at a point farther inward on the tibia (Heineke).
3. The patellar ligament may be split and the outer side cut below, passed behind the attached side, and sutured to the internal tuberosity of the tibia (Goldthwait).
4. A long band of fascia at the inner side of the patella is left attached at the two ends, transplanted, and sutured to a long separated incision on the outer side (Krogius[42]), or free aponeurosis may be transplanted (Goebell). Murphy[43] also has an excellent plastic operation.
5. The intercondylar groove may be deepened, and an exostosis, if present, removed.
6. The capsular ligament on the inner side of the patella may be folded and sutured (Le Dentu).
7. Artificial bow-leg may be produced after a supracondylar osteotomy (Chiene).
8. The patella may be excised (R. Fowler).

Ankylosis of the Patella.—After inflammation of the knee-joint involving the contiguous articular surfaces of the patella and femur, the patella may become adherent. This of course prevents voluntary motion at the knee. Where the joint surfaces between the femur and tibia are good, or where it is necessary to do so in order to correct the position of the knee, the patella may be separated by the fingers, mallet, or chisel (see papers by Hübscher[25] and Cramer[26]). If the ankylosis is of long standing and mobility is desired, it is necessary to interpose free or pediculated fat and fascia flaps between the raw surfaces. In arthrolysis of the knee Murphy[44] provides in one of the following ways against adhesion of the patella: (1) interposition of a flap from vastus externus or internus; (2) splitting patella from above downward into two parts and turning the upper under the lower half so that a smooth fibroaponeurotic surface comes next to the femur; (3) freeing patella and quadriceps tendon by longitudinal incisions and separate from overlying skin, rotate 180°, so that the bursal surface of the patella becomes the articular surface, and suture the edges to the vasti; (4) covering the undersurface of the patella with a fascia lata graft detached from the trochanteric region.

Arthrodesis of the Patella.—The denuded patella

either attached or detached may be utilized to produce ankylosis of the knee as practised by Hibbs.[45] The patella bared of its cartilage is placed against the denuded anterior surfaces of the femur and tibia, and the tissues united over it. Hibbs performed this operation seven times for the dangle knees of infantile paralysis, instead of doing a knee excision. In all, the knee was firmly ankylosed after five or six months. The same procedure might be employed for greater stability in excisions of the knee where the patella is sound.

Atrophy of the Patella.—The patella follows the usual law of bone growth, increasing in size and density according to the work put upon it; active muscular individuals have large and strong patellæ. The patella also adjusts itself to the shape and pressure of adjacent structures; hence its size and shape are altered in various pathological conditions. If the function of the leg is interfered with, the development of the patella is retarded or checked, and later atrophy may set in. Individuals with club-foot, congenital dislocation of the hip, and other affections which limit the use of the limb, show less development of bone as well as of muscle on the affected side. In infantile paralysis the effect on function and on bone growth is much more marked, and has been thought to be largely due to interference with trophic centers in the cord. It is well known that chronic joint disease has a profound effect on bone growth. In osteitis of the hip all the bones of the affected limb are shortened, thinned, and narrowed, and this is due to atrophy as well as to retardation of growth. In a series of hip and knee cases measured by the writer,[27,28] the patella was found to be from one-eighth to one-half inch narrower on the affected side within two years of the onset of the affection. The bone was markedly diminished in bulk, in many instances being less than half the size of its mate.

Riders' Painful Patella.—Rosenberger[29] has described a painful affection of the patella observed in cavalry and mounted officers, who have worn tight, stiff breeches and have been continuously in the saddle. The inner border of the patella, which has little adipose padding, and which is most exposed to pressure in riding, is the most painful part. There is at first more or less disability, which together with the pain soon passes off on rest and relief from pressure. No other symptoms were observed by him, but according to Düms[30] there may be inflammatory swelling of the quadriceps tendon with crepitus.

Diseases of the Patella: Primary Tuberculosis.—Fibrous, fatty, sarcomatous, and other tumors of the patella or of parts adjacent to it have been reported, and syphilitic and staphylococcic infections may occur, but the most common and important disease of the patella is tuberculosis. Secondary infections, especially of the articular surface proceeding from tuberculous or other inflammation of the knee-joint, are not infrequent, and are a common cause of adherent or ankylosed patella. Infection may also occur from disease of the prepatellar bursa. Primary tuberculosis of the patella has been described by Volkmann and others, and has attracted considerable attention. Gross[31] in an excellent paper reports thirty-six cases, including four of his own. In thirty-three the age was known, of which thirteen were under and twenty over the age of twenty. There is spontaneous pain in the patella in the daytime and often at night, with extreme tenderness on pressure; the subcutaneous surface of the patella may be uneven to the touch; during the early stages before the involvement of the joint, the functions of the knee are but little interfered with and there may be normal freedom of motion. Later there may be effusion into the knee and synovial involvement; the knee is usually held in extension or nearly so. The most significant symptom is cold, prepatellar abscess of slow formation with enlargement of the patella. Such an abscess is much less movable than a bursal swelling, and puncture or exploration should clear up doubtful cases. Later on, sinuses may form, leading to cavities in the cancellous tissue. Volkmann[32] depicts such a case in section. If it is overlooked or neglected extensive disease of the knee-joint usually results.

Gross' conclusions are that primary tuberculosis of the patella is more frequent than is usually supposed; that treatment is usually too long postponed; that it is a serious affection rapidly perforating into the joint; that with an early diagnosis a relatively simple operation will cure it; the procedures ordinarily employed are *évidement* of the focus, and in the later cases subperiosteal or total ablation of the patella, with synovectomy or arthrectomy when necessary. Absence of the patella interferes but little with function, and it may be reproduced after total subperiosteal ablation. He remarks that: "If one bears the possibility of tuberculosis of the patella in mind many knees will be saved." Murphy[46] reports two cases of primary tuberculosis of the patella in men, with excellent functional result after a plastic operation, whereby after removal of the patella a flap from the vastus externus was brought down and sutured to the edges of the gap.

Other papers on primary tuberculosis of the patella by François,[33] Forget,[34] Ménard,[35] Ribas,[36] Schlüter,[37] Kummer,[38] Kocher,[39] and Röpke[47] may be consulted.

HENRY LING TAYLOR.

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Patin, Gui.—Born on April 31, 1601, in the village of Oudan, near Beauvais in the present department of Oise, France. He studied medicine at Paris and received the degree of Doctor on Dec. 17, 1622. Ten years later he was appointed Professor of Surgery at the Faculty of Medicine of Paris, and, a few years later still, he accepted a call from the Royal College to fill the Chair which for several years had been occupied by Riolan. In 1650 he was chosen Dean of the Faculty. He died on Aug. 30, 1672.

Gui Patin was a great admirer of the teachings of Hippocrates, Galen, Fernel, Duret, Houillier, Baillau, and Heurnius. All other medical treatises, he claimed, were only pale and weak copies of these good authors. His methods of treatment were extremely simple: in acute diseases he employed bloodletting, and he never administered the more violent purgatives. He did not approve of the use of antimony, the remedy which in his time had only recently been introduced. He classed those who prescribed this drug as little short of poisoners. He was not a fortune-hunter, he did not cultivate the great and influential men of his day, nor was he willing to accept any of the attractive positions which were offered to him in other cities of Europe.

The only important writings that we possess today from the pen of this famous Paris physician are the letters which he wrote at different times to his friends. The titles under which they were published a few years after Patin's death are as follows: "Lettres choisies, etc., nouvelle édition augmentée de plus de trois cents lettres," 3 vols., 1692; "Nouveau Recueil de lettres choisies," 1695, and again in 1725, 2 vols.; and "Nouvelles lettres de Gui Patin, tirées du cabinet de M. Spon," 1718, 2 vols. A. H. B.

Pau.—The city of Pau, chief town of the Department of the Basses-Pyrénées, France, stands upon the north or right bank of the river called the Gave de Pau, at the height of 130 feet above the river-bed, and 620 feet above sea level. The latitude of Pau is 43° 17′ N.; its longitude is 0° 23′ W. The population of the town is about 35,000. Its situation, on the edge of a plateau immediately above the river-bed, and the location, at the brink, as it were, of this plateau, of the old castle with its terrace, of the Place Royale, the Boulevard du Midi, and the Parc (containing thirty acres of ground and beautifully planted with shade trees) render the town a decidedly picturesque place in appearance, while the view of the Pyrenees Mountains, which may be had from all the points just mentioned, is remarkably fine.

The reputation of Pau as a winter health resort (Oct. 1 to April 30) is notoriously great, particularly with the English as indicated by the fact that there are no less than four English churches, and its hotels are excellent, especially such as lie in that part of the city which is nearest the edge of the plateau, and from which the view just mentioned is obtained. There are also apartments and furnished villas in great numbers and all prices.

The climate of Pau is characterized by its freedom from winds. Equability of temperature and comparative mildness. Although not so mild as the Western Riviera, it is warmer in winter than at Montreux or Meran. Frost and snow, however, are not uncommon according to Yeo. The mean winter temperature is 43° F. and for the whole year 56° F. For the five months, November to March, the mean temperature according to Hann, is as follows: November 47.84° F.; December 43.34° F.; January 42.26°F.; February 44.42° F.; March, 48.20° F. The mean annual rainfall is 43 inches of which 11.3 inches fall in winter: and during the six months from November to April the average number of days upon which rainfall is between eighty and ninety. Although falls of rain are frequent they are not usually of long duration and commonly occur in the early or latter part of the day. (Dr. A. Rotureau, Dictionaire Encyclopédique des Sciences Médicales.) The average relative humidity is from 73 to 85 per cent.

"Compared with French health resorts on the Riviera," says Dr. I. Burney Yeo ("The Therapeutics of Mineral Springs and Climates"), "it is moister, its rainfall and number of rainy days are greater, it has less sunshine and sun heat, and periods of cold weather are more common. On the other hand, its temperature is more equable, and it is much freer from winds. The climate of Pau is sedative," not bracing.

The diseases for which the climate of Pau is regarded as beneficial are the various catarrhal conditions of the respiratory passages: dry bronchitis with irritable cough, emphysema, and nervous complaints of an erethistic nature. Formerly Pau enjoyed a wide reputation as a winter resort for cases of pulmonary tuberculosis, but at the present time it is considered too moist for the successful climatic treatment of this disease. There is, however, in the neighborhood of Pau a small sanatorium (The Trespoey Sanatorium) six hundred and ninety-five feet high, for the treatment of pulmonary tuberculosis; it is open from the middle of October to the middle of May. One can find at Pau good facilities for golf, polo, tennis, and cross-country racing. There are four English churches and a Scotch one, and a good English club. Many delightful excursions can be taken from Pau as a center. "It is only a few hours from Biarritz and the shores ofthe Bay of Biscay, and most beautiful and interesting tours of any length can be made into the Pyrenees in the fine days of spring" (Yeo). There has recently been opened a winter palace of much magnificence, where operas, etc., are given. English physicians are also to be found here. Edward O. Otis.

Paulus Ægineta.—Born in the Greek island of Ægina. According to some authorities he lived during the fourth century of the Christian era, according to others during the seventh. He was not an original author, yet on the other hand he was not a simple copyist. To quote his own words: "The object which I had in view when I began writing this work was to make a sort of epitome of medical knowledge which the physician might readily take with him on his travels. It will perhaps serve to recall to mind the things which one has read about in some larger treatise. From each author I have taken what I considered his best, and I have striven hard not to omit any of the ills of which these writers speak." The most valuable part of the work is that in which he discusses surgical matters. In no other ancient treatise will one find the art of surgery described so fully or so clearly as in this book of Paulus Ægineta. It bears the title: "Pauli Æginetæ de re medica libri septem, græcè," Venice, 1528. A. H. B.

Pavilion Spring.—Berks County, Pennsylvania.

Post-office.—Wernersville. Sanatorium.

Access.—Via Bound Brook route, Central Railroad of New Jersey, Lebanon Valley Railroad, or Phila-

delphia and Reading Railroad to Wernersville; thence one and one-half miles by private conveyance to spring.

The Pavilion Spring is not itself a resort, but its waters are used commercially, and locally it is used to supply the Grand View Sanatorium. It is located on the grounds of the sanatorium, near Wernersville, and nine miles from the city of Reading. The situation of the sanatorium is on the South Mountains, about 1,000 feet above tide water, in the midst of charming and picturesque surroundings. This institution is an old and well-known health resort, having been established in 1847. The buildings have been greatly enlarged and improved recently, and the resort is now fitted up with all kinds of appliances and conveniences for combating morbid conditions. A beautiful natural park of 600 acres of mountain and cultivated land surrounds the buildings. The culinary department is ably managed. The table is largely supplied from the large sanatorium farms. The Pavilion Spring has been analyzed by Prof. Otto Luthy, analytical chemist, of Philadelphia, with the following results:

Reaction neutral. One United States gallon contains: Potassium sulphate, gr. 0.18; sodium sulphate, gr. 0.02; sodium chloride, gr. 0.06; sodium carbonate, gr. 0.33; calcium carbonate, gr. 0.23; magnesium carbonate, gr. 0.12; iron oxide and alumina, a trace; silica, gr. 0.94; organic and volatile matter, gr. 0.10. Total, gr. 1.98.

This water is very lightly mineralized, containing, indeed, fewer solid ingredients than that supplied to many of our larger cities. It is remarkably pure, however, and well adapted for table purposes. The water contains a considerable amount of carbonic acid gas and atmospheric air.

Additional springs have been developed, among which is the Keystone Spring, a medicinal chalybeate water, a natural tonic indicated in many anemic conditions.

This locality is noted for the healthfulness of its climate. The air is very dry and invigorating.

The diseases treated are chiefly those of a chronic but curable nature. The climate is especially desirable for catarrhal conditions, rheumatic troubles, gout, neuralgia, liver disorders, and various forms of nervous diseases, as well as cases of debility.

EMMA E. WALKER.

Pavor Nocturnus.—*Synonym:* Night terrors. This is a nervous disorder of early life, being characterized as a paroxysmal neurosis of the higher centers, manifesting itself as a disturbance of sleep somewhat allied to nightmare. The following admirable description is given by Cautley: "The attack comes on in the early part of the night, an hour or two after going to sleep. The child suddenly starts up with a piercing shriek and is found sitting up in bed, standing on the floor or hiding in some part of the room, in a state of terror and mental confusion, with sometimes a sense of suffocation. Sometimes he is very pale. He may scream with fright, and cry out inarticulately and unintelligibly. He is oblivious of his surroundings, does not recognize his nurse though he may cling convulsively to her, and has hallucinations of vision, rarely of hearing. His pupils are dilated, eyes wide open and staring, the body trembling, hands clenched or moved as if in self-defense, and he sweats freely." According to the above author the distinguishing features of pavor nocturnus are emotional distress, hallucinations, abeyance of consciousness, and lack of remembrance the next day. The condition is to be differentiated from nightmare, somnambulism, somniloquence, and nocturnal epilepsy. It has certain features in common with enuresis nocturna. Coutts draws this distinction between pavor and nightmare; in the former the child sees visions; in the latter he dreams dreams. In pavor the nature of the hallucination is constant from one attack or one night to another, while the dream in nightmare may vary. Nightmare is associated with ill health, with recollection of the nature of the dream, and with recognition of the nurse and surroundings.

The attack of pavor lasts from a few minutes to an hour, and rarely occurs more than once during the night. It may occur every night or at infrequent intervals. The condition is found as a rule in children of distinctly neurotic heredity and is sometimes associated with other forms of disturbance of sleep. Goodhart notes that of thirty-seven cases there was a family history of rheumatism in nineteen. This fact may account for the occasional though rare occurrence of chorea as a sequel of pavor nocturnus. The proportion of boys and girls is three to two. There have been described two types of pavor: asphyxial and primary cerebral. In the former the attack develops slowly as the result of respiratory obstruction from hypertrophied tonsils or adenoids, or reflex stimulation of the vagus by some gastric or intestinal disturbance. The primary cerebral or indiopathic type occurs in children who are predisposed by a neurotic or rheumatic heredity, and in whom the exciting causes of the attacks are "school work, pantomimes, dark rooms, variable shadows, gruesome pictures, or tales of ghosts." The age incidence of pavor is generally from the third to the eighth years of life, but most frequently during the fourth year.

PAVOR DIURNUS or day terror may be associated with or replace pavor nocturnus. It is characterized by sudden attacks of screaming and terror that may arise even in the midst of play, and in young infants by attacks of paroxysmal screaming.

In the treatment of pavor the attempt should be made to diminish the susceptibility by regulating the mode of life. School work should be restricted and the child should be kept from unpleasant sights and pictures and protected from gruesome tales. Any peripheral exciting cause such as hypertrophied tonsils and adenoids should be removed. Attention should be paid to the gastrointestinal tract: the diet should be carefully supervised and a laxative should be administered. A dose of bromide or of bromide and chloral may be given at bedtime. In some cases associated with anemia the use of iron, particularly of the syrup of the iodide, is quite effective in controlling the attacks. ALEXANDER SPINGARN.

Pavy, Frederick William.—Born at Wroughton, Wiltshire, England, on May 29, 1829. He received the M. B. degree of London University in 1852, being medallist of his class in medicine, and the next year obtained his M. D. degree.

His medical life centered around Guy's Hospital, London, where he was appointed both House Surgeon and House Physician, and in 1854 was appointed lecturer on anatomy. In 1859 he became assistant physician at Guy's Hospital and a lecturer on clinical medicine during the summer session. In 1860 he was admitted to fellowship in the Royal College of Physicians of London, and a year later he presented his first communication to the Royal Society, presenting his researches on sugar formation in the liver. During 1862–63 he delivered the Goulstonian lectures on Assimilation and the Influence of its Defects on the Urine. In 1871 he was appointed full physician at Guy's Hospital and lecturer on medicine at its medical school, which appointments he held until 1890 and 1886 respectively. In 1878 he delivered the Croonian lecture before the Royal College of Physicians of London on the subject of "Certain Points Connected with Diabetes." He became Harveian orator of the Medical Society of London in 1886, and in 1888 he received his degree of LL. D. at Glasgow. In 1890 he was admitted to the con-

sulting staff at Guy's Hospital. In 1893 he was made president of the Royal Medical and Chirurgical Society, and in 1894 he again delivered the Croonian lecture before the Royal College of Physicians, and in 1897 a supplementary Croonian lecture on "Points Connected with the Pathology and Treatment of Diabetes." In 1901 he was presented with the Baly gold medal from the Royal College of Physicians for his work on physiology. In 1908 he delivered some lectures on "Pathology and Treatment of Diabetes Viewed by the Light of Present-day Knowledge" before the same society. In 1909 he became a Lauréat de l'Académie de Médecine de Paris, receiving the Prix Godard for his researches in physiology.

Pavy's name is associated with the study and research on diabetes and sugar in the liver. He contended that there was no normal passage of absorbed carbohydrates from the intestine to the liver, but that it occurred only when an undue amount of sugar is present in the digestive tract. He also advanced the theory of postural albuminuria, and the one that the living gastric wall owes its protection from autodigestion to the alkalinity of the blood.

He began his writings when as assistant physician at Guy's Hospital in 1859 he published in the Guy's Hospital Report a paper on the Lesions of the Nervous System Producing Diabetes. His most celebrated books are "Researches on the Nature and Treatment of Diabetes," published in 1862, the second edition appearing in 1869; "A Treatise on the Function of Digestion; Its Disorders and their Treatment," 1867; in 1874 there appeared his "Treatise on Food and Dietetics," which made a profound impression on the medical profession; in 1894 "The Physiology of the Carbohydrates, their Application as Food and Relation to Diabetes," was issued; and in 1906 he published his last work, "Carbohydrate Metabolism and Diabetes." E. L. J.

Peaslee, Edmund Randolph.—Born in Rockingham County, N. H., Jan. 22, 1814. He obtained his early professional training from the Yale Medical School, at New Haven, Conn., and received the degree of M. D. from that institution in 1840. About one year after he had graduated he was elected Professor of Anatomy and Physiology in Dartmouth College, as successor to Dr. Oliver Wendell Holmes who had been called to fill the same chair in the Harvard Medical School. In 1871, after a service of thirty years in the department of anatomy, Dr. Peaslee resigned this chair and was immediately elected to occupy that of gynecology in the same institution. During the first seventeen years of his professional career—that is, until 1858—he was both a teacher and an active practitioner of medicine, his practice being carried on in the college town of Hanover, New Hampshire. During the year last named, however, while still retaining his professorship of anatomy, he removed his residence to New York and established himself in practice in that city, more especially as a gynecologist. In 1872, when the Woman's Hospital was reorganized, Dr. Peaslee was appointed one of its Attending Surgeons. From 1874 to the time of his death (1878) he held the position of Professor of Gynecology in Bellevue Hospital Medical College.

Dr. Peaslee performed the first successful ovariotomy in New England, in September, 1850; all of his first six cases, previous to 1857, being successful. He also was the first (in 1855) to make use of injections into the peritoneal cavity after the operation of ovariotomy.

Of his various contributions to medical literature the following deserve to receive special mention: "Human Histology," printed in 1858 and said to be the first systematic work on this subject published in the English language; "Ovariotomy, When and How to Perform It, and Its Treatment," 1867; and "Ovarian Tumors and Ovariotomy," 1872. A. H. B.

Pecquet, Jean.—Born at Dieppe, in France, about the year 1622. While he was pursuing his medical studies at Montpellier he made the discovery (1647) that has permanently connected his name with a part of the lymphatic system—viz., Pecquet's reservoir or cistern (cisterna chyli), and the thoracic duct. Subsequently, while carrying on his anatomical researches at Paris, he demonstrated the fact that the lacteal vessels do not terminate (as was then generally supposed) in the mesenteric glands, in the spleen, or in the liver, but pass on into the lower dilated part of the thoracic duct, which in turn empties its contents into the left subclavian vein. Pecquet's discovery removed the last obstacles which stood in the way of the acceptance of Harvey's theory of the circulation of the blood. Pecquet died in February, 1674.

His anatomical discovery is described in the work entitled: "Experimenta nova anatomica quibus incognitum hactenus chyli receptaculum, et ab eo, per thoracem in ramos usque subclavios vasa lactea deteguntur," etc., Paris, 1651. A. H. B.

Pediculidæ.—A family of insects including the lice. These parasites are found all over the world on man and animals. Aside from their bites they carry protozoan parasites. There are six genera and over forty species. Important genera are *Pediculis*, *Phthirius*, and *Hæmatopinus*. See *Insects, parasitic.* A. S. P.

Pediculoides.—A genus of mites in which there is striking sexual dimorphism. These arachnids are usually parasitic on insects but may be accidental parasites of man. *P. ventricosus* often causes dermatitis among men handling grain. Other constitutional symptoms may be present, such as chilliness, nausea, albuminuria. See *Arachnida.* A. S. P.

Pediculus.—A genus of lice, containing two species which attack man. *P. humanus* (= *P. capitis*) is the head louse; *P. corporis* (= *P. vestimenti*) is the body louse; See *Insects, parasitic.* A. S. P.

Pellagra.—*Definition.*—An endemic malady, characterized by an erythema (generally bilateral and symmetric) upon the exposed surfaces of the body, by gastrointestinal disturbances, and by nervous and psychic phenomena.

Synonyms.—These of the past and present times are numerous, among which are Alpine scurvy, Asturian leprosy, Asturian rose, Disease of the Landes, Maidismus, Psychoneurosis maidica, Mal de la rosa, Mal del sole, Mal de misere, Mal del padrone, and many others. The name pellagra (*pelle*, skin, and *agra*, rough) we owe to Frapolli, and this writer declared that the disease was an ancient one, and none other than the sickness *pellarella*, which was noted in 1578 by the authorities of the Hospital Major, of Milan.

History.—To trace back the history of this disease among the rather scattered archives of the middle ages is both interesting and difficult; and to weave a chronicle of pellagra without encountering the visage of maize seems almost impossible. Through the tangled skein, as it is interwoven with the destinies of several nations and peoples, we see the rise and decline of this malady almost coincident with the consumption of Indian corn; and, try as we may, we cannot dissociate the two.

In 1600, Baruino, in a medical treatise, called attention to a peculiar sickness prevailing among certain tribes of the American Indians. His incomplete description leads to the belief that it was pellagra, and he even then ascribed it to the use of corn. A few months later, Francisco Scipione, an Italian litterateur, described more completely a similar disease.

The first authentic accounts of pellagra in Spain appeared between 1680 and 1700 and, strange to say, corn was introduced as an article of food about that time. The first really scientific account is ascribed to Gaspar Casal, who, in 1735, observed it in the vicinity of Oviedo, and gave it the name of "mal de rosa."

In Italy it appeared about twenty-five years later where Frapolli named it. By 1776, also a notable year in American annals, the disease had spread to such an extent that the Venetian authorities, at the request of the sanitary commission of Venice, issued an edict prohibiting the sale or exchange of ill-smelling, ill-tasting, or discolored corn.

From this period till 1839 but little was done to check the ravages of pellagra, when the Lombard government, becoming alarmed, appointed a commission to investigate and act. From then up to the present date the various governments of the Old World have been alive to the importance of this problem.

No nation of the Old World seems to have been exempt, even England furnishing a number of cases. It is proper to say, however, that it has made but scant headway in the colder countries, while in the warmer there either has been established somewhat of an immunity, or the various health boards have the situation well in hand. Though many thousand cases of pellagra are undoubtedly present in the Old World, the situation does not seem as acute as in the United States of America.

Pellagra in the United States.—As early as 1863 two cases were recognized in New York and Massachusetts, and about that time an epidemic of supposed pellagra raged in Halifax, Nova Scotia. During the late Civil War the fearful mortality in several of the southern prison camps, notably that at Andersonville, was ascribed by some to this malady.

Up to 1883 no cases were reported till Dr. Sherwell, of Brooklyn, diagnosed it in a Genoese sailor. In 1889, Dr. Bemiss of New Orleans left a written diagnosis of a case occurring in Charity Hospital in that city. During these years it is certain that pellagra existed in the Southern States under various diagnoses. The writer recalls an undoubted case occurring under his observation twenty-two years ago.

In 1902 the disease was recognized in Georgia, and since then its prevalence has been more and more generally noted, until now it is known to be present in every State in the Union. A late estimate by Dr. Beall of Texas places the number of pellagrins in this country at 50,000. The writer believes that a conservative view, and one well within reasonable bounds, would put the number at about 40,000, a large proportion being in the Southern and Middle-Western States.

Etiology.—This has not been proved satisfactorily. Etiological viewpoints have veered from the syphilitic to the zeist; from the zeist to an infection carried by a winged blood-sucking insect; as a water-borne disease, where the potable waters contain silica in colloidal solution; and as a nutritional condition, precipitated by the lack of certain necessary elements in the diet.

The writer has not abandoned the theory that the ingestion of spoiled maize or some form of deteriorated carbohydrate food bears an etiological relation to pellagra. In addition, as markedly in accord with the writer's views, both written and expressed for the last five years, may be quoted Dr. Joseph Goldberger, Surgeon U. S. Public Health Service in Charge of Pellagra Investigations: "The writer (Dr. Goldberger) is satisfied that the consumption of corn or corn products is not essential to the production of pellagra, but this does not mean that corn, the best of corn, or corn products, however nutritious or however high in caloric value they may be, are not objectionable when forming of themselves or in combination with other cereals and with vegetables, a large part of the diet of the individual."

In the meanwhile, considering the great uncertainty that exists as to the true cause of pellagra, it may be suggested that, pending the final solution, it is well to attempt to improve the dietary of those among whom it seems most prevalent. There should be advised a reduction in cereals, vegetables, and canned foods that enter to so large an extent into the dietary of many of the people of the South, and an increase in the fresh animal food component, such as fresh meats, eggs, and milk.

Symptomatology and Course.—Seldom in the history of disease processes has there been studied one whose symptoms and clinical history presented such a varied panorama as pellagra. The gastroenterologists have noted the ever-present digestive disturbances; the dermatologists have followed the skin lesions, from simple erythema to the many grades of dermal inflammation; the neurologists and alienists have found it a fertile field for investigation; while even the surgeons have attempted to show a causative relation between pellagra and intestinal stasis or infected gall-bladder.

Digestive Symptoms.—The gastric disturbances do not differ materially from those of chronic catarrhal gastritis, mostly of the hypoacid or anacid variety. In gastric analyses of 64 cases of undoubted pellagra, free hydrochloric acid was absent in 18, deficient in 31, excessive in 12, and normal in 3. There seemed an excess of stomach mucus in 41. In those who were nauseated or vomited frequently, bile was invariably found in the stomach. It was particularly observed that the gastric secretions were diminished or absent in most of the long-standing cases, while the few hyperacid cases were generally recent.

In many instances the first train of ailments bringing a suspicion of pellagra is a sensation of burning in the mouth and stomach, accompanied by vague digestive and neurasthenic fancies. Slight paresthesias and formications of small areas are generally also present. Upon examination the physician observes a diffuse redness of the buccal mucous membrane—not the bright scarlet of scarlatina, nor the angry hue of stomatitis proper, but rather a decided pink, glistening on the membrane and imparting to the lips a cherry red, with a well-marked line of demarcation at the juncture of the skin. Another point is the tendency for the corners of the mouth to become sore. The appearance of the tongue is often quite characteristic. It may be coated centrally, but the edges are smooth and slick, showing a surface denuded of epithelium. In early cases only the tip and sides show this denuded condition, but later the whole tongue may lose its epithelium, giving it the bald look, sometimes called the "cardinal tongue." When the redness is pronounced the tongue may be exquisitely sensitive, but many times a semi-pallor supervenes, and a lack of sensation almost akin to anesthesia is there.

At this early stage the patient may complain of an ill-defined dyspepsia, with flatulence, pyrosis, eructations, and epigastralgia. A large majority of pellagrins are dyspeptic, this symptom persisting to a lesser degree during remissions of the disease.

It should not be forgotten that pellagra can be engrafted on any of the organic or functional gastric affections, so the medical attendant should be alert in the presence of atypic digestive symptoms. Gastric flatulence is extremely common, accompanied by loud and explosive eructations.

Occasionally constipation is found in the earlier stages of pellagra, but this is exceptional. The usual history includes attacks of diarrhea, apparently causeless, not depending upon what is eaten, and ceasing suddenly. This diarrhea is of central origin, and to an extent compensatory. Another peculiarity of this diarrhea is its explosive nature and difficulty of control. The odor of these pellagrous stools is almost characteristic. To describe an odor is at best unsatisfactory, but, like that exhaled from smallpox patients in the desquamative stage, or the peculiar smell of the vaginal discharges in uterine carcinoma, these feces have a distinctive odor. Those who have examined many cases of pellagra, can almost diagnose it by the olfactory senses. Later this diarrhea may merge into the irritative or dysenteric, or even choleraic, and become a terminal symptom.

Skin Symptoms.—The dermal manifestations, though generally in evidence at some stage of the disease, are not necessarily the first; on the contrary, they sometimes do not appear until late in the course, and in exceptional instances usher in the closing scene.

The first eruption begins as an erythema, not unlike a sunburn, and, as it generally shows on the exposed parts of the body, is often thought to be that. Though this lesion gave pellagra its name, it should be no more considered a purely skin disease than leprosy or syphilis. This erythema, when first noticed consists of a redness, swelling, and tension of the skin, sometimes persisting only a short time, and leaving the surface where it appeared scaly and rough.

One of the most characteristic features of the eruption is its symmetry. A skin lesion seen on one hand or arm is almost sure to be duplicated on the other hand or arm; or one showing on one part of the body or side of the face is equally in evidence on the corresponding side or part. A "one sided" eruption should possess much corroborative proof ere it marks the diagnosis of pellagra.

Another noticeable feature of the skin lesions, fully as important as their symmetry, is the sharply circumscribed border seen most frequently in the patches upon the neck and hands. Indeed, the lesions upon the neck, forming the so-called "necktie" of Casal, are absolutely distinctive. A striking picture is also presented by the eruption on the backs of the hands and wrists, in many cases seen not only on the back, but also upon the front of the wrists. During the subsidence of the eruption the sharp border is not so well defined.

Comparatively few show lesions upon the face. Some have them on the dorsal surfaces of the feet, and in others a large part of the surface of the legs, or even a large area of the body may be involved. To be more exact, it might be well to consider the early eruption as an erythema, while the later is a dermatitis of a greater or lesser intensity.

Sometimes this dermatitis involves the vulvar region, as well as the perineal, the anal fold, and the internal surfaces of the thighs, which are brought in contact by adduction. In some cases the surfaces of the elbows and to a less extent the knees may be involved. There is also a tendency for the dermatitis to extend from the elbow down the ulnar, meeting the "gauntlet" coming up from the hand.

After the eruption has persisted for a time, it tends to assume a dingy black hue, rough and hard, and disagreeable to the sufferer. These dark patches are generally on the palms of the hands, soles of the feet, on the sides of the nose, or on the forehead at the junction of the eyebrows.

The deeper forms of pellagrous dermatitis may exfoliate in large scales, leaving raw, bleeding surfaces, or even ulcerated patches, requiring granulations for healing. The very deep inflammations of the skin, where extensive loss of tissue and gangrene take place, are rare, generally marking the termination of the pathologic drama.

Nervous Phenomena.—Many of these are the logical expressions of a trophoneurosis, as the shooting pains, the burning surfaces, the quick and surprising changes in the aspect of pellagrins from day to day—all pointing to central and material nervous disturbance.

From the first fleeting pains, accompanied often by paresthesias and formication, to the flickering pangs of a disappearing neuritis, nervous symptoms are in evidence practically the entire time.

Among the earliest symptoms may be a dysphagia, burning of the mouth and tongue, burning hands and feet, and lightning pains not unlike tabes. These neuroses, especially the burning, should always excite suspicion. Contractures are generally late, and seldom appear until other diagnostic signs are unmistakable.

The skin reflexes are rarely normal—either diminished or exaggerated. Cephalalgia is not uncommon. Insomnia comes on early, persisting until convalescence is well under way. Few pellagrins are good sleepers while the disease is progressing.

Psychic Symptoms.—These are in many instances hard to differentiate from the nervous, but few cases are without psychoses of some description. Ranging from indefinable mental distress or gloom to acute mania, from a mild melancholia to dementia, from a nagging restlessness to suicidal tendency—the psychic picture presents a changing panorama, which taxes to the uttermost the acumen of the medical attendant.

Pathology.—This is not distinctive, and will not be elaborated. Broadly speaking the changes are analogous to those of senility, with atrophic degeneration.

Apart from a calcareous degeneration of the cerebral vessels, a thickening of the membranes of the brain and its vessels, which help to explain the frequent psychoses, and the tendency to atheroma and precocious senility, there are no constant pathologic or pathognomonic changes.

Prophylaxis.—Pellagra is not considered contagious, and no specific infection has been found. It would appear, however, that certain environments lend aid to its spread, and feeble or ill-nourished individuals would do well to avoid such apparent foci.

The investigations of the Thompson-McFadden Commission seem to have proved the value of good sewerage and hygienic surroundings in fighting this disease, and such precautions should be observed as far as practicable.

Dietetic measures will be covered under treatment.

Quarantine or isolation does not seem to be required or justified.

Treatment.—*Hygiene.*—The hygiene of pellagra is similar to that of other exhausting diseases, with two exceptions. The first is that alcoholic beverages in any amount seem to be highly detrimental. While an occasional alcoholic stimulant may be of questionable aid in conditions of extreme weakness, a favorable prognosis should be given with caution in those of convivial habits. The second exceptional hygienic precaution is that sunlight, direct or reflected, should be avoided during the spring and summer months; and danger also lies in becoming overheated. The actinic rays exert a peculiarly irritating effect on the skin of pellagrins, which is seemingly most marked in early spring. Exposure to these rays or to radiant heat from a stove or furnace will, in a pellagrin, bring out an erythema, or will renew one that has been apparently healed. Pellagra flourishes in hot weather, and subsides in cold; consequently, the sufferers fare much better if they can be kept in a cool environment.

Diet.—In this disease corn-bread and corn-products should be prohibited, unless it is positively known that the corn is fresh, and has undergone no "heating." Until the "zeist" theory is thoroughly disproved, we owe our pellagrins this precautionary measure.

As to other dietetic rules, we should remember that in this malady the gastrointestinal manifestations are the expressions of a disease not primarily localized in that tract, but of a centralized irritation, plus the effect of toxins eliminated through the intestinal mucosa. As demonstrated by the writer five years ago, the early diarrhea is mainly of central origin, and to some extent compensatory. It, therefore, does not require a too limited regimen, nor does such seem to aid the disordered bowels. Woody vegetables and those yielding a large amount of residue are mechanically contraindicated at any time diarrhea is present, but care should be taken to replace them with other nourishing food. The flesh proteins are specially well borne. Tender broiled steak, roast beef or mutton may be allowed once or twice daily; or, if the mouth is too sore to allow chewing, beef or white meats, either scraped or ground, may be substituted. Eggs generally agree, though it is well to use only the whites, if flatulence exists.

Sweet milk is valuable when it agrees, and also buttermilk, fresh or artificially prepared, is suitable.

Dried beans or peas, well boiled and put through a colander, with an abundance of butter, should be insisted upon at least once daily. Thoroughly baked Irish (not sweet) potatoes, oatmeal, rice and like articles are indicated. During the whole course of pellagra the invalid must be nourished to the limit of assimilation, and it will generally be found that the gastrointestinal tract in this disease will bear and care for more aliment than when similarly inflamed from other disorders.

Drugs and Hydrotherapy.—Hypodermically there may be used ampules of iron arsenite solution (sixteen minims) and sodium cacodylate solution ($\frac{3}{4}$ grain of the salt), on alternate days, injecting them under careful aseptic precautions, and giving one daily for about two weeks. After that, an ampule may be given every other day, still alternating. After the acute symptoms seem to be controlled, two injections weekly may be kept up (still alternating the ampules) for several months. Should the patient be quite anemic and nervous, there may be substituted for the two previously mentioned ampules the ampules of the green citrate of iron (1 c.c.) and glycerophosphate compound (1 c.c.), alternating as before. Large doses of sodium cacodylate are dangerous, and liable to set up late ocular symptoms.

Internally there should be administered a combination of saturated solution of potassium iodide and Fowler's solution, in the proportion of five of the first to three of the second. Beginning with five drops in water three times daily after meals, the dose should be increased one drop each day, until symptoms of arsenical saturation are manifested. This generally appears when twenty to twenty-five drops are being taken. When there is puffiness about the eyes on arising, the drops should be discontinued for two days, beginning again at the minimum dose of five drops, and increasing as before. This procedure may be continued until the eruption and sore mouth are abated, and then the prescription may be kept up in eight- or ten-drop doses for several months.

For the frequent diarrhea, satisfaction will be obtained from bismuth betanaphthol and resorcin, with milk of bismuth as a vehicle. This failing, fifteen grains of tannigen after each loose action may be given, or, as a last resort, powdered opium. A colonic injection on alternate days of a pint of plain kerosene oil will be found quite effective. This may be allowed to remain in the bowels about half an hour. Two to four injections are generally sufficient.

For the infrequent constipation either castor oil or liquid paraffin or phenolphthalein is best, drastic cathartics being unwise.

For the sore mouth a twenty-five per cent. solution of boroglycerin may be allowed as a mouth wash, and a daily application of silver nitrate solution (twenty grains to the ounce of water) will generally prove efficacious.

Gastric lavage is seldom indicated, except in rare instances, where a great excess of sticky mucus constantly arises.

The simple erythematous rashes or even the sloughing conditions in the hands or feet may be benefited or cured by the bland ointments, as zinc oxide, five per cent., boric acid ointment, or the scarlet red salve. Raw or weeping surfaces are soothed by a lotion of calamine and zinc oxide, to which may be added a little rose water or other pleasing adjuvant.

For the intense burning of the hands or feet, either ice-cold compresses of a mild solution of mercuric chloride, phenol, sixty grains to the pint, applied at frequent intervals to the unbroken skin, or baths of hot mustard water are indicated. Two- or three-grain doses of acetanilid, or five-grain doses of acetylsalicylic acid, when the heart action is good, will greatly relieve neuralgic pains, while brisk rubbing with petrolatum to which has been added capsicum or menthol is advisable for the pseudorheumatic pains in many joints and muscles.

After the erythema has subsided, leaving a rough and hard surface, alcohol rubs at frequent intervals will facilitate the disappearance of this horny layer.

Special treatment of the purely mental symptoms cannot be covered here. Should such predominate, deepening into melancholia, or lapsing into dementia, the patients should be placed in an institution for the mentally sick, as it is unwise, because of their varying or suicidal moods, to attempt their care at home.

Hydrotherapy has in many instances proved so beneficial in pellagra that some form of it, such as hot or cold baths, simple or medicated douching, packs, moist or dry rubs, accompanied by special massage, may be employed in nearly every case. Increased oxidation of the tissues, more rapid elimination, greater metabolic activity, sharpened appetite, improved digestion and assimilation, and a noticeable tonic effect on the whole living organism follow their use.

Electric-light baths, or the use of the Röntgen ray in any form are contraindicated at all times.

Psychotherapy.—Just now, when a widespread pellagraphobia prevails, when the unhappy victim finds most hospitals, hotels, and boarding-houses closed to him, and many nurses afraid to attend him, can we wonder that the knowledge of its presence carries distress of mind? Much of the fear of this disease is due to unwise words of physicians, perhaps lightly spoken, but deeply impressive and harmful to the already perturbed pellagrin. It is wrong, in any way, to add to the anxiety of the patient, and every legitimate effort should be used to encourage and cheer him. He should be assured that he does not endanger his family and friends, that many cases are permanently cured, and that energy and perseverance on his part will greatly brighten his prospects. Though pellagra is always a grave malady, an unfavorable prognosis, except in extreme cases, should not be hastily advanced.

The writer has in several pellagrins seen pronounced psychoneuroses seemingly arise from discouragement, from sluggish conditions developing in the bodies as a result of lack of hope, and from the refusal to take air and exercise, which accompanies despair. In pellagra, as in many other complicated diseases, many intercurrent ills arise at frequent intervals. Many of these can be promptly alleviated, and a much more sanguine frame of mind may be induced, even if the main lesion is untouched. As has been well said, "though nothing can be done for the disease, much can be done for the patient." In such conditions the mental healers and quacks get their occasional spectacular results.

The belief is reasonable that by suitable suggestions we can delay, if not arrest, nerve degeneration, for a buoyant body and hopeful mind present a firmer bul-

wark against cellular destruction. Therefore, while recognizing the easily managed intercurrent ills and promoting comfort, the physician and those around the patient should endeavor to inspire courage and optimism, so that the higher psychic centers may exert their untrammeled influence for good over the lower.

Prognosis.—The writer's experience in the treatment of nearly 800 cases has taught that there are four classes in which the prognosis should be extremely guarded: persons over fifty or fifty-five years of age; alcoholics; patients with marked mental symptoms, evidencing seriously damaged nerve centers; and those intellectual weaklings, who capriciously veer from one plan of treatment to another.

On the other hand, if the patient is under fifty and has sufficient intelligence and perseverence to adhere to a fixed line of well-advised treatment, and will faithfully cooperate with the physician, a permanent cure may be expected in the majority of cases.

George M. Niles.

Pelvic Inflammation.—Generically speaking this term may be applied to all inflammatory processes involving the contents of the pelvis. In a more restricted and commonly accepted sense however it may be taken to refer to the inflammatory lesions affecting the pelvic cellular tissue and peritoneum. Other descriptive terms include parametritis, perimetritis, pelvic abscess, pelvioperitonitis, pelvic cellulitis, pelvic exudate, etc.

Pelvic inflammations manifest themselves in a variety of ways, but the synonymous terms referred to are apt to be applied rather carelessly, no account being taken in many cases of the exact location of the lesion. It should not be forgotten, however, that an inflammatory process in one part of the pelvis may readily extend and involve some other part, so that the general term "pelvic inflammation" serves a practical purpose.

In considering the underlying causes upon which pelvic inflammatory processes depend, the anatomy of the parts must be taken into consideration. The various pelvic organs are surrounded or are in intimate association with a variety of cellular supporting structures, which are amply supplied with nerves, blood-vessels, and lymphatics, so that communication between the different portions is very free. Anatomists differentiate various distinct arrangements of the pelvic cellular tissue, but the free communication already referred to fails to limit in most instances any restriction in an inflammatory process. Most authors have attempted to distinguish between inflammations involving the peritoneum and those of the connective tissue, describing several forms of peritonitis which depend on the invasion of specific organisms. Aside from lesions of a specifically gonorrheal or tubercular origin, it is questionable whether such distinctions are of any practical value. For purposes of description, however, we may discuss in turn, first the inflammatory disturbances in the pelvic connective tissue and then those which involve the peritoneum either primarily or secondarily.

Parametritis.—The name parametritis was first employed by Virchow and the lesion must be accepted as the result of an infectious process. As a general rule infective organisms enter from the external or internal genitals, but it is possible that the point of entrance may be in the intestines or the bladder. A parametritis most frequently results as a complication of the puerperal state and may take the form of a thrombophlebitis or lymphangitis. This results in the production of an exudate which extends horizontally in the lower segment of the broad ligament and may involve the retrocervical connective tissue. These exudates have a tendency to bring about a fixation of the uterus, particularly in the lower segment of the cervix. Exudates limited to the upper portions of the broad ligament are more infrequent and usually develop from the body of the uterus. These have a tendency to extend upward along the ilia, but may also involve the sacro-uterine ligaments and extend downward into the rectovaginal septum. A still more infrequent localization is met with in the precervical or the paravesical connective tissue and it may also extend upward along the anterior abdominal wall.

Pelvic cellulitis or parametritis may clinically be divided into acute and chronic types. The *acute* varieties include septic puerperal parametritis, septic traumatic including gonorrheal, and a third variety resulting from infection due to foci outside of the genital mucous membrane.

The *puerperal form* of pelvic cellulitis is the most common and the most frequent cause of subsequent gynecologic disturbances. The usual picture presented by a case of this kind is as follows: a rise of temperature and pulse rate within a few days after labor may persist for the first week, after which a gradual reduction takes place. An initial chill may be present accompanied by a circumscribed area of pain in the lower abdomen or side. This condition may persist for a considerable period until resolution gradually takes place or it may go on to a localized abscess formation. In a great many pelvic exudates which follow labor gradual resolution takes place but sometimes we find that after the patient gets up the condition immediately returns. Perforation into the free peritoneal cavity is very unusual, but even where the focus is small a rapidly fatal peritonitis may result. Another complication that may result from the presence of pelvic exudates is a thrombosis of the veins of the pelvis or thigh. The ureters may also be displaced by the formation of the exudate so that renal stasis may result. On examining a patient with a pelvic exudate we find locally more or less rigidity around the uterus that interferes with its mobility. On either side or posteriorly may be felt a brawny mass which is tender to the touch and has a doughy feel. In advanced cases this mass may involve the entire pelvis. If localized on one side or the other the uterus may be displaced laterally. It is impossible in most cases to differentiate the upper borders of such pelvic exudates. Constipation, or in severe cases diarrhea with involuntary movements may result. The bladder is likewise liable to be irritable. As the process subsides the areas of induration rapidly diminish and the uterus again becomes movable.

Persistency of the exudate in the region of the sacro-iliac ligaments is not unusual for many months after apparent recovery. In cases where the exudate goes on to pus formation the pain and tenderness is increased. There is a rise in the pulse and temperature, and the blood count shows a high leucocytosis. A considerable period may elapse before a breaking down results, and even then sometimes absorption may take place without rupture of the purulent focus. In making a diagnosis of this condition its association with a previous pregnancy must not be lost sight of.

Histologically considered we find the cellular tissue which is involved in pelvic inflammation marked by edema and infiltrated with round and plasma cells. Groups of cocci of various types may be demonstrated by staining, both in the tissue and the lymphatics. The blood-vessels usually contain thrombi and their walls show inflammatory changes and infiltration. The exudate may become converted into rigid cicatricial tissue or break down and become purulent. In the latter case the pus is usually of a creamy consistency and presents a foul odor from the presence of migrated intestinal bacteria. If a purulent focus is formed it may in time break through and point in the anterior abdominal wall above Poupart's ligament or through the obturator foramen and point on the anterior surface of the

thigh. In other cases the pus may find its way through the greater sciatic notch and appear as a subgluteal abscess, or finding its way through the pelvic floor appear in the ischiorectal fossa. Perforation of the rectum, bladder, vagina, and even the cavity of the uterus may occur. As a result of chronic inflammations of the pelvic cellular tissue a marked atrophy of these structures may take place.

Pelvic peritonitis is quite generally assumed to depend on a bacterial origin although mechanical, chemical, and thermal effects may become manifest that lead to a similar ending because of the production of adhesions.

The exciting causes of pelvic peritonitis are varied. If the infection takes place through the genitals, streptococci, staphylococci, colon bacilli, gonococci and tubercle bacilli may be found. Among these the streptococcus and gonococcus are the most frequent, while an infection with the colon bacillus is usually of a mixed type. The pelvic peritoneum is very much more resistant to bacterial infection than that in the upper segments of the cavity and a considerable number of microorganisms may be overcome in this manner, but it is essential that the structure remain intact to accomplish this purpose, and the virulence of the infection or the number of the invading organisms be not excessive. It is possible that a pelvic peritonitis may be produced without the presence of a distinct infection and bring about adhesions between the uterus and the pelvic peritoneum. Hofmeier believes that this may result from displacements, neoplasms, and excessive coitus, which bring about an injury to the peritoneal endothelium by either actual pressure or chronic hyperemia. This form of pelvic peritonitis is quite rare in comparison with the true infectious type. A peritonitis of the latter kind may result from puerperal infection, from gonorrheal invasion of the genital tube, from the rupture of purulent foci, or from the torsion of infected ovarian or parovarian cysts, and in children attention has been called to the possibility being due to the irritation from pin worms resulting in an ascending infection from scratch wounds. The acute vaginitis which often arises during the course of a variety of infectious diseases in children may bring about a peritonitis in a similar manner. Finally we find that a salpingitis usually causes localized peritonitis. Perforation of the uterus occurring as the result of attempts at criminal abortion or operation may bring about a severe infection of the pelvic peritoneum. Tuberculosis of the genitals frequently leads to this condition. The migration of germs from inflammations of the colon, the appendix, or other segments of the intestinal tract, or their hematogenous transference may result in pelvic peritonitis. Necrotic stumps, or blood accumulation from ruptured ectopic or other causes serve as favorable culture media in the production of peritoneal infection. In cases of puerperal peritonitis the infectious organisms, usually streptococci, find their way from the endometrium through the lymphatics to the peritoneal covering of the uterus, although in some cases a direct extension may take place through the tubes.

In cases where the infection is a highly virulent one the patient may become poisoned so rapidly that at autopsy the only evidences of a peritonitis are the somewhat dry serous coating of the pelvic organs and intestinal distention, merely a few flakes of fibrin being noted. The fatal issue in such cases may be ascribed entirely to the absorption of bacterial toxins. In cases of a more chronic type the lymph flakes are numerous and extensive adhesions are present between the intestinal loops and the internal genitals, pus being found in spots throughout the lower portion of the peritoneal cavity. Where an intestinal perforation has resulted the purulent exudate will have a foul odor. A generalized peritonitis of this kind may become converted later on into a localized abscess, the pus finding its way into the culdesac of Douglas where it becomes incapsulated by a false membrane formed from the adherent intestines and sometimes the omentum. Such an abscess may later rupture into the vagina, the rectum, or the bladder, and occasionally through the abdominal wall. A generalized or diffuse peritonitis may also result from the rupture of a pyosalpinx or an ovarian abscess. If the peritoneal invasion is of a less virulent type a more circumscribed peritonitis occurs because the infective organisms are held in check by the formation of adhesions. It has been disputed whether a generalized gonococcic peritonitis is possible, many authors claiming that the infection is always of a mixed type. In children, however, a primary gonorrheal peritonitis may occur. In gonorrheal infections the adhesions are formed very rapidly and a localized peritonitis results. This may be accompanied by collections of pus, usually in Douglas' culdesac, and later on adhesions of varying degrees are produced, some of which may be sufficiently thick to bring about a displacement of the uterus, ovaries and tubes. In the course of time such adhesions diminish in density but never entirely disappear.

Tuberculous peritonitis has been estimated to occur in over ten per cent. of all tuberculous women. In well-developed cases of this kind we find the pelvic peritoneum studded with tubercles and this is accompanied by the formation of a thin exudate; the serosa is reddened, occasional lymph flakes are present, and adhesions to other parts may form.

Symptomatology.—In considering the symptomatology of pelvic infection a few cardinal features may be noted that apply practically in all cases. We find that the illness is usually preceded by a chill followed by a rise of temperature and the production of pain. The temperature varies in the individual case, depending largely on the etiology. In the foudroyant type the temperature may go to 105° F. and be accompanied by a pulse rate of 140 to 150; the patient is greatly prostrated and the pain severe. In other cases in which the infection is equally virulent we may actually have a subnormal temperature but the pulse is high and the patient is apparently in a condition of deep shock. In other instances where the infection is a slowly progressive one, the temperature rise may not be above 102° F. and the pulse not above 100, but a reduction usually takes place within twenty-four hours followed by a remission. These variations of temperature may continue for a considerable period until the infection is brought under control. Pain of a dull aching character is usually complained of in these more chronic types and the patient's general condition is not affected, although there is no evidence of shock or prostration such as we find in the more acute forms. The differential diagnosis of the various forms of pelvic inflammations in the early stages is of comparatively little importance, as the treatment must be governed largely by the factors in the individual case.

Treatment.—The key-note of the present-day therapeutics of pelvic peritonitis can be characterized by the phrase "masterly non-interference." This does not mean that nothing ought to be done, but it is based on the observation that the more the normal resisting powers of the patient can be built up the better the final results. Thus in an ordinary case of pelvic inflammation, whether of the cellular or peritoneal type following a labor or an abortion, the patient should be propped up in bed or the head of the bed elevated so as to secure better drainage of the uterine discharges, and likewise mechanically limit the infectious process to the peritoneal cavity. Absolute quiet with the application of ice-bags to the pubis and enough morphine to keep the patient com-

fortable should be insisted on. The bowels are preferably moved at the beginning with one or two soapsuds enemas and no cathartics should be given nor further enemas employed unless definite indication for the same is present. Otherwise the irritation of the rectum and the increased peristalsis will only serve to aggravate the infectious process. If the pelvic inflammation follows operative interference the same policy may be pursued. Where an abscess has resulted and the same points either in the vagina or less commonly in the lower abdomen, anterior surface of thigh, perineum, or the gluteal region, this should be opened up under anesthesia if necessary, the pus evacuated and drainage tubes or gauze inserted. In most instances, however, abscess formation does not take place immediately. If a thrombosis of pelvic, femoral, or saphenous veins occur as a complication of pelvic cellulitis, the treatment must vary with the individual case and the environment. Operation for thrombophlebitis of the pelvic veins has been advised, but is of doubtful expediency. Where the process is localized in the veins of the thigh, absolute rest, the local application of an ice-bag and the elevation of the limb are essential. In the severe cases the symptoms of general peritonitis usually supervene upon the local evidences of the disease and the patient is subject to nausea and vomiting together with the development of meteorism, constipation, and sometimes true or apparent intestinal obstruction. If the process involves the neighborhood of the bladder an annoying dysuria may result which requires sedatives. The importance of suitable nourishment in all such severe cases must not be lost sight of, and if nausea and vomiting has been present it can best be overcome by stomach washing and the administration of alkalies. Fluid nourishment in the form of milk, broths, sugar solution, strained gruels, etc., should be pushed. Hot douches are commonly employed in cases of pelvic inflammation, but they are really of no practical value except in the chronic types and may even do harm in the acute stages. They are of value, however, in the chronic processes where the absorption of exudates will be hastened by the administration of douches of not less than four quarts of water at a temperature of 115° F. An antiseptic is not necessary, although the weak astringent effect obtained from dilute iodine solutions (one dram to the quart) may be of assistance. The absorption will also be hastened by the daily use of the sitz-bath and the application at intervals of from two to four days of a depleting tamponade, such as a ten per cent. solution of ichthyol in glycerin. In considering the puerperal forms of pelvic inflammation the original cause must not be lost sight of and the absorption from the uterus may be largely inhibited by the effective administration of oxytocics, especially of the fluid extract of ergot given in doses of one dram three or four times daily. In the gonorrheal types of infection it is very essential that the patient be kept as quiet as possible during the acute stage and nothing done until the process becomes localized or subsides in virulency. When the acute stage has subsided the absorption of exudates can be hastened by the methods already referred to. If the gonorrheal process becomes localized in the tubes as it frequently does, the treatment at the present day is also largely conservative, no salpingectomy being considered necessary in the ordinary case. The treatment of the tubercular forms of pelvic inflammation is largely symptomatic, operative treatment with the removal of affected internal genital organs is often followed by persistent sinus formation, and fresh air, proper nourishment, and rest will be more efficient in most cases. Geo. W. Kosmak.

Pelvis, Anatomy of the.—(Latin, derived from the Greek πελλίς, a basin, the same root as Eng., pail.) The appropriateness of the appellation will be evident on placing a human pelvis on a table in a horizontal position, when it will be seen to resemble a somewhat deep wash basin, with the rim broken away in front and behind. In a restricted sense, the pelvis is the bony and ligamentous skeleton of that portion of the trunk to which are attached the abdominal limbs. Topographically the term is used to designate the whole region for which the bony pelvis serves as a framework, comprising, in this sense, the whole of the pudendal, perineal, sacral, subinguinal, coxal, trochanteric, and gluteal regions, and a part of the pubic and inguinal regions.

The importance of the skeletal framework is great and twofold. First, because it is through it that the weight of the body is supported, and from it that arise the powerful muscles that move the inferior limbs; second, because it forms a bony canal which contains an important portion of the urogenital apparatus, and through which the matured fetus must pass to reach the outer world. The first of these considerations is architectural, the second obstetrical, while both have important surgical bearings.

Boundaries.—This portion of the trunk is defined on the surface of the body by certain landmarks and furrows. Above, there may be noted, in well-nourished individuals, crossing the median line in front, a shallow depression, concave upward, separating the public eminence (mons pubis, mons veneris) from the general superficies of the abdomen. This may be called the pubic furrow and extends from groin to groin. From either end of this the shallow but well-marked inguinal furrow (sulcus or plica inguinalis) may be followed upward and outward to the anterior superior iliac spine. The iliac crest may then be easily traced along the flank backward as far as the depression which marks the posterior superior iliac spine. From this a line should be drawn to the spinous process of the fifth lumbar vertebra, which for topographical purposes is usually included in the pelvic region, and is characterized by a well-marked depression. This boundary, drawn on each side, will mark the limits of the pelvis above.

Below, it is best defined behind by the well-marked gluteal furrow (sulcus gluteus) that indicates the lower border of the nates or rump. An arbitrary line drawn horizontally outward from the outer end of this furrow, around the thigh to the inguinal furrow, will roughly include somewhat more than may properly belong to the pelvis, as it takes in the upper part of the femur with the great trochanter, usually regarded as belonging to the crural region.

Surface Markings.—Within the area thus delimited there is in front the pubic eminence, covered with hair in the adult and resting upon the pubic bone. It is more prominent in the female. On either side of this the inguinal furrow follows the course of the inguinal ligament from the anterior superior spine of the ilium to the pubic tubercle. It is maintained by fibers passing from this ligament to the skin, resembling in this respect the axillary fossa. Shallow and broad when the subject is standing erect, it is deep when the thigh is flexed. Above, it is continuous with the iliac furrow; below, it ends in the pelvicofemoral furrow. In females and well-nourished persons a second furrow is usually seen, corresponding more nearly to the flexion of the thigh. This terminates before reaching the anterior superior iliac spine at a depression corresponding to the separation between the sartorius and the tensor of the fascia lata. Below, it runs into the inguinal furrow.

In muscular persons, not too fat, the outer edge of the rectus abdominis, well defined upon the abdomen, may be traced down to the inguinal furrow, which it cuts at an acute angle. It is at this point (the inguinal trigone of Henke), immediately above and external to the pubic tubercle, that is found the subcutaneous inguinal ring from which the spermatic cord in the male and the round ligament in the female may

be easily traced to the scrotum and the labium majus respectively. The deep inguinal abdominal ring is a little more than half an inch (fifteen millimeters) above the inguinal ligament, and midway between the anterior superior iliac spine and the symphysis pubis.

The pubic tubercle lying, as it does, between the course of an inguinal and that of a femoral hernia, becomes an important point to determine. In fat persons it cannot be felt with ease except by pushing up the skin of the scrotum or labium, but may always be found by tracing up the tendon of the adductor longus muscle, made tense by adducting the thigh. The tubercle is nearly on a level with the top of the great trochanter, and this enables us to determine its position when it is desired to avoid external manipulation. Between the tubercle and the symphysis pubis the iliopectineal eminence may be made out.

Another important point is the anterior superior iliac spine, always easily felt. It is used as a point of reference in judging of deformities and injuries to the pelvis, and in measuring the relative length of the two limbs. Although situated much farther from the median line than is the spine of the pubis, it will be seen, when the pelvis is viewed laterally in its normal position, to be in the same frontal plane. A line connecting the anterior superior spines of opposite sides passes just above the level of the promontory of the sacrum. In females it is, when the pelvis is normally placed, at the same height as the middle of the third sacral vertebra, and very nearly on a level with the upper edge of the great sciatic notch. In males it is one or two centimeters higher.

Below the pubic eminence appear the external organs of generation, separated from the thigh by a deep groove, the pelvicofemoral furrow, more fully seen on the perineal aspect. The angle of the pubis, where the two pubic bones unite at the median line, may be obscurely felt from without. In the female it is much more obtuse than in the male, and is easily accessible by vaginal examination. In the normal position of the pelvis its vertex is on a level with the lower bony edge of the obturator foramen and with the middle of the posterior surface of the ischial tuberosity.

If the pelvis be looked at from the side, it is seen to be limited above by the crest of the ilium, whose general situation is indicated by a slight superficial depression, the iliac furrow (sulcus coxæ). This does not, however, exactly correspond with the underlying crest, the difference depending on the varying length of the aponeurotic fibers of the external oblique muscle of the abdomen, which is inserted on the outer lip of the crest. The midaxillary line produced passes through the highest point of the crest (punctum coxale), the most prominent part of the great trochanter and the lower part of the ischial tuberosity (punctum ischiadicum), and bisects a line connecting the anterior and posterior iliac spines. When the arm is extended at right angles in front, the scapula is so rotated as to bring its inferior angle into this vertical. The level of the iliac crest is usually a little lower than the umbilicus, corresponding to the disc between the fourth and fifth lumbar vertebræ, though it may reach as high as the body of the fourth.

On this aspect the situation of the great trochanter should be noted. Usually a distinct prominence, more in relief than the iliac crest, in fat persons, owing to the tendinous insertion of the gluteus maximus, it may be marked by a depression. Its top is on a level with the middle of the acetabulum, and when the thigh is at rest, with the muscles relaxed, it just touches a line drawn from the anterior superior iliac spine downward and backward to the ischial tuberosity (Nélaton's line). It may rise somewhat above this line when the thigh is fully abducted (Sheild).

The most prominent features of the pelvic region, when viewed from the rear, are the rounded masses forming the buttocks or nates. While the main body of these protuberances is formed by muscles they owe their rounded outlines to a thick layer of fat. For this reason they are better developed in well-nourished persons, in the young, and in women, than in athletes, and are frequently the seat of lipomatous tumors. In some African tribes the deposit of large quantities of fat in this region seems to be normal, especially among the females, and it forms a large projecting mass (steatopygy). The underlying masses that influence surface form are the gluteus maximus nearest the median line and the gluteus medius laterally. In muscular individuals in good training the separation between these two muscles is usually observable on the surface. They are especially important for keeping the trunk upright; and since man is the only animal that habitually walks erect, the prominence of the nates is peculiar to him.

The nates are separated from each other by a well-marked cleft, the anal cleft (crena ani), usually quite deep. At its bottom is found the tip of the coccyx, a little lower than the horizontal line drawn through the top of the symphysis pubis, and about a finger's breadth farther forward is the margin of the anus, hidden from sight except in emaciated persons. Here the furrow ends in the male; in the female it becomes continuous with the beginning of the genital cleft.

Below, the nates are limited by a sharp crease, the gluteal furrow (fold of the nates, gluteofemoral fold, sulcus gluteus), caused by the attachment of the integument to the deep fascia by means of fibrous bands, which prevent the fat of the buttock from sliding down into the thigh when the sitting posture is assumed, thus making of it a veritable cushion. This fold does not correspond to the edge of the gluteus maximus, which runs obliquely downward and outward to its femoral insertion, but is nearly or quite horizontal when the subject is standing erect. When he is resting on one leg only and allowing the gluteus maximus of the free member to become stretched, the fold assumes more nearly the direction of the muscle. Externally each natis is defined by a broad, shallow depression (lateral gluteal furrow), due to change from muscle fibers to aponeurosis of insertion.

The nates are bounded above by the crest of the ilium, which terminates toward the middle line in the posterior superior spine, on a level with the spine of the second sacral vertebra, and at a point corresponding to the middle of the sacroiliac synchondrosis. Immediately above the spine is a small area of bone quite free from muscle fibers, and therefore marked externally by a depression, especially noticeable in females. Below this the converging masses of nates leave between them a flattened triangular area which extends down as far as the fourth or fifth sacral vertebra. This flattening extends upward as far as a depression just below the spine of the fifth lumbar vertebra, and taken altogether the area constitutes a rhomboidal field (sacral rhomboid, Kreuzraute of Waldeyer) of which the two upper sides are much shorter than the two lower ones. In females the upper angle is three to four centimeters higher than the line connecting the posterior superior spines. Through the middle of this there extend from above downward on the median line the coalesced spines of the sacral vertebræ (sacral crest, crista sacralis media), the most prominent part of which is the third sacral spine.

The general direction of the gluteus maximus is indicated by a line drawn from the posterior superior iliac spine to the most prominent part of the great trochanter. The juncture of the first and second thirds of this line is at the level of the great sciatic notch, where the superior gluteal artery emerges from the pelvis.

The ischial tuberosity (tuberosity of the ischium), on which the body rests when sitting, is readily felt beneath the gluteal furrow. It is situated in the same frontal plane as the transverse process of the fifth lumbar vertebra, and its middle is nearly the same horizontal distance behind the center of the acetabu-

lum that the anterior superior iliac spine and the pubic tubercle are in front. A line drawn from the posterior superior iliac spine to the outer part of the ischial tuberosity crosses the posterior inferior spine at four centimeters and the ischial spine at ten centimeters distance, and the inferior gluteal and internal pudendal arteries make their exit from the pelvis at the juncture of its middle and lower thirds. The tuberosity is well padded with fat contained in small loculi formed by fibrous bands that pass between it and the skin. Several small bursæ are frequent near it, one, under the tendon of the biceps and semitendinosus, being quite constant.

There is, besides, another aspect of the pelvis almost wholly concealed when the subject is standing erect with the thighs approximated, being then reduced to a mere furrow. This is the inferior or perineal aspect, corresponding to the lower opening of the lesser pelvis. To examine it the thighs should be flexed and abducted when there will be displayed a rhomboidal space known as the perineal region, lying between the thighs, having its angles at the angle of the pubis in front, the tip of the coccyx behind, and the ischial tuberosities on either side. Its sides are formed in front by the ischiopubic rami, behind by the sacrotuberous ligaments, which may in this position be felt in thin subjects on deep pressure along the edge of the gluteus maximus.

It will be seen that the gluteal furrow encircles on each side the inner aspect of the thigh and ends in the pelvicofemoral furrow. Frequently an accessory furrow is found running parallel to it. From the rounded protuberance of the nates a pointed process extends forward, bounded laterally by the gluteal furrow on the outer side, mesially by a furrow (gluteoperineal furrow) that separates it from the external genitals and ends in front by uniting with the pelvicofemoral furrow.

In both sexes the external genital organs impinge upon the anterior part of this space, the area occupied by them being known as the pudendal region. The remaining space is usually divided for topographic purposes by a line drawn arbitrarily between the anterior part of the ischial tuberosities (interischiadic line). It has been pointed out by Waldeyer and others that a more suitable line, from a morphological point of view, is formed by curving somewhat forward to where the urogenital diaphragm (triangular ligament) meets the pelvic diaphragm (line of the perineal septum). This separates a urogenital region through which the urogenital orifices pass, from an anal (ischiorectal) one through which the alimentary canal discharges.

In this region there may be noted, in the median line, the tip of the coccyx, often marked by a slight depression; the anus, its center about three to four centimeters in front of the coccyx in the male and a little farther in the female; then the median raphe of the perineum, extending in the male from the anus to the scrotum, in the female lost almost at once in the genital cleft. The point where the raphe crosses the line of the perineal septum is called the tendinous center of the perineum (centrum perineale), where the two layers of deep fascia and the urogenital diaphragm meet. It affords a point of origin for several muscles. A slight swelling in front of this marks in the male the underlying bulb of the urethra, situated 1 to 1.5 centimeters from the anterior edge of the anus.

The Osseous Pelvis.—Of the bones composing the pelvis two, the sacrum and the coccyx, belong to the spinal column; and two others, the so-called ossa innominata, or hip bones, belong to the limbs and constitute the pelvic girdle, which differs remarkably from the thoracic girdle in that it is articulated firmly with the sacrum, thus affording a firm basis of support.

The Sacrum.—This bone is said to owe its name to the use made of it by nations who offered human sacrifices, it being held to be particularly sacred to the gods, because it was used as an offering representing the entire victim, it being evident that the subject must be dead if the sacrum was offered. It is reputed to be found entirely uninjured when other portions of the skeleton have decayed, and a rabbinical tradition holds that it is the essential or sacred part of man, which is to be preserved, and from which the entire body is to sprout at the judgment day. Hyrtl, whose authority on such matters is entitled to weight, considers, however, that these are mere etymological fantasies, and that in the phrase *os sacrum* the adjective is used in the sense of great or important, because it is the largest bone of the spinal column.

The bone presents the appearance of an irregular pyramid, the axis of which has been curved so that the concavity looks downward and forward, the base presenting upward, jointing with the last lumbar

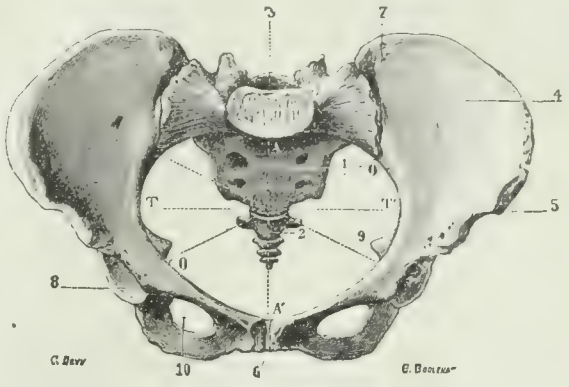

Fig. 4236.—Anterosuperior Aspect of the Pelvis. (From Testut.) 1, Sacrum; 2, coccyx; 3, sacral canal; 4, iliac fossa; 5, anterior superior iliac spine; 6, symphysis pubis; 7, sacroiliac articulation; 8, acetabulum; 9, ischial spine; 10, obturator foramen.

The dotted lines indicate the diameters of the superior aperture of the lesser pelvis. *A*, *A'*, conjugate diameter; *T*, *T'*, transverse diameter; *O*, *O'*, oblique diameter.

vertebra, the apex downward, jointing with the coccyx. Laterally it articulates with the innominate bones. Even a superficial examination shows it to be composed of coalesced vertebræ, normally five in number, six or four being occasionally found; but this is usually accompanied by a corresponding increase or decrease of the vertebral elements of contiguous regions of the spinal column. Accordingly the main descriptive features of the sacrum depend upon its composite character. There are, on the anterior surface, transverse lines showing the original divisions; on the posterior, vestiges of the spinous and articular processes, and of the laminæ; on both surfaces foramina for the exit of nerves from an axial canal, a continuation of the spinal canal of the lumbar region. Anteriorly, obliquely cut grooves lead from the sacral foramina outward, affording, to the sacral nerves that lie in them, some protection from sliding pressure.

The non-articular vertebræ diminish rapidly in size, their characters are more obliterated, and they curve forward much more than the others. The summit of the curve formed by the sacrum is therefore in the third sacral vertebra, the spine of which projects in the median line. The prominence of the spine is not, however, a good guide to the convexity of the curve, which varies much in different individuals. The depth of the curve from a line subtending the arc averages 18.8 millimeters, having a maximum of 44 millimeters and a minimum of 4 millimeters. The curve is developed during intrauterine life, being probably due to an adaptation of the spinal column to the pelvic viscera. Cunningham found it in a

fetus 46 millimeters long (about ten weeks). It is also seen in anthropoids.

Meyer calls that part of the sacrum which articulates with the ilium the pelvic portion, the remainder the perineal portion. Broca has pointed out that, in considering the question of the number of bones that form the tail of a vertebrate animal, we should not make the division at the sacrococcygeal joint, as that is a character which may be considered merely a matter of special arrangement for each animal, but should rather begin to count at the non-articular portion of the sacrum. Viewed in this manner the articulating vertebræ would form a true sacrum, and those which follow would belong to the tail, and be divided into *true caudal*, having a spinal canal, and *false caudal*, reduced to centra only. According to this view, almost all the lower apes agree with man in possessing three sacral vertebræ; and man has a tail formed of from six to eight pieces, resembling in this respect the anthropoid apes, they varying merely in the unimportant circumstance of having a few segments more or less.

The rectum reaches the spinal column at the third sacral vertebra and thence continues along it. Rose therefore designates the portion of the spinal column thus related as the rectal cover (*Mastdarmdeckel*). As it may be necessary to remove some of these vertebræ in operations for tumors, it becomes important to know how high it is safe to go. While the spinal cord terminates far above this, its envelopes continue down within the sacral canal, and the sac containing the cerebrospinal fluid may reach as low as the third sacral vertebra. It is therefore allowable to remove the fourth and fifth sacral vertebræ; and, since the sac is pointed, to encroach laterally upon the third. In children the sac is lower than in adults. The width of the sacrum at the upper limit of surgical interference (between the second and third sacral vertebræ) is 8 to 11 centimeters ($3\frac{1}{2}$ to $4\frac{1}{3}$ inches). In the last two vertebræ the arch becomes deficient behind, leaving the sacral canal covered by membrane. This is, therefore, a weak point where sloughing bedsores may invade the canal and induce a meningitis. At the sides of the coalesced vertebræ fused costal elements form strong bars known as the lateral masses of the sacrum.

As compared with other animals the sacrum of man is broad in proportion to its length. The same holds when the sacra of Europeans are compared with those of the lower races of man. In order to express this Sir William Turner has devised the *sacral index*, obtained by multiplying the breadth of the sacrum by 100 and dividing by the length. The following are the average results of many measurements: European, female, 116; European, male, 112; negro, 106; Australian, 99; Andaman Islander, 94; Orang, 87; Gorilla, 72.

Sacra having an index above 106 are termed platyhieric; those between 100 and 106, subplatyhieric; those below 100, dolichohieric. The variations in width appear to depend mainly upon variations in the lateral masses.

The Coccyx.—This is also an assemblage of from four to five coalesced vertebræ, and corresponds to the tail of lower mammals; and in very rare instances it may, like that, be enclosed in a fold of skin. The vertebral characters of its elements are very much reduced, there being but little more than the centra or bodies, with two vestigial articular processes called the cornua, which articulate with the sacrum. It is triangular in form and continues forward the curve of the sacrum, making together with it an almost complete quadrant, so that the apex points directly forward. It may be readily felt in rectal or vaginal examination.

The number of vertebræ in the coccyx is subject to considerable variation; five is considered the normal number in the male, four or five in the female, while six are sometimes found. In vertebrate animals the number of caudal vertebræ varies greatly, from two hundred and seventy in some sharks to two in the gibbon and fruit-bat.

The Innominate Bone.—This is a complex of three originally distinct elements, the ilium, the ischium, and the pubis. When complete it resembles in shape two of the twisted blades of a propeller extending radially on opposite sides of an axial depression, the acetabulum, which receives the head of the femur. The upper expanded and somewhat longer blade is the ilium; the lower one, which has a large fenestration called the obturator foramen, is formed by the combined ischium and pubis, the pubis forming the anterior portion, the ischium extending backward and downward to afford support while sitting. The narrowest part of the bone (the isthmus coxæ of Waldeyer) is just above the acetabulum, lying between the greater iliac notch of Henle (from the anterior inferior iliac spine to the symphysis pubis) and the great sciatic notch.

Fig. 4237.—Innominate Bone of Alligator, showing the Rod-like Character of the Separate Elements.

A study of the characters of the bone throughout the vertebrate series shows that its components were originally rod-like in form. This is shown in a striking manner in the alligator (Fig. 4237), and is also indicated by the course of ossification in the human bone, for accessory points form at the crest of the ilium, the symphysis pubis, the tuberosity of the ischium and within the acetabulum, that is to say, exactly where terminal epiphyses would form at the extremities of long bones. Even in the higher mammalia the rod-like character of the bones is still apparent. When the upright position begins to be assumed, lateral expansions become necessary to support the weight of the viscera. A transition form is seen in the pelvis of the gorilla (Fig. 4238).

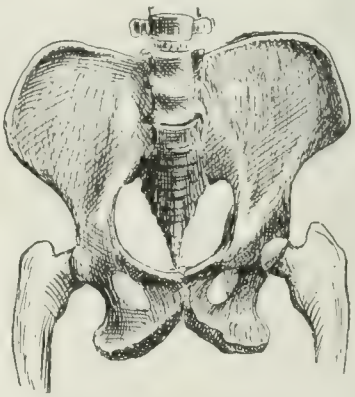

Fig. 4238.—Pelvis of a Gorilla.

The thickness and strength of the different parts of the innominate bone vary according to the weight and strain to which they are subjected. While a person is standing, the weight of the body is supported by the upper lip of the acetabulum, whence it is transmitted to the symphysis pubis on the one side and the sacroiliac joint on the other. Hence a strong bar of bone extends from the symphysis along the upper edge of the acetabulum and the iliopectineal line to the posterior superior iliac spine, where it ends in a

protuberance called by Waldeyer the tuber glutæum posterius. This bar may be called the pubic trabeculum. While an individual is sitting, the greater portion of the weight is borne by the ischial tuberosity, and is transmitted through the thick strong body of the ischium (superior ramus of many authors) and the posterior edge of the acetabulum, directly upward to a thickened portion of the crest of the ilium (tuber glutæum anterius of Waldeyer). This also is a thickened bar, and may be called the ischial trabeculum. These bars cross each other at about right angles near the axis of motion of the hip-joint.

The upper edge or crest of the ilium is sinuous and thick, and gives attachment in front to the great, sheet-like muscles that form the parietes of the abdomen, and behind to the muscles of the back. Below the crest is a comparatively thin portion caused by the hollowing out of the substance of the bone within, for the attachment of the iliacus muscle, forming the iliac fossa, and without, for the attachment of the glutei muscles, forming what is sometimes called the wing of the ilium (ala ossis ilium). The iliac fossa supports the weight of the intestines laterally and forms in the articulated pelvis the lateral portion of what is known as the greater or false pelvis (pelvis major), separated from the lesser or true pelvis (pelvis minor) by a ridge (iliopectineal line, linea terminalis) passing from the crest of the pubis backward and upward.

The acetabulum or cotyloid cavity appears a little below the middle of the external surface of the innominate bone. It is hemispherical in shape, formed by portions of the ilium, ischium, and pubis, and receives the head of the femur. It may become perforated by suppuration within the cavity, and thus inflammation of the intrapelvic structures may be induced. Below, the edge of the cavity is incomplete, giving passage to vessels that supply the joint. This notch is usually directed downward, and it therefore affords a means for establishing the normal position of the bone.

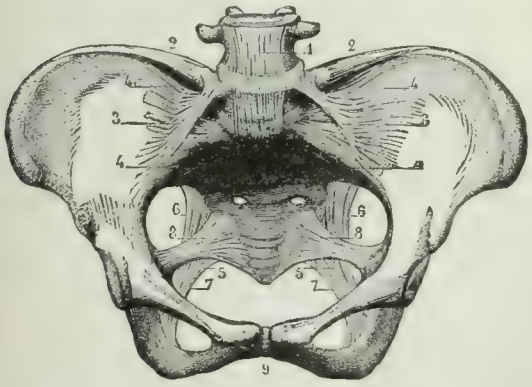

Fig. 4239.—The Articulations of the Pelvis as Seen from the Front. 1, Anterior ligament; 2, iliolumbar ligament; 3, lumbosacral ligament; 4, anterior sacroiliac ligament; 5, sacrotuberous ligament; 6, its external border; 7, its internal border; 8, sacrospinous ligament; 9, symphysis pubis.

The united ischium and pubis constitute the side of the true pelvis. They here form three bony bars that surround the large obturator foramen, closed in, during life, by a thick sheet of fascia called the obturator membrane. This is deficient above, affording, between it and the bone, a passage about an inch long, walled in above by the bone and below by the membrane, the obturator muscles and some masses of fat. This passage, the obturator canal, contains the obturator vessels and nerve. The membrane is reinforced near the canal by independent bands attached to small bony projections on the edge of the foramen. Three of these projections have been distinguished as fairly constant. They are named by Waldeyer according to their situation—the superior and inferior lateral and the medial obturator tubercles. The arrangement of the fibrous bands and the shape of the canal have important effects upon obturator hernia.

The two anterior bars enclosing the foramen are known as rami, the upper one being the superior ramus of the pubis, the lower one being the inferior ramus of the pubis above, and of the ischium below. Along these bars are attached the muscles of the perineal floor and the urogenital diaphragm, on the inner side the muscles of the abdominal wall, below the adductors and rotators of the femur.

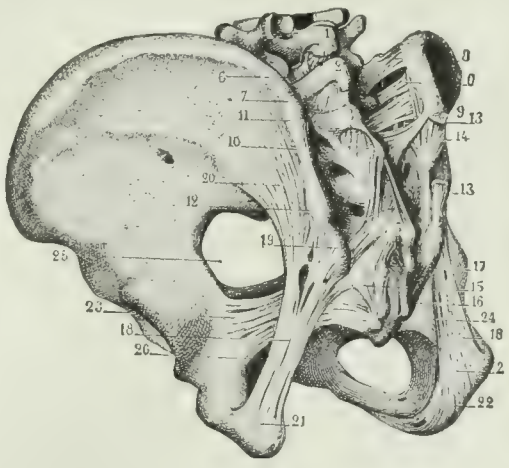

Fig. 4240.—Posterior View of the Ligaments of the Pelvis. 1, 2, 3, 4, 5, Interspinous ligaments; 6, 7, ligamenta subflava; 8, iliolumbar ligament; 9, posterior sacroiliac ligament; 10, its oblique portion, continuous externally with the great sacrosciatic ligament; 11, posterior superior spine of the ilium; 12, tubercle representing the transverse process of the fourth sacral vertebra; 13, deep layer of the posterior sacroiliac ligament; 14, insertions of the same; 15, 16, lateral ligaments of the sacrococcygeal articulation; 17, posterior ligament of the same; 18, great sacrosciatic ligament; 19, its sacral insertion; 20, its iliac insertion; 21, its ischiatic insertion; 22, reflected portion; 23, lesser sacrosciatic insertion; 24, its attachment to the sacrum and coccyx; 25, great sciatic notch converted into a foramen by the sacrosciatic ligaments; 26, lesser sciatic notch, forming with these ligaments a triangular orifice.

Behind, the ischium expands to a large tuberosity that gives origin to the great hamstring muscles (biceps, semitendinosus, semimembranosus), and affords attachment to the sacrotuberous ligaments. A pointed process (ischial spine) divides the posterior border into two notches, the greater the lesser sciatic.

Articulations.—The pelvic bones are joined together by five joints, all of which are synchondroses (Figs. 4239 and 4240). Two of these are vertebral joints, viz., the lumbosacral and the sacrococcygeal; there is one on either side of the sacrum where it unites with the ilia; and one in front, where the innominate bones join, called the symphysis pubis.

At the lumbosacral joint we have the same general features as in other spinal joints, viz., a union by means of fibrocartilage between the bodies of the last lumbar and the first sacral vertebra, and a pair of arthrodial joints between the articular processes of the two bones. The anterior longitudinal ligament of the spine passes downward upon the sacrum in front, and within the spinal canal the posterior longitudinal ligament does the same. Besides these the anterior lamina of the lumbodorsal fascia becomes thickened to strong bands, which, springing from the transverse processes of the fourth and fifth lumbar vertebræ, pass to the inner lip of the iliac crest (iliolumbar ligament) and to the brim of the true pelvis and the base of the sacrum (lumbosacral or sacrolumbar ligament).

The joint is indicated by a well-marked angle, the promontory of the sacrum, slightly greater in females than in males, being determined by Cunningham as averaging 137° 40′ for females as against 133° 6′ for males. This is not usually the most anterior part of the spine, for that must be sought in the forward projection of the lumbar curve, that is to say, in the fourth lumbar vertebra or even as high as the disc between the fourth and the third. Externally it may be felt on deep pressure of the relaxed abdominal wall if the subject be lean. It is one of the landmarks by which a contracted pelvis is known, and cannot, in a properly formed pelvis, be reached by the finger through the vagina, but can easily be felt in a rectal examination.

The joint between the sacrum and the coccyx is very simple, being entirely similar to that between the bodies of the vertebræ. The articulation is usually sufficiently free to permit the apex to be displaced some two centimeters or more, and there is sometimes a midcoccygeal articulation between the first and second coccygeal vertebræ. Movement usually occurs during defecation and labor, but the bone may be so firmly ankylosed to the sacrum that it offers an obstacle to the delivery of the head of a child. In the male pelvis the joint is frequently obliterated quite early. A number of ligamentous bands have been described, but they appear to have no practical importance beyond that of an investing capsule.

The joint between the sacrum and the iliabones on either side possesses an incomplete synoc vial cavity. The ear-shaped articular surfaces may be divided into two parts—a lower which is clothed with cartilage, and an upper whose surfaces are interconnected by means of an interosseous ligament. The joint must necessarily be a very strong one, as the entire weight of the trunk is thrown upon the articulation. Owing to the wedge-like shape of the sacrum it is often described as the keystone of the pelvic arch. It should be noted, however, that in the natural standing position the bone is somewhat narrower behind and above than below and in front, so that it would seem that the weight of the body resting upon it from above might tend to displace it. This is prevented, (1) by the sinuous character of the articular surfaces; (2) by the extremely strong sacroiliac ligaments that bind the sacrum closely between the two iliac bones, so that any displacement forward tightens the joint; (3) by the sciatic sacrotuberous and sacrospinous ligaments that stretch from the sacrum and the coccyx to the ischial tuberosity and spine and counteract any tilting forward of the upper end of the sacrum. The interosseous ligament that closes the joint behind is very thick and strong, while the anterior ligament that closes it in front is thin. Hence it is easy to open the articulation from the abdominal cavity, but difficult to do so from behind. Injury to it is rare, but when it occurs is of a serious nature, owing to the weight the joint carries in the standing posture.

The articulation usually affects the three upper sacral vertebræ, but variations from this frequently occur. The following arre the results of 265 cases observed by Paterson and Waldeyer:

S1+2	21 times.
S1+2+3	242 times.
S1+2+3+4	3 times.
S −2+3	3 times.
S −2+3+4	3 times.
L5+S1+2	1 time.
L5+S1+2+3	1 times.
L6+S1+2	2 times.
L6+S1+2+3	1 time.
Total	280 times.

The total amounts to 280 instead of to 265 for the reason that in fifteen cases the articulation differed on one side from that on the other. It will be noted that the second sacral vertebra is always involved in the articulation.

As already mentioned, the sacrosciatic ligaments act as restraining bands to this articulation. (See Figs. 4239 and 4240.) The great or posterior sacrosciatic ligament (ligamentum sacrotuberosum) appears as if a continuation of the sacroiliac, passing to the lateral parts of the sacrum and the coccyx and then to the external surface of the ischial tuberosity. It is somewhat narrower in the middle than at either extremity, and in its course becomes twisted upon its axis. At its lower insertion it runs as a thin sharp band (falciform process) along the ramus of the ischium and protects the internal pudendal artery. Its interlaced fibers are somewhat extensible, so that it offers no considerable resistance to the moderate movement of the coccyx during labor. It is believed to represent a former continuation of the biceps and semitendinosus muscles whose tendons pass directly into it.

The small or anterior sacrosciatic ligament (ligamentum sacrospinosum) lies in front of the sacrotuberous ligament and is partly covered by it. Triangular in form, it passes from the side of the sacrum and coccyx to the spine of the ischium. It blends at its insertion with the coccygeus muscle and is regarded morphologically as a fibrous reduction of it.

These two ligaments convert the sciatic notches of the innominate bone into foramina, through which pass important structures. The greater sciatic foramen, above the spine of the ischium, is nearly filled by the piriformis muscle, small intervals being left above and below—the suprapiriform and infrapiriform foramina of Waldeyer. Through the former pass the superior gluteal vessels and the pudendal nerve; through the latter the internal pudendal vessels and pudendal nerve, the sciatic nerve, the inferior gluteal vessels and nerve, the posterior femoral cutaneous nerve and the nerves to the obturator internus and quadratus femoris muscles. Through the lesser sciatic foramen, below the spine of the ischium, pass the obturator internus muscle, and the pudendal nerve and internal pudendal vessels re-entering the pelvis.

The two pubic bones are united in front by a fibrocartilage that forms a slight eminence on the pelvic aspect of the joint. During pregnancy this swells and relaxes, and there is thus obtained a mobility that may persist for some time after delivery. Traces of a synovial cavity are occasionally found as a small slit lying near the pelvic surface, not lined with synovial membrane and apparently being a simple lymph space. This is found in both males and females, though it is larger and more constant in the latter, and is not dependent upon pregnancy. It is not found in young children. Two peripheral ligaments are described: superior, and inferior, the latter being known as the arcuate ligament of the pubis. The investment is strengthened by fibrous expansions from the recti muscles of the abdomen and the adductors of the thigh. Malgaigne considered that the height of the symphysis increased considerably after the menopause, being thirty-eight millimeters at forty-five years, and forty-five millimeters at seventy and eighty years. The arrangement of the abdominal muscles in their insertion about the joint is such as to draw the ends of the bones together, so that during the bearing-down pains of labor the joint is strengthened.

The Ligamentous Pelvis.—Taking now the pelvis as a whole, we find it to be divided into two well-marked parts by a line, the linea terminalis, made up of the promontory of the sacrum, the rounded angle between the upper and the lower surfaces of the sacrum, the iliopectineal line, the pecten or crest of the pubis, and the upper surface of the symphysis pubis. The part above this line which supports the abdominal contents is termed the greater or *false* pelvis (pelvis major); the part below it, containing the pelvic vis-

cera, the lesser or *true* pelvis (pelvis minor), forming the bony ring through which the fetus is expelled.

The superior opening of the true pelvis is termed the inlet or the superior strait (apertura pelvis superior). (See Fig. 4236.) Its shape is reniform in the female, cordiform in the male. Similarly the lower opening, by which the fetus is expelled, is called the outlet, or the inferior strait (apertura pelvis inferior). (See Fig. 4241.) It is bounded by the ischiopubic rami in front, on the sides by the ischial tuberosities, behind by the sciatic ligaments and the coccyx, only about half of its circumference being bony. Its form is elliptical, slightly encroached upon by the coccyx.

That part of the pelvic canal between the inferior and superior straits is called the cavity of the pelvis. It is customary to divide this into four regions, an anterior, a posterior, and two lateral. The anterior comprises the symphysis pubis, the posterior surface of the body of the pubis, and the obturator foramen with its membrane. It is limited by a line passing from the ischial tuberosity to the iliopectineal eminence. The posterior region is formed by the anterior surfaces of the sacrum and the coccyx; the lateral regions are between the anterior and the posterior. Each is again subdivided into two portions called the anterior and posterior inclined planes. The anterior comprises the internal face of the ischium and the interior surface that corresponds to the acetabulum. Its direction is oblique, downward, and backward. The posterior inclined plane is entirely composed of soft parts, and is directed downward and forward. The planes meet at a line passing through the ischial spines.

Normal Position.—When standing erect the pelvis is tilted forward, so that the anterior superior iliac spines and the pubic tubercles lie in the same vertical plane. The promontory of the sacrum is then 9.5 to

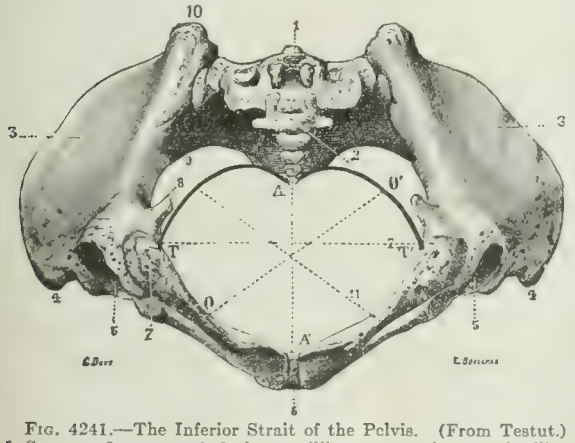

Fig. 4241.—The Inferior Strait of the Pelvis. (From Testut.) 1, Sacrum; 2, coccyx; 3, 3, dorsum ilii; 4, 4, anterior superior iliac spines; 5, 5, acetabula; 6, symphysis pubis; 7, 7, ischial tuberosities; 8, ischial spine; 9, great sciatic notch; 10, posterior inferior spine of the ilium; 11, ischiopubic rami.

The dotted lines indicate the diameters of the inferior strait. *A*, *A'*, conjugate or coccy-pubic diameter; *T*, *T'*, transverse or bischiatic diameter; *O*, *O'*, oblique diameter.

9.9 centimeters ($3\frac{3}{4}$ to $3\frac{7}{8}$ inches) above the upper edge of the symphysis pubis and at about the same level as the posterior superior iliac spines and the interspace between the first and second sacral spines. The frontal plane tangent to it cuts the middle of the acetabulum and passes close behind the angle of the pubis.

In this position the planes of the pelvic inlet* and outlet are inclined to the horizontal plane, the first making an average angle of about 60° (from 55° to 65°, Naegeli), the second an angle averaging about 12°. (See Fig. 4242.)

Meyer proposed to measure the inclination of the pelvis by taking that of a line drawn from the summit of the curve formed by the sacrum (at the body of the third sacral vertebra, see *ante*) to the upper border of the symphysis (normal conjugate). He thought this angle to be more constant than that made by the plane of the inlet, and estimated it as averaging 30°.

Measurements.—For obstetrical and surgical purposes it is important that the average dimensions of the pelvis should be accurately known. Of these the diameters of the inlet and the outlet are the most

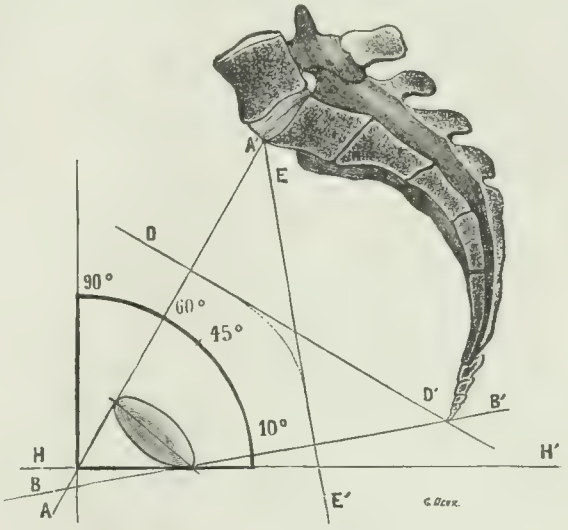

Fig. 4242.—Axes and Inclinations of the Pelvis. (From Testut.) *A*, *A'*, Plane of the superior strait; *B*, *B'*, plane of the inferior strait; *D*, *D'*, axis of the superior strait; *E*, *E'*, axis of the inferior strait; *H*, *H*,' the horizontal plane, with which the plane of the superior strait, *A*, *A'*, makes an angle of from 55° to 60°.

generally useful. The older obstetricians, considering these openings as approximately elliptical, applied to them designations derived from the diameters of an ellipse; so the anteroposterior diameter is often spoken of as the conjugate, the others as the transverse and the oblique diameters.

The conjugate of the inlet might be measured from the middle of the promontory to the top of the symphysis (anatomical conjugate), but for practical purposes the shortest line between the promontory and the symphysis is taken (true conjugate, obstetrical conjugate) which strikes the symphysis below the upper edge, usually about the junction of the upper and middle thirds. The transverse diameter is the longest transverse line that can be drawn between two symmetrical points of the brim. These points are usually situated about the juncture of the posterior and middle thirds of the circumference. The oblique diameter is measured from the sacroiliac articulation to the point on the opposite side where the linea terminalis meets the iliopectineal eminence. (See Fig. 4236.)

At the outlet the conjugate is measured from the tip of the coccyx to the angle of the pubis, and is increased by about two centimeters by moving the coccyx backward. The transverse diameter is measured between the middle points of the posterior borders of the ischial tuberosities. No satisfactory oblique diameter of the outlet can be measured. When stated it is considered to be the shortest distance from either ischiopubic ramus to the sacrotuberous ligament of the opposite side. (See Fig. 4241.)

The caliber of the cavity of the pelvis varies some-

* Strictly speaking the limits of the superior strait do not lie in the same plane, as the promontory never coincides with the plane of the linea terminalis (iliopectineal line).

what from that of the brim. The widest part (amplitudo pelvis) is in a plane passed through the midpoints of the acetabula, the synostosis between the second and third sacral vertebræ and the middle of the symphysis pubis. The narrowest part (angustia pelvis) is between the lower end of the sacrum behind, the summit of the pubic arch in front, and the two ischial spines on either side. The contraction here is caused by a slight elevation (angulus ischiadicus, Waldeyer) that runs on either side from the ischial spine to the lateral tubercle of the obturator foramen, separating a supraspinous from an infraspinous plane.

While these measurements are especially important as relating to normal labor, the following are commonly used for ascertaining pelvic deformities:

The External Conjugate (Baudelocque's diameter). The distance between the upper edge of the symphysis pubis and the tip of the spinous process of the fifth lumbar vertebra. This is readily measured with calipers in the living. When less than nineteen centimeters the pelvis is too narrow for safe delivery.

The Diagonal Conjugate. Distance from the vertex of the pubic angle to the promontory of the sacrum. This may be measured by means of a pelvimeter or closely approximated by measurements made by introducing two fingers into the vagina. In a normal pelvis the promontory cannot be reached by introducing a single index-finger.

The distance between the anterior superior iliac spines.

The greatest distance between the iliac crests.

The greatest distance between the great trochanters.

The external circumference of the pelvis measured from the spine of the fifth lumbar vertebra around to the symphysis pubis on either side, passing between the iliac crest and the great trochanter.

The following table of measurements is from the determinations of Waldeyer, C. Krause, and Schröder:

	Male.	Female.
Inlet.		
True conjugate diameter	10.5 cm.	11.0 cm.
Transverse diameter	12.5	13.5
Oblique diameter	12.0	12.75
Outlet.		
Conjugate diameter	7.5 (9.5)	9.0 (11)
Transverse diameter	8.0	11.0
Amplitudo.		
Conjugate diameter	11.0	12.75
Transverse diameter	11.0	12.5
Angustia.		
Conjugate diameter	9.5	11.5
Transverse diameter	8.0	10.5
External conjugate	18.0	20.0
Diagonal conjugate		13.0
Distance between anterior superior spines	26.0	26.0
Distance between iliac crests	26.0	29.0
Distance between great trochanters	31.5	31.5
External circumference		89.0
Dorsal length of sacrum		12.5
Ventral length of sacrum	13.5	12.0
Height of symphysis pubis	5.5	4.5

The *axis* of the superior strait is a line perpendicular to the plane of that strait at its central point. (See Fig. 4242.) It nearly coincides with a line drawn from the tip of the coccyx to the umbilicus. The axis of the inferior strait is similarly obtained, and when produced reaches the promontory of the sacrum. The axis or traction line of the pelvis is one that bisects all possible conjugate diameters. It is practically parallel with the curve of the sacrum and coccyx, and therefore, in the female pelvis, nearly straight above and sharply curved below. It is important to bear in mind its direction when attempting traction upon the fetus and when introducing instruments.

Indices.—The method of proportional measurements or indices, first devised for the cranium, has also been applied to the pelvis. Two of these are used, first that which Topinard calls the general index of the pelvis, found by comparing the greatest width between the iliac crests with the height taken from the punctum ischiadicum or lowest point of the ischial tuberosity to the punctum coxale or highest point of the crest; second, the index of the superior strait, found by comparing the anatomical conjugate diameter with the transverse diameter of the inlet.

By the first method the height is taken as 100, and the index expresses the proportionate breadth. Topinard obtained the following averages:

46 European males	126.6
17 African negroes, males	121.3
11 Natives of Oceanica, males	122.7
24 European females	136.9
10 African negresses	134.2
10 Natives of Oceanica, females	129.0
20 Anthropoids	105.6
16 Ruminants	77.2
12 Carnivores	68.1
4 Rodents	66.8
4 Kangaroos	63.0
2 Edentates	61.4

These figures appear to show that as we rise in the scale of races the pelvis broadens. It should be remembered, however, that exceedingly heavy animals, like the elephant and rhinoceros, have a proportionately wide pelvis to permit of the insertion of the muscles necessary for sustaining their enormous weights. Some authors use the breadth of the pelvis as the basis of comparison, which changes the figures without altering their serial relation. It will be noted that in all human races the female pelvis is broader in proportion to its height than that of the male.

By the second method the breadth of the superior strait is taken as 100, and the index expresses the proportionate value of the conjugate diameter. Sir William Turner used this index in his investigation of the bones brought back by the *Challenger*. He devised the terms *dolichopellic* for pelves having an index above 95, *mesatipellic* for those from 90 to 96, and *platypellic* for those below 90. The Andaman Islanders appear to have the inlet most nearly circular of any yet examined, Garson finding the index 99 in an average of thirteen cases.

Dolichopellic.—Australians, Bushmen, Hottentots, Kaffirs, many Polynesians, Malays.

Mesatipellic.—Negroes, Tasmanians, New Caledonians, many Melanesians.

Platypellic.—Europeans, Mongolians, East Indians.

This relates to male pelves only, as nowhere do females possess dolichopellic pelves. Anthropoid apes have markedly dolichopellic pelves, much exceeding in this character any human forms. Indeed, as compared with lower animals, the pelvis of man is much broader and of greater capacity. These differences are occasioned by the erect attitude, which necessitates an effective support of the viscera. In some races of men slight peculiarities appear which may be considered to be transitional forms. The Veddahs of Ceylon, for example, have pelves in which the inlet is remarkably contracted in front, so that the inlet appears almost wedge-shaped.

Sexual Differences.—From what has been said above it will be seen that the highest and best developed forms of pelvis are not found in the human male but in the female, contrasting markedly with other sexual characters which usually tend in the female toward embryonic or undeveloped forms. This also is a natural result from the erect attitude. In the quadrupedal position comparatively little weight is hung from the pelvic arch, and a marked separation of the

bones during parturition does not necessarily impair to any considerable degree the stability of the support of the body. In the erect position, however, so great a weight is thrown upon the arch that no considerable amount of separation is practicable, and there comes to be an antagonism established between the constantly increasing size of the child's head and the diameters of the pelvic straits. The female pelvis therefore becomes comparatively wider, shorter, smoother, and more capacious than that of the male. It has been described as a short segment of a long cone, that of the male being a long segment of a short cone.

The following table, mainly from Waldeyer, gives the principal sexual differences in the articulated pelvis:

Portion.	Male.	Female.
Sacrum	Relatively longer and narrower. Average index 103.5.	Relatively shorter and wider.
Curvature	Generally more marked, uniform.	Usually less; flatter above, more curved below.
Promontory	More prominent	Less prominent.
Coccyx	More frequently has five vertebræ. Co-ossification earlier, projects forward more.	More frequently has four vertebræ. Synchondroses remain later; projects forward less.
Ilium	Higher, narrower; placed more obliquely, inclination of borders to each other = 53°.	Lower, broader, less obliquely placed; inclination averages 50°.
Crests	Thicker, rougher, more sinuous.	Narrower, less rough, less sinuous.
Posterior superior spines	Average distance apart 50 mm.	Average distance apart 40 mm.
Fossæ	Deeper	Shallower.
Ischium	Stronger, thicker	Less massive.
Tuberosities	Nearer together, inflexed.	Wide apart, everted.
Ischiopubic rami	Margins more everted.	Margins less everted.
Pubis	Arch pointed, more angular (70°–70.95°). *Angulus pubis.*	Arch rounded, archlike (90° 100°). *Arcus pubis.*
Symphysis	Deeper. At birth its width is narrower than or equal to its height (Fehling).	Shallower. At birth its width is greater than its height (Fehling).
Joint cavity	Rare	Frequent.
Spines	Nearer together	Farther apart.
Crests	Shorter	Longer.
Insertions of gracilis muscles	Nearer together	Farther apart (Cleland).
Obturator foramen	Higher, more oval, obturator canal narrower.	Lower, almost triangular, obturator canal wider.
Acetabula	Nearer together, show less in front.	Wider apart, show more in front.
Great sciatic notch	Lower, more oval	Higher, more circular.
Distance from body of ischium to posterior inferior iliac spine.	Averages 40 mm.	Averages 50 mm. (Cunningham).
True pelvis	Deeper, narrower, more funnel-shaped, capacity less.	Shallower, wider, not markedly funnel shaped, capacity greater.
Superior strait	More heart-shaped and dolichopellic, transverse diameter less, plane less inclined.	More elliptical (reniform) and platypellic, transverse diameter greater, plane more inclined.
Inferior strait	Narrower	Wider.
Inclination	Less marked	More marked.

Development.—Each of the three or four upper vertebræ which form the sacrum are developed from eight centers, three of which are primary and like those of other vertebræ, namely, one for the body appearing at the fourth to the eighth month, and two for the neural arch. (See Fig. 4243.) From these latter grow out the articular and transverse processes. There are also five secondary centers, two for the epiphyseal plates, that from the tenth to the thirteenth year form along the upper and lower surfaces of the body of each vertebra, one for the spinous process, and two situated laterally and representing costal elements. The lower vertebræ usually lack these. In addition, there are formed in the seventeenth or eighteenth year two marginal epiphyses on each side, the upper ones being connected with the auricular facets. The bone is complete from the nineteenth to the twenty-first year.

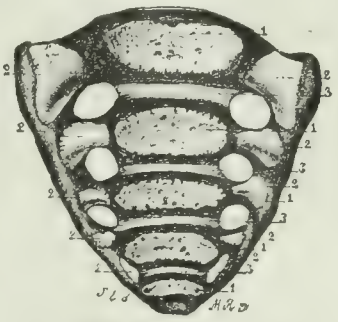

FIG. 4243.—Sacrum of a Child of Eleven Months. 1, 1, Ossific points for bodies; 2, 2, lateral points; 3, 3, intervertebral ligaments.

FIG. 4244.—Development of the Coccyx. 1, 1, Centers for bodies; 2, 2, articular processes; 3, 5, epiphyses.

Each coccygeal vertebra ossifies from a single primary center, which does not appear until from four to nine years after birth, and there appear later secondary centers representing the upper and lower epiphyseal plates, and in the upper vertebra two additional centers for the cornua. (See Fig. 4244.)

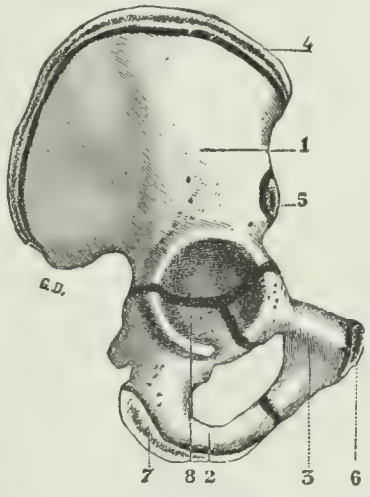

FIG. 4245.—Development of the Hip Bone. (From Testut.) 1, Ilium; 2, ischium; 3, pubis; 4, epiphyseal point for the iliac crest; 5, epiphyseal point for the anterior inferior iliac spine; 6, epiphyseal point at the symphysis pubis; 7, epiphyseal point for the ischium; 8, Y-cartilage uniting the three primitive portions of the hip bone.

The hip bone is formed from three cartilages that originate separately, the one for the ilium appearing latest. (See Fig. 4245.) Ossification occurs by three primary and nine secondary centers, the primary ones being first separated in the acetabulum by a Y-shaped piece, the triradiate cartilage. In rare cases

an independent center, the os acetabuli, may remain in the acetabulum ununited. Marks of the original composition remain on the developed bone: (1) at the iliopectineal eminence; (2) on the ischiopubic rami, at the seat of origin of the corpora cavernosa; (3) as a thickened bar extending from the posterior border of the acetabulum to the great sciatic notch. Ossification occurs in the order shown in the following table:

Centers	Time of appearance	Time of union
Primary.		
Ilium	3d to 4th month.	17th to 18th year.
Ischium	4th to 5th month.	17th to 18th year.
Pubis	5th to 7th month.	17th to 18th year.
Secondary		
Epiphyses acetabuli.		
Between ilium and pubis.	12th year.	18th year.
Between ilium and ischium.	12th year.	15th to 16th year.
Between ischium and pubis.	12th year.	15th to 16th year.
Epiphyses marginales.		
Iliac crest	15th to 16th year.	21st to 25th year.
Symphysis pubis.	18th to 20th year.	20th to 21st year.
Ischial tuberosity	15th to 16th year	17th to 22d year, female. 21st to 24th year, male.
Anterior inferior iliac spine	15th to 16th year.	16th to 17th year.
Pubic tubercle	18th to 20th year.	20th year.
Ischial spine	15th to 16th year.	17th to 18th year.

FRANK BAKER.

Pelvis, Deformities of the.—Any marked deviation in size or symmetry from the normal pelvis may be regarded as constituting a deformity of the pelvis, whether the effect on the course of labor be serious or not.

A deformed pelvis may be due to an error in development, to local disease, injury, or new growth, or indirectly to injury, disease, or maldevelopment of the adjoining skeleton. Thus from errors in development there are the abnormally large pelves, called justo-major; the justo-minor, or disproportionally small, sometimes of a persisting infantile type; and the pelves of the masculine type, large and thick-boned, but with a narrowed pubic arch and pelvic outlet.

From local errors in development there are the rare varieties, where one or both of the sacral alæ are lacking, giving the Naegele (oblique) or Robert (transversely contracted) pelves. The split pelvis is one in which there is failure of meeting of the pubic bones at the symphysis.

From constitutional disease or errors of nutrition causing softening of the bones, there result the pelves deformed by rachitis and osteomalacia. From local disease there may be caries of some of the pelvic joints, with arrest of development and later ankylosis. The sacroiliac joints, if diseased in early life, may cause extreme deformity. Following injuries there may be pelvic fracture with formation of callus. New growths may limit or obliterate the pelvic cavity—a primary sarcoma or secondary carcinoma, or some form of enchondroma or exostosis.

Any injury or maldevelopment of parts of the skeleton adjoining the pelvis, especially during early life, may have an important bearing upon the subsequent developments of the pelvis, and leave indirectly its stamp on the general contour of the latter. Thus, for example, poliomyelitis, causing a paralysis and subsequent atrophy of one limb, leaves the pelvis on that side comparatively undeveloped. As a further result of the shortening of the limb there must be compensatory scoliosis, with its effect upon pelvic growth.

Other forms of paralysis of the lower extremities, or joint diseases of hip, knee, or ankle, may affect the pelvis in the same way. A congenital hip-joint dislocation may seriously affect the normal growth of the pelvis. Other results of skeletal deformity upon the pelvis are not infrequently seen from defects in the spinal column, such as simple, compensatory, or rachitic scoliosis, caries of the vertebræ, and, rarely, the anterior dislocation of the bodies of the lumbar vertebræ, known as spondylolisthesis. Senile changes in the pelvis before the end of the child-bearing period sometimes cause obstruction by ankylosis of the coccyx with the sacrum.

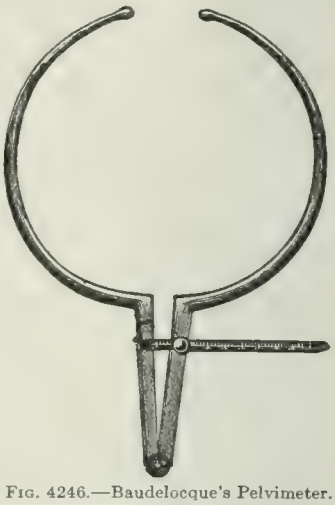

FIG. 4246.—Baudelocque's Pelvimeter.

Habits of living must always be counted upon as etiological factors. The poorly nourished and poorly housed are the ones who present pelves deformed from rachitis and tuberculosis. For this reason the percentage of deformities is small among our native country classes, large among the dwellers in cities, especially of the slums, and greatest among the immigrant population. Abroad, where the sanitary conditions of life are worse, still higher proportions of deformity are found, and osteomalacia is occasionally met with.

There are racial peculiarities in the shapes of the pelvic brim. The Caucasian normal type is one which is wide transversely; the outline of the Australian pelvic brim is almost circular; while the African pelvic brim is one which is relatively constricted transversely, and has a long anteroposterior diameter. This type of pelvis, if affected by the unsanitary conditions in which the negroes commonly live in this country in cities, supplies a large proportion of bad pelvic deformities. Thus one author has reported seven per cent. of deformed pelves in whites in a city hospital service, as against twenty-one per cent. in blacks.

The recognition of the deformity is important. One "must learn pelvimetry if he is to do intelligent obstetrics." Much can be ascertained by inspection of the patient. The facial appearance, form, carriage, height, gait, or obvious deformities of spine or lower extremities may lead to suspicions and put one on the track of a pelvic defect. A careful questioning may elicit a history of diseases such as rachitis or tuberculous bone disease, to bring out information concerning previous difficult labors.

But the history may be lacking, and all external appearance of deformity absent. Moreover, in all cases, no matter how obvious the deformity, its true extent and its obstetric significance can be ascertained only by careful pelvimetry, through palpation, vaginal examination, and instrumental pelvic measurements. External measurements, except in some cases of great obesity, are of a certain value in determining the types of deviation from the normal. Of greater importance is the exploration by vaginal examination of the pelvic cavity.

For external measurements there have been chosen certain easily recognized bony landmarks. The distance between these points is taken by a form of

caliper called the pelvimeter. Of the commoner types perhaps those of Baudelocque and Breisky are best known. The essentials of a good pelvimeter are compact size and an accurate and legible scale, preferably in centimeters.

The first measurement usually taken is the distance between the anterior-superior spines. For this measurement the patient should be flat on the back, with all but the thinnest clothing removed from about the hips and lower abdomen. The thumb and forefinger should steady each tip of the pelvimeter. The thumb should now be allowed to rest in the notch below the spines and the tips of the pelvimeter be lightly pressed against their outer side and the reading made. Taken in this way the measurements will be fairly constant when made by different individuals. The average interspinal diameter is twenty-four centimeters.

The next measurement should be the distance between the crests of the ilia, this measurement being made between the points which are most widely separated. The patient lying in the same position, the tips of the pelvimeter are slipped back along the outside edge of the crests, and the widest points of divergence noted and measured. This is called the intercristal measurement. It should average about twenty-eight centimeters. These two distances furnish an indication of the transverse diameter of the pelvic brim, especially if taken in consideration with the so-called external oblique measurements.

The ratio of the interspinal measurements to the intercristal has a distinct value in the study of certain types of deformity, especially the rachitic.

The external oblique measurements are those taken from one posterior-superior spine to the opposite anterior-superior spine. To take the left oblique measurement the doctor stands on the right of the patient, who lies on her left side. The distance from the left posterior-superior spine to the tip of the right anterior-superior spine is measured. The posterior spines are not very prominent, but are usually indicated by the presence of a dimple on either side of the sacrum from one and one-half to two inches from the median line. The patient now lies on the right side, and the right oblique measurement is taken. The average length of these measurements is twenty-two centimeters. The right oblique is 0.5 centimeters larger the left. The obliques furnish a fair idea of the oblique diameters of the pelvic brim. Any marked deviation of their normal relation to each other is a good index to oblique pelvic contraction.

For estimation of the anteroposterior diameter, or so-called conjugate of the pelvic brim, a measurement is taken which is called the external conjugate. This is the distance from the tip of the last lumbar spine to a point about one-quarter of an inch below the upper edge of the pubic symphysis in the median line. Some authorities give the depression just below the last lumbar spine as the posterior landmark, but this gives less constant and exact measurements. The last lumbar spine is usually the most prominent spine in that region. It is found about two centimeters above the level of a line drawn through the two posterior-superior spines. This measurement calls attention to contractions in the anteroposterior diameter of the pelvis. In the normal pelvis it measures from twenty to twenty-one centimeters. Any pelvis measuring less than eighteen centimeters, even if justo-minor, should be regarded as flat. There are, however, possibilities of error in this measurement. Occasionally a pelvis which has an external conjugate of large size will show flattening upon internal pelvimetry.

One other external measurement is sometimes of importance; that is, in the type of pelvis where there is obstruction at the pelvic outlet due to a narrowing of the pubic arch and an approximation of the tuberosities of the ischia. This is called the bi-ischiatic diameter. It is easily taken, while the patient is in the lithotomy position. The tuberosities may be readily felt, and the distance between them taken by tape measure or pelvimeter. If the distance be below nine centimeters the narrowing is dangerous.

The most valuable information is furnished the physician by vaginal examination. After he has acquired some experience he will be able to make out variations in the size of the cavity of the pelvis. If he can readily with the finger touch the sacral promontory, flattening is certain. Fairly accurately to estimate the internal conjugate, the first and second fingers of the right hand are introduced until the middle finger rests against the promontory. At the point where the index-finger intersects the symphysis a mark is made by the finger nail of the left forefinger. The internal oblique conjugate is the distance between this mark and the tip of the middle finger. Subject to slight variations the true internal conjugate may be estimated by the subtraction of 1.5 centimeters from these figures. The normal internal conjugate is eleven centimeters. Any conjugate below ten centimeters indicates a dangerously flattened pelvis.

Fig. 4247.—Breisky's Pelvimeter.

Of the various types of deformities which are perhaps most commonly seen are the pelves of normal symmetry but of extremes of size. The justo-major pelves are those of exaggerated size. They occur usually in women of robust type, who have an otherwise large frame. These women are often tall, but they may be of normal stature. The effect of such a pelvis upon labor is slight. Certain authors suggest that from the lack of bony resistance there is a tendency to precipitate labors and resulting lacerations. There may be an increased proportion of uterine displacements from lack of bony support. The practical obstetrician may disregard this deformity. The diagnosis of this condition may be made in those cases in which the oblique diameters measure twenty-four centimeters or more.

The justo-minor or equally contracted pelvis is of more serious moment. It is usually found in smaller women, but may occur in women of otherwise normal development. It may be classified as one of symmetrical shape, but with external obliques measuring twenty centimeters or less. The etiology of this condition cannot always be explained. It is of great frequency in the African race. In this class, however, the deeper conjugate acts somewhat in compensation. In some cases the justo-minor pelvis is only a part of a dwarfed general system. In some cases it seems to go with underdeveloped pelvic organs, a retention of the juvenile type. Unfavorable surroundings in childhood or during intrauterine life may have affected development unfavorably. The effect upon labor depends necessarily upon the degree of the deformity and the size of the child's head. In those patients who are naturally small the child will be in proportion, except where the father is of large size or where pregnancy has been prolonged beyond the normal time or when there has been dietary indiscretions with considerable muscular inactivity on the part of the mother. In these cases the only safety for the child depends on strong uterine contractions and a capacity for extreme moulding of the fetal

head. In the African race, as the fetal cranial bones are notably soft, and the uterine pains usually very effective, the head moulds extremely well. The justo-minor pelvis, therefore, in the negress has little significance except in those cases in which some other kind of deformity is added to the general contraction. In the Caucasian the larger and firmer head of the fetus causes trouble, and may necessitate very active interference.

The mechanism of the labor in the justo-minor pelves is as follows: The head, unable to engage by moderate flexion, becomes more and more flexed until the occipital bone presents. The external occipital protuberance may be felt. Engaging in one oblique the head gradually descends, under the influence of strong pains. The overlapping of bone at the lambdoidal sutures is an index of the amount of moulding accomplished. If the obstruction is so moderate that the pains can accomplish the delivery, after a rather protracted second stage the head reaches the pelvic outlet. Obstruction occurs until the head is well past the mid-pelvis. During this time the suffering from the pressure against the pelvic bones may be very severe. At the time of the uterine contraction the patient cries out as if suffering intensely. Between the pains there is aching discomfort from the continued pressure of the impacted head. Rarely, after the head has safely passed the pelvic brim, the shoulders may furnish some obstruction.

If the pains are not effectual in advancing the head, and artificial assistance be not forthcoming, the muscular force may diminish. Weaker and infrequent contractions may cause labor to linger along until the patient suffers from extreme prostration; or the pains may be so severe as soon to develop a tonic uterus, with retraction and migration of the muscular fibers to the fundus and a thinning of the lower uterine segment. The end result of such a case may be spontaneous rupture of the uterus. Should the breech present in a patient with a justo-minor pelvis, the complication for the child is apt to be fatal; for while the body moulds easily into the pelvis, the descent of the head can be accomplished only by moulding, which is impossible in the short space of time that safety permits for the extraction of the after-coming head. There are cases on record in which the force necessary to deliver the head through a justo-minor pelvis has caused a diastasis of one or more of the pelvic joints, usually the pelvic symphysis.

The *masculine type of pelvis* is most often found in women with large muscular frames. The external measurements may be even justo-major. The bones are unusually thick. The peculiar deformity in this type of case is in the narrowing of the pubic arch. The pelvis may be shallow or deep. In the latter case it is best described as funnel-shaped. The true funnel pelves, however, are more extreme cases than those of the masculine type, and usually occur in connection with some spinal deformity, especially kyphosis.

The diagnosis is an easy one to be overlooked, because of the otherwise large development of the patient. Indeed, in many instances the case is allowed to go on until the obstruction during the second stage of labor calls attention to the deformity. It is upon the vaginal examination that the diagnosis must be based. The pelvic walls are felt to be drawing nearer together as the outlet is approached. At the outlet the approximation of the ischial spines and tuberosities to each other should be recognized, and also the sharper angle of the pubic arch.

In the masculine pelvis labor progresses normally, even to the time of the appearance of the caput in some cases. And then as the head encounters the bony obstruction all progress ceases, or very slowly and by increased expulsive effort the head is moulded past the outlet. The narrowed arch forces the head posteriorly, and, thus increasing the tension upon the perineum, causes a liability to extensive lacerations. These lacerations may involve not only the perineum, but sometimes run up on either side of the vulva, along the line of the pubic rami. A complete rupture of the rectum may inevitably occur, so that the child is practically delivered through the rectum. Where they extend into the venous plexuses of the vestibule, hemorrhage may be very persistent. From the prolonged pressure various necroses of the vagina or the cervix, or a trauma to the bladder, may be caused.

The pelvic narrowing sometimes causes faulty flexion of the head. The occiput may be forced to rotate posteriorly. Sometimes rotation is so interfered with that the head is born obliquely or even transversely.

The treatment is usually by assistance with low forceps. If this is not sufficient, pubiotomy may be of especial value in this deformity. But the fact that the prolonged pressure in the second stage may have injured the child beyond hope of recovery must be taken into consideration before any major surgical operation on the mother is undertaken.

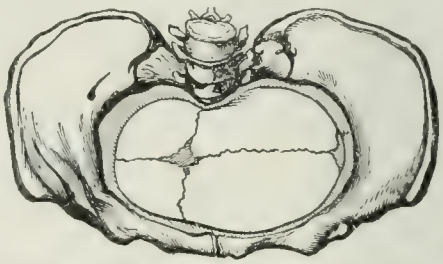

Fig. 4248.—Position Assumed by the Head in a Flat Pelvis (After Simpson.)

The *simple flat pelvis* is a fairly common type of deformity, and one which may have a serious effect on labor. It occurs usually in pelves with measurements otherwise normal. If this deformity be engrafted on a justo-minor pelvis, the consequences are most serious. The cause of this condition is not always plain. A slight degree of rachitis, the carrying of heavy burdens, excessive standing on the feet, prolonged illness in bed in early life may all have some effect. This flattening is most often met with in the lower classes and the foreign born.

The deformity may be anything from a simple jutting forward of the promontory to a marked approximation of sacrum to symphysis, changing the cordiform outline of the brim to a shape more reniform. There is a compensatory slight widening of the pelvic brim transversely. Nothing about the general appearance of the individual in most cases would lead one to suspect the difficulty. The external conjugate in some cases shows no shortening. The internal measurement is therefore of greatest importance. The flattening, if of much significance, will allow the promontory to be easily reached by the examining finger. The extent of the deformity may be readily ascertained by the method suggested above.

If the narrowing be of slight extent, normal spontaneous delivery is possible, but there is a tendency to dry labors and a slight modification of the mechanism. The head engages transversely, poorly flexed, but slightly inclined laterally, so that the anterior parietal bone presents. Occupying the direction of least resistance the occiput slips to one side, thereby causing the bitemporal diameter to engage the conjugate rather than the biparietal. During the time of moulding the woman suffers severely from the pressure of the head against the sacrum.

As soon as the widest part of the head has passed the constriction advance may be rapid. Because of the poor flexion of the head rotation of the occiput to the front occurs late if at all. The head is often born

obliquely, sometimes even transversely, or with the occiput still posterior. The shoulders and hips are apt to be born transversely. If much moulding has been necessary, the posterior parietal bone may show a grooving parallel with the coronal suture, caused by the pressure of the head against the promontory. The posterior parietal bone is overlapped by the anterior.

The effects of the flat pelvis upon labor may be only those mentioned above. If the child be small, attention may be drawn to the deformity. The well-known tendency of women to have larger children in succeeding pregnancies, however, often brings the first manifestation of a flat pelvis in a later pregnancy in a woman who has already had several normal deliveries.

If the deformity be more serious the head engages, but cannot mould sufficiently to pass the brim. After a reasonable length of time artificial assistance must be employed. In the cases of greater flattening no engagement occurs and exhaustion soon supervenes from the futile efforts of the uterus at expulsion. The head rides high above the pelvic brim. The uterus tends to fall forward, causing a pendulous abdomen, which makes the efforts at engagement of the head still more ineffectual.

The flattening, preventing the fitting of the head in the pelvic basin, may cause malpresentations. The lack of adjustment between head and pelvic brim may cause a prolapse of the cord. In the earlier months of pregnancy the projecting promontory may force the uterus into retroflexion and ultimate incarceration in the hollow of the sacrum. Where the head cannot engage or descend into the pelvis the dilatation of the cervix is incomplete because the presenting part does not reach it to cause pressure against it. Instead of the usual meniscus-shaped bag of membranes a cylindrical-shaped bag forms which is ineffectual as a dilator and very prone to early rupture.

The flat pelvis may be the cause of a breech presentation, and when this condition occurs in a pelvis which by measurements other than the conjugate is shown to be ample, the breech labor seems to be the safest. The reason for this is that the after-coming head enters the pelvic canal, with the smallest part of the wedge first. The larger part adjusts itself to the most roomy part of the pelvis. The occiput slips toward one side of the pelvis, and in so doing causes the bitemporal diameter to engage the conjugate, instead of the biparietal, as is usual in vertex cases. The bitemporal diameter has the advantage of being at least one centimeter smaller than the biparietal. The force which must now be applied from below, by traction on the child, will complete the necessary moulding in the safest possible way.

It is for this reason that the method of delivery by version and breech extraction is often considered and safely employed in a labor case with a flat pelvis.

A kind of pelvis which always shows flattening and yet is quite distinctive in type occurs in those women who have suffered from rachitis in infancy or childhood. The rachitic pelvis shows the effect of various pulling and pressure forces upon the different bones.

The extent of the deformity varies with the severity of the disease and depends somewhat upon the position occupied by the patient during the course of the disease, *i.e.* whether lying in bed, sitting up, or walking about. One other factor is the arrested general development which occurs at that time.

The weight of the pelvic viscera combined with muscular traction tends to flatten the ilia and to prevent the inward curvature of the crests to the anterior-superior spines. In this way the spines are thrown outward. In severe cases the ilia flare to the spines. The intercristal diameter is thus smaller than, or of the same width as, the interspinal. About two-thirds of the way to the posterior spines on the crests there is frequently a sharp angle where the crests turn in toward the spines.

The brim of the pelvis is diminished in the conjugate by the pressure of the weight of the trunk transmitted along the spine to the sacrum, and forcing it down and forward on its transverse diameter. The lower half of the sacrum tends to be thrown backward, but the tip is pulled forward in compensation, in sharp flexion, by the sacrosciatic ligaments. The sacrum is further changed, so that its anterior surface instead of presenting a concavity from side to side is convex or flat. Sometimes there is a sharp bending backward of the lower part of the sacrum at the juncture of the first and second sacral vertebræ, causing the second vertebra to form a false promontory, which in estimating the internal conjugate must be accepted as the working promontory.

There is a widening of the pubic arch from muscular traction on the ischial tuberosities. If the patient be allowed to walk during the disease, there may be some constriction of the pelvis transversely by pressure over the acetabula. In general the size of the pelvis is restricted. The flattening is the worst feature. The pelvic brim presents a reniform outline, with a slightly increased transverse diameter. The pelvic cavity is usually ample and the outlet wide. The symphysis forms a wider angle with the plane of the sacrum. All degrees of deformity are met with.

The diagnosis of the extreme cases is easy. In slighter deformities the history of the patient is of some help—late walking, late dentition, unhygienic surroundings. There may be evident the square forehead, rickety chest, bowlegs, or any of the rachitic skeletal changes apart from the pelvis. Locally, there is found the changed ratio of the interspinal to the intercristal measurements; the easily felt promontory, with perhaps a false promontory at the junction of the first and second lumbar vertebræ; the sacrum convex from side to side; and the wide pubic arch.

The effect of *rachitis* on labor depends on the extent of the deformity. Even in cases of slight deformity the effective working space of the bony passages is circumscribed. In lesser cases the mechanism may resemble that of a simple flat pelvis. In worse cases a spontaneous delivery or even engagement of the head is impossible.

Osteomalacia, or *malacosteon*, is a disease which causes a softening of the pelvic bones by the absorption of the lime salts. It develops during pregnancy or lactation; more usually the latter. The condition is rarely met with in this country. Nothing is known of its etiology other than that it is a disease of nutrition. The softening of the bones, however, is the occasion for an extreme collapse of the pelvic basin. The sacrum and the regions of the acetabula are crowded in so that the pelvic brim is triradiate in shape. This collapse leaves the symphysis projecting like a beak, giving the pelvis the name of the "rostrate pelvis." The pubic arch is much narrowed. Severe cases of rachitis show a similar deformity. For differentiation, in the cases of osteomalacia the ilia are curved like scoops and the crests are more sharply curved, while in rachitis the ilia flare and the spines are widely separated.

The history of cases of osteomalacia is characteristic. The trouble develops during the child-bearing period. There are dull aching pains in the extremities and lumbar region, with difficulty in walking and rotation of the body as one foot is advanced in front of the other. The stature is appreciably diminished during the course of the disease. There may be tenderness over the anterior pelvic wall. Examination reveals the beaked pelvis, the narrow pubic arch, and, if the finger can reach so high, the triradiate pelvic brim. Such a pelvis, unless in the earlier stages and quite soft, will not allow any form of conservative operative delivery *per vias naturales*. The cesarean operation with extirpation of the uterus furnishes the best solution of the difficulty.

Kyphosis developing in early life from caries of the vertebræ, possibly from rachitis, leaves its stamp upon the pelvis, producing the type known as the *kyphotic pelvis*. This was first described by Breisky in 1865. The difference in the direction of the pressure, transmitted through the spinal column on the sacrum, is dependent upon the location of the kyphos. The deformity is most marked when the kyphos is low down. In the upper dorsal region spinal deformity will affect but slightly pelvic development.

The characteristic kyphotic pelvis has a displacement of the upper end of the sacrum backward. This gives an unusually deep conjugate. The lower end of the sacrum is thrown forward. There is an approximation of the posterior-superior spines and of the ischial tuberosities. There is a narrow pubic arch. The sacrum is long, narrow, and straight. This pelvis presents therefore the funnel type. The pelvic brim is deep and ample, but the outlet is much narrowed. Combined with kyphosis there is usually some scoliosis, causing some pelvic obliquity. Some of these individuals have smaller measurements in general, due to arrested development.

A kyphotic pelvis does not affect the course of the labor to the extent that would be anticipated from the examination and inspection of the patient. The successful outcome of labor in these dwarfed women is often a suprise to even the experienced.

There is always a pendulous abdomen with anteflexed uterus and a tendency to malpresentation, which is usually corrected by the onset of pains. Engagement of the head in the first stage may be delayed. As soon, however, as the head is engaged progress is normal until the outlet is reached. Here the bony obstruction may be such that prolonged moulding or assistance by forceps becomes necessary for the extraction of the head. The narrowing may prevent the forward rotation of an occiput posterior, or even cause an anterior position of the occiput to turn into a posterior. Four per cent. of cases are reported to present by the face. In this deformity the bi-ischiatic measurement is of importance in prognosis. If it is below 8.5 centimeters there is probability of serious difficulty.

Oblique deformities of the pelvis of the extreme type are due to failure of growth of one of the sacral alæ. To this deformity the name of Naegele, who first described it, has been given. The oblique measurements vary widely. The short oblique is that of

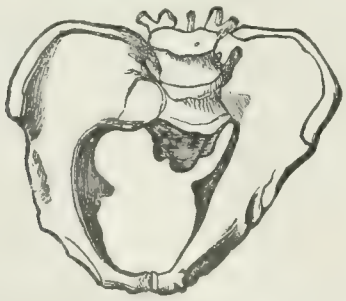

Fig. 4249.—Obliquely Contracted Pelvis. (After Duncan.)

the normal side. The sacrum, which is narrowed, faces from the small side. The pubic arch is asymmetrical. The sacrum is narrowed. Vaginal examination shows the front of the sacrum and promontory facing toward the diseased side. The ischial tuberosity is higher on that side and the corresponding posterior-superior spine is higher, lying closer to the sacrum. The subpubic angle is asymmetrical and looks toward the diseased side.

The failure in growth may be due to a congenital developmental defect or to disease. If it is due to a congenital defect, the deformity is not evident until after walking has occurred. Pressure then causes the crowding up, in, and back of the innominate bone on the diseased side, and the rest of the asymmetry noted above. If it is due to disease of the sacroiliac joint, tuberculosis, or some acute arthritis secondary to the general disease, must in early life have been sufficiently extensive to destroy the bony nuclei of the ala of the sacrum on that side. Ankylosis of that joint is the usual accompaniment of the deformity, but is not the absolute rule.

The diagnosis is easily made by means of the pelvimeter and the vaginal examination. If disease be an etiological factor the presence of a scar or sinus over the affected iliac joint aids in the diagnosis.

The effect produced by this deformity upon labor in the less extreme cases may not be serious. But usually the distortion is so extreme that the natural delivery is impossible. The delivery, if possible, is accomplished by extreme flexion and moulding of the head, as in the generally contracted pelvis. Abnormalities of rotation and flexion are apt to occur in the lower pelvis.

The forceps may be tried, and if this fails, craniotomy or the cesarean section may be performed. Symphyseotomy is contraindicated on account of the probable ankylosis of the sacroiliac synchondrosis on the affected side.

Where both sacral alæ have failed of development that rare deformity, the *double obliquely contracted pelvis*, is found. In 1842 this type of pelvis was described by Robert, and has since been known as the Robert type. Very few cases of this type have been reported. From the same causes as in the Naegele pelvis, the sacral alæ are both absent or only partly developed. There results the extreme type of transversely contracted pelvis. The pelvic brim presents the outline of a long narrow ellipse. The conjugate is of normal or only slightly lessened size, the obliques are much shortened, and the transverse diameter excessively narrow. The sacrum is long, narrow, and oblong rather than triangular. Both sacroiliac joints are usually ankylosed. The posterior-superior spines are very close to each other. The pubic arch is narrowed. Unequal development, due to partial growth of one ala, may cause a slight degree of obliquity.

The effect of such extreme contraction must be complete obstruction to the passage of a viable child.

Fig. 4250.—Robert's or Double-obliquely Contracted Pelvis. (After Duncan.)

Another rare type of developmental deformity is that in which the pubic rami have not developed sufficiently to meet at the symphysis. This is called the *split pelvis*. It furnishes no obstruction to delivery.

The lesser degrees of obliquity, which rarely have much effect on the mechanism of labor, are due to scoliosis; to injuries or disease of hip-, knee-, or ankle-joint; to failure in development of one limb from some kind of paralysis, usually poliomyelitis; or to club-foot.

In cases of *scoliosis* extra pressure is transmitted

through the lower acetabulum and there is consequent shortening of that oblique. Simple scoliosis is common, but it often accompanies rachitis or vertebral caries. If there is rachitis, there are the other rachitic effects on the pelvis and a greater obliquity. If scoliosis is combined with Pott's disease, there is merely slight obliquity added to the typical kyphotic pelvis. This is the so-called *kyphoscoliotic pelvis.* The slight obliquity caused by such simple scoliosis is of no significance, but the shortening of the spinal column may cause a pendulous abdomen, which will give trouble in the engagement of the head at term.

FIG. 4251.—Pelvis in which the Pubic Rami Fail to Meet at the Symphysis. (Schauta.)

Any cause which acts so as to limit or do away with the use, in early life, of one of the lower extremities, reacts upon the pelvis by throwing greater pressure upon the well side. Tuberculous disease of the hip, knee, or ankle-joint is the most common disease affecting the lower extremities. Local deformity of the pelvis has been encountered from erosion of the acetabulum and displacement of the head of the femur through into the pelvic cavity. Ankylosis of one or both femora in adduction may cause an obstruction to delivery.

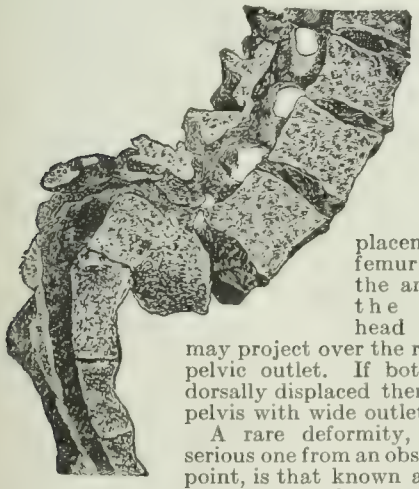

FIG. 4252.—Spondylolisthesis. (Neugebauer.)

A congenital hip dislocation causes the pelvis to develop with one short oblique from pressure on the healthy side. An anterior displacement of the femur may drive in the anterior wall of the pelvis. The head of the femur may project over the ramus into the pelvic outlet. If both femora are dorsally displaced there is a shallow pelvis with wide outlet.

A rare deformity, but a most serious one from an obstetrical standpoint, is that known as *spondylolisthesis* of the lumbar vertebræ. It was described by Rokitansky in 1859, and later by Neugebauer. The bodies of the vertebræ are dislocated forward. There is some lumbosacral dislocation permitting a slipping of the body of the last lumber vertebra in front of the sacrum. Here it becomes ankylosed. Then exaggerated lordosis occurs, and possibly there is a descent of the fourth and third lumbar vertebræ, so that they project over the pelvic brim. The sacrum is pushed down and back. In compensation the symphysis rises, lessening the inclination of the brim. There is narrowing of the brim, with anteroposterior limitation, which will prevent the passage of the head.

This deformity may be started by disease, especially lumbar caries, or by injuries, or perhaps it may date from intrauterine life. For diagnosis we must depend upon the history of the case—the story of injury from a fall or accident, or of spinal disease; perhaps the fact of carrying heavy weights.

There are extreme shortening and a pendulous abdomen. Examination shows the ribs lying close to the ilia. The shoulders are carried well back, as the patient stands in lordosis. There may be lumbar crepitus, felt while walking. The vulvar opening, due to the change in pelvic inclination, presents anteriorly as the patient is standing or sitting. By vaginal examination the bodies of the projecting vertebræ may be easily felt and the contracted outlet also noted. The limitation at the pelvic brim precludes any possibility of a normal fetal head engaging.

Tumors of the pelvis may be of large size and may almost obliterate the pelvic cavity, or they may be merely bony excrescences springing from the region of the pelvic brim. They may grow from the inner surface of the symphysis, from the sacroiliac joints, or from the ileopectineal line. If sharp they form what is known as the pelvis spinosa. The projecting bits of bone may cause dangerous circumscribed pressure on the child's head. The larger tumors may be enchondromata, sarcomata, or carcinomata. They necessitate embryotomy or cesarean section. Fractures of the pelvis rarely may cause deformity from the growth of callus.

Ankylosis of the sacrococcygeal joint, which normally occurs after the menopause, may happen prematurely and furnish some resistance to the passage of the child's head. The uterine contractions are usually of sufficient force to fracture the bone. Sometimes the head is held by this deformity until the bone is artificially fractured or the forceps is applied. With the fracture a snap is sometimes plainly heard and the head thereafter advances readily. The fracture of the bone should be accomplished under chloroform, the thumb and forefinger of the accoucheur grasping the coccyx.

The consideration of pelvic deformities is incomplete without a word concerning *prophylaxis.* The possibility of the results of rachitis upon the pelvis should make the mother careful about the feeding of the infant, its general hygiene, and especially about its allowance of fresh air. Early attempts at walking should be forbidden, especially if the infant is heavy. The effect of disease or deformity of the skeleton of the female child upon the pelvis is an argument for early consultation with the orthopedic surgeon and the early correction, if possible, of existing deformities.

When the deformity exists in the child-bearing woman the obstetrician must be able to recognize the deformity, and by trained judgment determine its probable effect on labor. The question may arise whether the patient is warranted in entertaining the hope of having children at all, or, if she be in earlier pregnancy, whether the deformity calls for an induction of premature labor. Should the patient be in labor, other conditions must be taken into account. These are: the extent of obstruction presented by the soft parts, the relative size of the child's head and its capacity for moulding, the force of the labor pains, and lastly, the ability of both mother and child to withstand the strain of delivery. The history of previous labors is of value, but it must be remembered that the size of the child tends to increase up to the fifth or sixth pregnancy.

If the child is small or premature, slight pelvic deformity may have no significance; and yet with a child above normal size this defect may constitute a serious obstruction. Such cases of overgrowth of

the child are occasionally met with, and are the result of a large father, overnutrition of the fetus from the mother, and sometimes of the prolongation of pregnancy one or more weeks beyond normal.

Those cases of slight obstruction, in which delay occurs in the second stage, justify a waiting policy. Nature with time will accomplish sufficient moulding in a safer way than if forceps were used. Good judgment requires that one know how long it is safe to allow this moulding to continue. Too long compression of the head gives danger of intracranial hemorrhage. Too long-continued pains expose the mother to exhaustion and shock, and ultimately to a tonic uterus with possible rupture, or an exhausted uterus with resulting postpartum hemorrhages. On the other hand, early interference before the head has had time to mould will expose both mother and child to needless trauma. Account must be taken of the force and frequency of the pains; the maternal pulse, and evident amount of suffering caused by the pains; the rate and force of the fetal heart; and the amount of moulding, as shown by the caput and overlapping suture, and by the advance of the child's head.

In some cases the severity of the pains or the poor condition of mother or child may necessitate operative delivery before the patient has been in the second stage an hour. In other cases in which the uterine contractions have been of poor quality some good may be accomplished by a delay of several hours. Uterine action may be stimulated meanwhile by tonics, such as strychnine or quinine. Where the obstruction is evidently slight and due to faulty pains, pituitrin may be cautiously employed. In cases of marked deformity pituitrin must never be used, because of the danger of uterine rupture. The erect posture increases the force of the pains. In cases with a flat pelvis some increase in the conjugate, from 0.5 to 1 centimeter, may be accomplished by the Walcher position. The patient lies in the dorsal position with the thighs extended over the end of the table, and the feet barely touching the floor. If there is some advance of the head, pressure on the fundus, during the pains, may be tried.

For the more extreme degrees of dystocia, due to deformity, there may be used the forceps, podalic version, usually combined with breech extraction, the induction of premature labor, pubiotomy with forceps, the cesarean section, craniotomy, or, in the cases of extreme contraction, craniotomy with evisceration.

The low forceps operation for deformities of the pelvis is usually necessary in those cases of limitation of the pelvic outlet, as in the kyphotic cases or those of the masculine type. In the worst kyphotic cases pubiotomy may be necessary. The medium forceps operation is more common in the generally contracted pelvis. For the flat and generally contracted pelves high forceps may be needed. In justominor pelves, the only possibility of safe delivery by the natural route lies in extreme moulding of a well-flexed vertex.

In the flat pelvis the indication for high forceps is not always so plain. The head in these cases coming down in the transverse diameter must often be grasped by the forceps with one blade applied to the occiput and one blade to the face. The effect of traction then is partly to mould the head so that the biparietal diameter tends to widen. As has been described above, the after-coming head in a breech extraction accommodates itself in such a way that the bitemporal diameter engages the narrowed conjugate. For this reason version and breech extraction are frequently resorted to, in cases of flattening, with good result.

If the head, in case of a flat pelvis, is engaging well, forceps may be tried gently. If the head persists in not engaging, version is preferable provided there is a reasonable possibility of bringing the head through. If in the case with the head engaged the forceps fails to accomplish advance, the head may be disengaged and version tried. It must be remembered that the version is of value only in the simple flat pelvis which is ample in other measurements. In a flat justominor pelvis version is worse than useless.

Where the conjugate is quite short, the head may be prevented by the deformity from descending far enough to dilate the cervix. In such a case, before any operative delivery is attempted, the cervix should be carried to full dilatation by means of the hydraulic bags or by digital stretching.

The *induction of premature labor* in selected cases is an operation which has a most important field of usefulness. If the pelvis is small and the head seems to be riding high, or if a woman habitually has larger children than can safely be born, it is proper carefully to watch the patient during the last two months of gestation and to terminate pregnancy at any time when the child's head seems, relatively to the pelvis, a close fit. Once a week the patient should be examined, and by the bimanual method the ratio between the size of the head and the diameter of the pelvis carefully estimated. There will be a certain proportion of disappointments, but what might be otherwise fatal dystocia will be avoided, and in many cases a healthy child secured.

As a rule any child of over eight months' gestation will do well with proper care, and sometimes one even younger will thrive. The success depends on the judgment of the physician, who should allow to the infant every week of intrauterine life that is possible. An error either way is bad. If the operation is delayed too long, the premature infant will resist very poorly the manipulation necessary for an operative delivery. If labor is induced too early, the child is robbed of just so much vitality. In general it should be said that the induction of premature labor at a period before the last two weeks of pregnancy, is apt to be a failure.

The operation of *symphyseotomy* has lost favor in the last few years because of the risk of infecting the mother, or of leaving her permanently crippled from failure of union of the symphysis, and because of its uncertain results as compared with the good results of a properly performed cesarean section. It has been superseded by the operation of pubiotomy which leaves a firm pelvis, and permits a more speedy recovery, while having all the advantages of the earlier operation. It must be restricted to cases in which the possible separation of the pubic bones of 7.5 centimeters will enlarge the pelvic canal sufficiently to allow the head to pass. Compared with the cesarean section, it is the more dangerous, more uncertain of the two, and of greatly restricted range of application.

The *cesarean section* must be employed in those cases in which there is no other possible method of delivery of the child living or dead (the absolute indication), or it should be employed (the relative indication) in cases in which delivery of a living child is possible only by laparotomy. The indication has been extended, by most operators even to those cases in which delivery of a living child is improbable except by laparotomy.

This operation in properly experienced hands seems to promise great usefulness. Every year the indications for this operation are enlarged. Whereas a few years ago, on account of the great mortality of the cesarean section, only the absolute indication for the operation was considered valid, now, granted good surgical facilities, the question of a conservative laparotomy in the interest of both mother and child may be decided in the affirmative in cases of obstructed labor. If infection is probably present, a hysterectomy may be performed at the same time, or the uterus incised and the child delivered through an extraperitoneal incision.

The mutilating operation on the child, commonly known as *craniotomy*, is indicated where the obstruc-

tion is absolute and the child dead, or where the condition of the mother, or the lack of facilities for operating, prohibits surgical interference. The crushing followed by traction on the head is usually sufficient to effect delivery without much additional shock. Rarely, if the child is of large size, evisceration or further mutilation of the child must be resorted to.

FRANKLIN A. DORMAN.

Pemphigus.—The word pemphigus does not convey the idea of one clear-cut disease; it is a conglomerate composed of several groups, the only common bond of union between which is the occurrence of bullæ. Although these bullous diseases differ widely from one another, yet owing to the prominence of their symptoms, and to the obscurity of their causes, it has been found difficult or inexpedient to segregate them.

PEMPHIGUS NEONATORUM.—This is an instance of the above-mentioned inexpediency of segregation. Etiologically there is no doubt it is impetigo contagiosa. It is described here for two reasons; the name is still a familiar one in medical literature, and its most striking symptom, sometimes its sole symptom, is a bleb, leading the observer most naturally to look for its description under the heading pemphigus.

Pemphigus neonatorum is an acute contagious disease characterized by the occurrence, during a limited time, of crops of blebs.

Symptoms.—In otherwise healthy infants of from three to eight days old, blebs suddenly arise. They vary from a pea to a hazelnut in size, or even larger. They are at first tensely filled with clear yellow serum, and are scattered anywhere over the cutaneous surface, and spring from an apparently normal or a reddened skin. After a short time the bullæ become flabby and the contents grow turbid. Then shortly the delicate covering of the bleb gives way, exposing a red weeping surface upon which the epidermis has more or less perfectly formed, according to the time, whether early or late, at which the bleb covering has broken. The blebs arise, become turbid, burst, and heal in a few days. The duration of the disease is from one to two weeks, in which time it produces several crops of bullæ. This constitutes the whole disease, which usually affects only the skin, and seems but rarely to have an influence on the constitution. It may, however, run a severe course, and cause death in a very short time.

Most of the recorded cases are reported as epidemics in foundling asylums. It is probable, however, that even a larger number occur scattered throughout the community, but are left unnoted. The sporadic cases are usually seen only by the obstetrician, who, observing that the general health is not affected, adopts some indifferent treatment under which the patients generally recover.

Diagnosis.—In the hereditary bullous syphilide the bullous eruption is particularly marked on the palms and soles, situations that remain free in pemphigus neonatorum. Besides this, in syphilis the base of the bulla is infiltrated and frequently ulcerated, and the pruption is polymorphous, consisting of papules, austules, and large erythematous infiltrations. In eddition, in syphilis, there are snuffles, mucous patches, and condylomata. In varicella the lesions are vesicles rather than bullæ and are rarely large. Ritter's disease is an unusually malignant variety of pemphigus neonatorum, in which an erythema, beginning near the mouth and spreading over large areas or the whole cutaneous surface, is the principal symptom. The bullæ are subsidiary to this. Besides this, in Ritter's disease, the connection between the horny layer of the skin and the rete Malpighii is loosened as in pemphigus foliaceus, so that the horny layer either comes away spontaneously, or may be taken off in large sheets or ribbons by a stroke of the finger. The patients usually run a temperature, and in about fifty per cent. of the cases die within a week.

Pathology.—Pemphigus neonatorum, some cases of pemphigus febrilis, impetigo contagiosa, and Ritter's disease are identical affections. The pronounced contagiousness of pemphigus neonatorum, its superficial situation, its frequent lack of constitutional symptoms, its self-limitation, and its duration, all correspond to what we know of impetigo contagiosa. We know also that impetigo contagiosa, even in adults, may be a bullous disease, and that it is particularly apt to be so in warm countries. In infants, who are always kept very warm and whose skin is delicate, the tendency to form bullæ, even in temperate climates, is marked. It has also been noticed that if an infant is infected from an adult who has impetigo contagiosa it gets pemphigus neonatorum, and the very reverse is the case if an adult is infected from an infant.

Treatment.—It has been found that pemphigus neonatorum occurs with noticeable frequency in the practice of uncleanly midwives and nurses, and therefore their thorough personal disinfection should be required. It is with a view to getting on the track of such disease carriers that the Berlin authorities have ordered all cases of pemphigus neonatorum to be reported to the health office.

If it be true that pemphigus neonatorum and Ritter's disease are simply forms of impetigo contagiosa, then the parturient woman and the infant should be carefully shielded from this very prevalent disease. Attention is here drawn to the facts that many cases of what are commonly called barber's itch in men and impetiginous eczema in children are really impetigo contagiosa, and that impetigo contagiosa is so frequent, particularly in children, that a skin clinic is scarcely ever without examples of it.

As the infants attacked rarely suffer from constitutional symptoms, and the disease is generally short and self-limited, no internal treatment is required. If, however, constitutional symptoms do arise, such as fever and exhaustion, they must be treated on the principles obtaining in general medicine. As the infections are streptococcic, the question of administering a serum arises. The difficulty here lies in getting the serum appertaining to the particular bacterial strain involved. As the malady is contagious and is scattered over the entire cutaneous surface, a general cutaneous antiseptic treatment is indicated. The antiseptics chosen, however, must be those that will neither injure the infant's delicate skin nor by absorption cause constitutional symptoms. In regard to absorption, it must be remembered that the thin skin of the infant more readily absorbs medicaments than the stronger, thicker skin of later life. As fulfilling these indications, two antiseptics come to mind: alcohol and boric acid. Boric acid may be added to the infant's bath; two heaping tablespoonfuls of the powder to the gallon, and a lotion consisting of a saturated solution of boric acid in dilute alcohol, may also be used as a rub-down. This solution, by the way, is one of the best to employ in any case of pyogenic infection of the skin. It may be readily made in the following way: A bottle is half filled with alcohol, then nearly filled up with water, and then boric acid is poured in until some of it remains undissolved in the bottom of the bottle after shaking. The supernatant fluid is of course a saturated solution of boric acid. When an ointment is necessary or desirable, as on the face or in the flexures, a weak ammoniated mercury ointment is the best; it is made by adding five grains of ammoniated mercury to an ounce of vaseline. When crusting takes place, the crusts must be removed before either lotions or ointments may be expected to be of any use. This is best done by applying boric acid starch poultices. These are made by adding hot water to ordinary laundry starch while constantly stirring, to make a moderately thick paste. To a large teacupful of the paste a heaping teaspoonful of boric acid powder is

added, and it is then folded between sheets of muslin and applied.

Pemphigus Acutus Febrilis Gravis (Darier).—Acute febrile pemphigus is not pemphigus in the real sense of the word. It is a pemphigoid sepsis, but is included here because it is so strikingly bullous that in looking up a case one would naturally turn to pemphigus. It is a general infectious disease that occurs almost exclusively among butchers, sausage makers, tanners and cooks; that is to say, among people who handle dead animal matter, and usually follows a wound on the hand. It comes on suddenly with prostration, chills, vomiting, diarrhea, and high fever (40° C.).

In from twenty-four to forty-eight hours the widespread eruption appears as well-formed bullæ with amber-colored or hemorrhagic contents, arising on an erythematous base. The mucous membranes may also be involved.

In more than three-quarters of the cases death occurs in one or two weeks. Recovery may take place in from three to six weeks.

The pathogenic microorganism is not known, and no specific treatment has been formulated, which, therefore, must follow the general rules of internal medicine. The external treatment would be that advised for pemphigus neonatorum.

Probably in the same class are the bullous septicemias occurring in inflammatory diseases of the umbilical cord, or the bullous septicemias in the new-born, coincident with septicemia in the mother. The affection on the skin in such cases may look like an extensive burn with scalding water. These grave bullous diseases seem in many instances to be different from what is understood in speaking of pemphigus neonatorum.

Pemphigus Chronicus Vulgaris.—*Definition.*—Pemphigus chronicus vulgaris is characterized by the appearance of blebs on the skin and also on the mucous membranes. Pemphigus foliaceus and pemphigus vegetans are to be looked upon as varieties of pemphigus chronicus vulgaris. They are worthy, however, on account of their peculiar clinical appearance and course, of a separate description.

Etiology.—The cause of pemphigus is unknown. That it is not merely a local, but a constitutional, disease is shown by the fever that accompanies it, and also by the more or less rapid deterioration in the general health of those afflicted with it. That a few blebs on the surface of the body should cause cachexia and death is not to be thought of as a possibility. The blebs are only one symptom of a general constitutional disease. Take, for example, pemphigus vegetans when at times the blebs cease to appear. This temporary cessation of the appearance of the blebs does not retard in the least the general course of the disease.

The occurrence of blebs in diseases of the nervous system, in nerve injuries, and in neural leprosy has led many to think that pemphigus is a disease of the nervous system. These are the only facts, however, that favor this view. That the disease is due to some toxic substance that acts through the nervous system, in some such way as an intoxication with rotten fruit will cause urticaria, is not impossible.

Symptoms.—Pemphigus vulgaris frequently commences with general as well as with cutaneous symptoms. The general symptoms are fever, malaise, gastric disturbance, sleeplessness, and decided nervousness. With these symptoms there appears on the skin a greater or less number of blebs, which may come in crops, each crop being accompanied by an exacerbation of the constitutional symptoms. The course of the disease may present great variations. In the first place the initial crop of blebs and those following may be accompanied by very little rise of temperature or none at all, or there may be much constitutional disturbance with very little eruption, or the reverse. The outbreak of blebs and the constitutional disturbance may be continuous, reducing the patient's strength very rapidly; or the disease may begin acutely and stormily, gradually linger on for weeks or months, and finally die down altogether, possibly to start up again at some future time. The blebs arise either from what appears to be a normal surface or from a reddened spot, and are at first filled with a fluid either as clear as water or of a yellow serous appearance, or red or brown or blue from mixture with blood. In any case this fluid quickly becomes turbid, then purulent. The blebs may be the size of a pea or a hen's egg, or even larger. After a

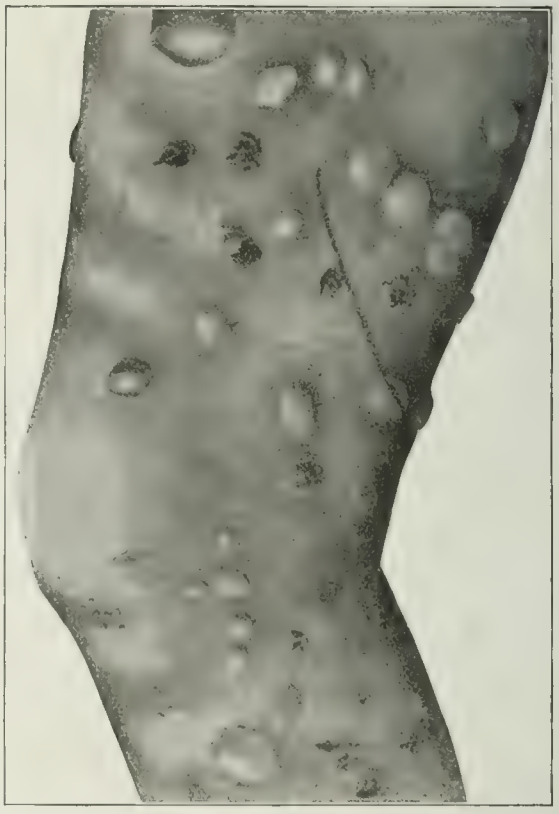

Fig. 4253.—Chronic Pemphigus Vulgaris. In the picture the bullæ can be seen with great distinctness to be full, tense, hemispherical and oval, variable in size and springing from a skin, which is, to all appearances, healthy. In some places there are vestiges of old bullæ that have gone through their evolution: some are broken, others are dried down. There are no evidences of scratching. (From a plate in L. Brocq's article on Pemphigus in "La Pratique Dermatologique" by Ernest Besnier, L. Brocq, and L. Jacquet, t. iii., p. 770. This figure is a reproduction of an aquarelle in Cazenave's collection in the Museum of the Hôspital Saint Louis, and had already been published in the "Lecons sur les maladies de la peau" by Alphée Cazenave, 1856.)

time they either dry down, forming a scab, under which healing takes place, or they may break spontaneously or be broken, leaving a non-infiltrated eroded surface upon which there forms a flat, yellow, brown, or black scab. In due course this scab falls off, leaving a more or less deeply tinted brown pigmented patch, rarely a scar. At times, after healing, milium bodies, first described by von Bärensprung, are found in the epidermis.

On the mucous membranes the lesions are rarely seen as blebs, because the delicate and moist epithelial layers soon burst, leaving non-infiltrated erosions, which are either red or covered by a yellowish coating.

The circular or polycyclic form of these erosions, together with the tatters of epithelium around their borders, show their origin as blebs. On either the skin or the mucous membranes any individual lesion may stop short of forming a bleb or an erosion as the case may be. On the skin such a lesion would be merely an erythematous spot, while on the mucous membranes it would show itself as a whitish-gray epithelial thickening. In pemphigus there may be no eruption whatever on the mucous membranes, or the outburst on the mucous membranes may precede, be simultaneous with, or follow the eruption of blebs on the cutaneous surface. Mosler and Köbner have seen pemphigus of the mouth exist for four years before there was an outbreak on the skin.

As has been said, it is very rare for scarring to follow pemphigus blebs on the skin. It is also rare, but not so rare, for scarring to occur on the mucous membranes. What is equivalent to scarring occurs on the conjunctiva, constituting what has been called essential shrinking, but this will be considered later on. Sometimes the erosions on the mucous membranes, especially of the mouth, ulcerate. Probably these ulcerations are not an essential part of the disease, but adventitious from the increased vulnerability of the eroded surfaces, and also from infection, usually with staphylococci or streptococci. In the same way pemphigus may be accompanied by lymphangitis and adenitis, the broken mucous membrane being the open door for the entrance of bacteria. It is said that ulceration in the cheek pouches may result in so much cicatricial tissue as to interfere with the action of the lower jaw. Pemphigus of the throat may cause hoarseness, suffocation from swelling of the glottis or of the mucous membrane of the larynx, a feeling as if a fish bone had lodged in the throat, or a disagreeable feeling of rawness. In pemphigus of the mouth or throat the interference with mastication and the difficulty or impossibility of swallowing solid food add to the misery and weakness of the patient.

As in pemphigus of the other mucous membranes blebs on the conjunctiva are very seldom seen. It may be that they very rarely form, or that if they form they quickly burst. The pemphigus lesion as seen on the conjunctiva consists of an irregular-shaped membranous exudation of grayish-white or grayish-yellow color. Pemphigus of the conjunctiva is almost always followed by cicatrization. It is not meant by this that every pemphigus lesion on the conjunctiva is followed by scar formation. In fact almost all the lesions here, as on the skin, heal without scarring. It seems necessary to scar formation that a number of pemphigus lesions should occur successively at one place (Michel), and, as this often happens, scar formation frequently results.

The scars may be localized, or they may involve almost the whole of the conjunctiva. If they are thus generalized, the conjunctiva will be turned into a dirty gray or whitened, thickened, cutis-like membrane, with a dull dry surface, called "essential shrinking." With much shrinking the entire conjunctival sac may be obliterated, and one or both lids may be entropioned, or drawn tight down on the edge of the cornea. In such cases the cornea itself is diseased from exposure, and from the eyelashes of the entropioned lids sweeping over it. It is white and opaque, and its surface is dull and dry, and covered with scaling epithelial cells. Michel never has seen a bleb of the cornea itself, but he quotes Seggel as having seen one, and Mueller as having seen an ulcer covered with a membranous exudation on the upper border of the cornea and on the neighboring conjunctiva; Pergens has also seen a broken bleb of the cornea in an infant.

Pemphigus of the conjunctiva may exist alone or with pemphigus of other mucous membranes such as the mouth, pharynx, trachea, or bronchi, or with pemphigus of the skin. It is held that a diagnosis of pemphigus, when the mucous membranes alone are affected, cannot be made. It seems, however, that the clinical picture is clear enough, and that such lesions are pemphigus is shown by the fact that after existing for a longer or shorter time pemphigus of the skin may supervene. Just as there can be a pemphigus of the skin alone without pemphigus of the mucous membranes, so also can there be a pemphigus of the mucous membranes without pemphigus of the skin (Kaposi).

Eosinophilia, either in the blebs or of the blood of the general circulation, seems to have very little value as a symptom.

Diagnosis.—In dermatitis herpetiformis the mucous membranes are not apt to be affected; the lesions on the skin are multiform and consist of erythematous patches, papules, wheals, vesicles, and bullæ; the itching and pain are severe and occur in distinct attacks; and the general health is undisturbed.

In epidermolysis bullosa the disease occurs in families and is hereditary; the bulla occurs when an injury has been received, even a slight pressure, as on the feet and hands, may cause it; and the general health is unimpaired. Colcott Fox has, however, reported a case in which the disease resembled epidermolysis in every particular except that it was not hereditary, and he warns against drawing too fine distinctions between it and pemphigus. In epidermolysis bullosa the nails also frequently become deformed, and the disease is probably something more than a mere oversensitiveness of the skin to pressure. Another instance showing the intimate relationship between these two diseases is the case reported by Mertens, in which there was pemphigus of the mouth, throat, and conjunctiva. Blebs appeared also on the skin, but only after trauma.

The vesicular and bullous eruptions that sometimes follow trauma and also those that sometimes follow vaccination, and that in either instance may last for years, resemble more closely the type of dermatitis herpetiformis than that of pemphigus. Just where they stand, however, in a classification, has not yet been determined.

Quinine, iodine, bromine, and copaiba may all cause bullous eruptions that have to be differentiated from pemphigus.

The blisters caused by the external application of drugs must also be considered. Sometimes these are applied with the intention of deceiving. The occurrence of the blebs exclusively on the skin in an hysterical person in situations easily reached by the patient may cause suspicion. The wings of the Spanish fly have been found on the blebs.

Hardy mentions the occasional occurrence of blebs on the hands and feet in eczema. I have seen this occur in two separate attacks of eczema in the same patient. Bullæ may also occur in lichen planus (Whitfield). The differentiation would here be made by the presence of the lichen papules and by the itching.

In impetigo contagiosa the eruption, as has been previously mentioned in the section on acute pemphigus, may be bullous even in the adult, especially in the tropics. The swift course of the disease, its marked contagiousness, its non-interference with the general health, the very large yellow superficial crusts, and the occurrence of pustules are differential points.

Prognosis.—Pemphigus is one of the few diseases of the skin in which the life of the patient is threatened.

In such a capricious disease the prognosis is always uncertain. Cases that begin benignly may end malignantly, and *vice versa*. Nevertheless, there are indications that point to a good or bad course of the malady. Luithlen, for instance, divides pemphigus, in regard to prognosis, into two classes of cases. In the first class the blebs appear on erythematous patches, and there is no rise of temperature. In these

cases the blebs are situated in the epithelium, and the rete is not raised away from its bed on the papillary layer. The prognosis here is favorable. In the second class the blebs arise on the perfectly sound skin, and their eruption is accompanied by fever and exhaustion. In these the blebs arise under the rete and lift it completely away from the papillary layer. The prognosis here is always unfavorable.

When the blebs are tense and filled with a clear white or amber-colored fluid it is viewed as a favorable sign; while, on the other hand, when the blebs are slackly filled and pus quickly forms, collecting as an hypopyon in the dependent portion of the hanging bag, the outlook is bad.

In pemphigus of the mouth and throat the difficulty or impossibility of swallowing solid food interferes with the patient's nutrition. Independently of this, however, the occurrence of pemphigus of the mucous membranes may be looked upon as ominous. In general, in those cases in which the mucous membranes are affected at the very first or early in the disease, the prognosis is the worst; but no matter at what time in the course of the malady the mucous membranes are affected the symptom is a bad one.

Pemphigus Foliaceus.—That form of pemphigus which is called pemphigus foliaceus has for its chief clinical characteristic the exfoliation of the skin. There may be very few blebs; indeed, when the disease is well under way and the exfoliation is active there may be no blebs at all.

It may attack either sex, at any age, even in childhood. The disease appears in all countries, and does not seem to depend in any way on climatic influences. It is neither epidemic nor contagious.

It is said that prodromal symptoms are either absent or not at all well marked, and that when present, they consist in a feeling of general lassitude and a slight rise of temperature. The first symptoms of the disease proper may appear on any part of the skin, or on the mucous membrane of the mouth. The blebs in pemphigus foliaceus, even at first, generally differ from those in ordinary pemphigus. Instead of being large, clear, and bubble-like, they are small, slackly filled, and slushy, with a delicate covering that soon breaks. The blebs often have a reddish tint from the red color of the injected blood-vessels shining through the thin layer of fluid and the very delicate covering of the bleb. The erosion left by the first bleb that appears in a given locality enlarges by undermining of the surrounding epidermis, and, moreover, new blebs form in ever-widening circles about the site of the first, which by this time will probably have healed. But when this healing takes place it does not end the process. It is just at this point that the most prominent characteristic of the disease and the one to which it owes its distinctive title of foliaceus begins. Serous exudation continues to be poured out rather into than under the newly formed, but by no means normally formed, epidermis. This exudate and the epithelial layers into which it is poured form leaflets resembling French pastry; hence Cazenave's epithet foliaceus as applied to this form of pemphigus. The loosening of the attachment between the layers of the epidermis is also a remarkable phenomenon in pemphigus foliaceus, and may be demonstrated by drawing the finger firmly along the apparently sound skin. The top layers of the epidermis will slip off, leaving an excoriation. This slipping of the epidermis is found in other forms of pemphigus, but is particularly well marked in pemphigus foliaceus.

By the spread and coalescence of diseased patches the whole cutaneous surface tends to become involved. This generalization may take place in a few days, or may not be completed before several months.

From the above description one can understand that the appearance of the patient will differ widely according to the stage at which the disease is seen. There may be groups of circinate patches of miserably formed bullæ, or there may be circular patches covered with yellow crusts, or the whole skin may be bluish or brownish-red and actively desquamating, with here and there raw patches, but yet with very little weeping. The skin in pemphigus foliaceus is only moderately or not at all thickened.

Gradually other changes occur. The hair falls out. The eyelids become ectropioned and their lashes fall. The nails atrophy.

At first the general health of the patient remains unaffected, but gradually, through the uncomfortable condition of the skin, the occasional fever, the sleeplessness aggravated by severe attacks of itching, the constitution becomes undermined. The patient becomes thin and poorly nourished, then through complications, either in the lungs, or intestines, or kidneys, he is carried off.

It is said that pemphigus foliaceus, after existing for a longer or shorter time as such, may turn to the type of pemphigus chronicus vulgaris (Kaposi).

Diagnosis.—The most important disease to differentiate from pemphigus foliaceus is dermatitis herpetiformis in its generalized exfoliative form. The two diseases are at this stage so closely alike that only a very clear history or a continued observation of a patient enables one to come to a definite conclusion. Severe attacks of itching, the occurrence of the vesicles or bullæ in groups, and only slight interference with the general health should lead one to suspect the disease in question to be dermatitis herpetiformis.

Pemphigus Vegetans.—In pemphigus vegetans the denuded areas left by the blebs, instead of healing over, sprout peculiar vegetations. This is one of the chief characteristics of this variety of pemphigus, and the one to which it owes its distinctive title of vegetans. It is, however, not the only point of difference between it and ordinary pemphigus. The individual cutaneous lesion is usually smaller and more flabby, the contents are more turbid, and the covering of the bleb is more delicate than in pemphigus vulgaris. The blebs and the subsequent erosions may, however, resemble those of pemphigus vulgaris in every respect up to the time when the vegetations sprout.

The bullæ appear suddenly on an apparently healthy surface, and are generally delicate and soon break, leaving smooth, deep, red excoriations exuding an abundant, foul-smelling serum. The border of both the bleb and its succeeding excoriation remains sharply limited, and there is no infiltration. The vegetations may be present before the bleb breaks, but more frequently they appear in the erosion, at first as a rounded, prominent, dirty-white elevation, in the center of which the vegetations sprout. This process slowly extends out over the entire excoriation and even beyond it. This growth is surrounded by a zone of dark red erosion, which in turn is bounded by a collar of loosened macerated epithelium. The vegetations are closely bunched, their free surface is necrotic, excoriated, and dirty, and they have in their substance many pinhead-sized pustules, giving them a stippled look.

Many of the vegetations are flattened across the top, and, although larger than the broad condylomata of syphilis, look strikingly like them. By individual increase in size neighboring lesions coalesce with one another, forming large patches with serpiginous boundaries of tattered, ragged epithelium. As a rule, the lesions on the tongue and mucous membrane of the mouth and lips resemble those seen in pemphigus vulgaris, but they may also become vegetative, although these vegetations do not reach anything like the size or extent of those seen on the skin.

The disease may begin by the appearance of blebs on any part of the skin or mucous membranes, but it is particularly apt first to show itself in the mouth. Spiegler has recently said that of twenty-eight cases

of which he had known, eighteen began with lesions in this situation.

It is only in bad cases that all the lesions on the cutaneous surface become vegetative. In certain regions, as in the nasolabial and labiomental grooves, in the armpits, groins, and navel, and on the belly, the lesions are particularly apt to become vegetative.

The constitutional symptoms, such as sleeplessness, fever, and loss of strength, are present as in pemphigus vulgaris, but are usually more marked.

The *prognosis*, although commonly far worse than in pemphigus vulgaris, is by no means fixed.

In all medicine there is no disease with a more dramatic course than that of pemphigus vegetans. For instance, a man consults a physician in regard to an insignificant erosion in the axilla. A simple treatment is prescribed. He appears shortly again with some vegetations on the erosion. These may be cauterized, and the patient dismissed without any thought of the serious nature of the malady. The lesion, however, does not heal, and new excoriations and blebs appear, especially about the privates, with coincident dirty white patches in the mouth. At the same time the patient gives off a most horrible carrion-like odor. He shortly becomes a miserable, fulsome, horrible object to himself and others; and, to add to his miseries, there is often the moral degradation of being thought to have syphilis. Inanition from refusal of nourishment, fever, exhaustion, marasmus, spinal irritation, and acute edema of the brain succeed one another rapidly, and in a few weeks or months the patient dies.

Where the lesions first appear is a matter of importance in the prognosis, for in those cases in which the lesions begin on the lips, in the mouth, on the scalp, or on the genitals the prognosis is bad.

Not all the blebs in a case of pemphigus vegetans become vegetative, and when only a few of them sprout vegetations the prognosis approaches more that of pemphigus vulgaris—that is to say, it is serious, but not necessarily fatal. On the other hand, the more blebs there are that become vegetative, the more quickly does the disease terminate in death.

Necrosis of the surface of the vegetations is the rule, and the more marked the necrosis the worse the outlook for the patient. If, however, this necrosis does not take place, and the vegetations tend to become covered with horny epithelium, the patients may recover and live for years (Neumann).

It is not an absolute rule that a pemphigus vegetans should remain as such throughout its entire course. In general, the vegetations cease appearing as a fatal termination approaches, and Kaposi has demonstrated a patient in whom pemphigus vegetans healed, but the disease returned some time afterward as a pemphigus cachecticus.

As above shown, the estimate of the course which a given case should take may be modified by a number of considerations, such as the severity of the constitutional disturbance, the localities where the lesions first appear, and the abundance and the dirty necrotic condition of the vegetations. The beneficial effects of treatment have also helped to modify the unmitigatedly bad opinion previously entertained of the course of pemphigus vegetans. Under drying disinfecting powders the prognosis has improved, and Köbner, Mueller, Kaposi, and Mraçek have reported cases showing at least temporary relief or cure.

The resemblance of pemphigus vegetans to syphilis is striking. The white patches in the mouth resemble absolutely the mucous patches of syphilis, and the vegetations, especially the button-like ones, differ in no respect, except in their larger size, from the broad condylomata that were at one time supposed to be found only in syphilis. These symptoms, together with the situation of the patches, especially those in the groins, in the folds between the thighs and the scrotum, and in the anal fold, all go to form a picture that is in the highest degree deceptive. There are differences, however, which aid in distinguishing the two diseases. For instance, the growths in pemphigus are always surrounded by the tatters of the blebs, while in the confluent condylomata of syphilis the patches are bounded by sharp infiltrated borders. Furthermore, the condylomata in syphilis always occur at an early stage of the disease and are accompanied by other symptoms of syphilis. In syphilis the growths when left to themselves tend to subside, while in pemphigus the longer the disease lasts the more the growths increase; and while they grow, the general condition of the patient becomes worse and worse. Furthermore, pemphigus vegetans is a disease of adult life, and the presence of blebs is unknown in the course of syphilis of adults.

Postbullous vegetations are not absolutely pathognomonic of pemphigus vegetans, as in rare instances they occur in several other affections, such as in dermatitis herpetiformis, impetigo contagiosa, and in the iodine (Hallopeau) and bromine (Wallhauser) eruptions. Postbullous vegetations also occur in impetigo herpetiformis, but impetigo herpetiformis is by many observers now considered a clinical variety of pemphigus vegetans.

Treatment.—The outlook for cure in any pemphigus, through either internal or external medication, is not good, yet much may be done to alleviate the symptoms and to stay the progress of the disease.

Arsenic.—So many have praised the effect of arsenic in pemphigus that it should be the first drug to receive a trial. The favorite way of giving it is as Fowler's solution, in increasing doses, beginning with six drops, and, as some advise, running up to twenty or thirty drops a day. Very high doses of arsenic are of questionable benefit as they depress. If such high doses are used it is entirely for their specific effect, and as soon as they are found valueless they should be stopped. On the other hand, small doses, on account of their tonic effect, may be continued for a long time. Jadassohn particularly recommends salvarsan, and also proposes injections of normal serum as having been found curative in individual cases.

Strychnine.—Its only effect seems to be that of a powerful tonic, useful in combating the great exhaustion, which is so frequently a marked feature of the disease.

Quinine.—Mosler has reported an apparent cure after taking forty grams of muriate of quinine in five weeks (Jarisch). In most cases, however, it acts simply as a bitter tonic.

Acids.—Dilute sulphuric acid, acetic acid, and citric acid have been recommended, but no specific action can be attributed to them. They probably act as tonics.

Opium.—Opium besides being a soporific is said by Malcolm Morris to be one of the best curative agents we possess.

Chloral hydrate is an excellent drug for the sleeplessness which is a marked symptom in some cases of pemphigus.

Ordinarily the simplest measures may be employed to relieve the local conditions. Frequently a mild antiseptic powder, made, for instance, of equal parts of boric acid, starch, and oxide of zinc, is all that is required. If the tension of the blebs is uncomfortable they may be opened, and the above powder may be used to soak up the secretions, and to prevent the excoriations sticking to the bedclothes. If there are much heat and inflammation, or if pus is retained under the crusts, mild antiseptic lotions or salves may be the best topical applications. Lotions will be mentioned after speaking of baths. A red oxide of mercury salve is excellent: ℞ Hydrarg. ox. rub., ʒ ss.; lanolini, vaselin. alb., āā ʒ ss. M. S.: Apply on cloths.

Carbonate of lead, employed as a salve, is also good: ℞ Plumbi carbonat., ʒ i., lanolini, vaselin. alb., āā ʒ ss.

Baths.—The continuous bath, when it can be obtained, is of the greatest comfort in severe cases. It relieves the tension and pain, softens the crusts, mitigates the fever, and induces sleep. With its help a patient may be carried through an eruptive attack that would otherwise have killed him. Hebra's water bed is excellent for the purpose (Fig. 4254). It consists of a box or bath lined with zinc, with a plug and overflow pipe at its foot, and the feed pipe with hot and cold water mixed, entering at the head of the bath near its bottom. The temperature should be maintained at about 36° or 37° C.

The patient rests on a wire netting over which are thrown woolen blankets. This wire netting may be raised and lowered as wished. After the patient is lowered into the water the bath may be covered over with blankets to retain the warmth.

When such a bed is not obtainable, the patient may be put in a bath for several hours a day. Soothing or antiseptic medicaments may be added to the bath, as for instance one or two drams of permanganate of potassium, or a couple of tumblerfuls of boric acid powder, or biborate of soda, or bicarbonate of soda, to sixty gallons of water. It must be remembered that there are people to whom baths are debilitating, and on whom, in such an asthenic disease as pemphigus, their use would be particularly disastrous. In such cases we must content ourselves with compresses either wrung out of simple water or wet with medicated lotions. These compresses may be covered either with oil silk or with rubber tissue. Hutchinson's lotion is an excellent one for allaying inflammation, irritation, and itching. It consists of: ℞ Liq. plumb. subacetatis, ʒ ss.; liq. carbonis detergentis, ʒ iiss. M. S.: A teaspoonful in a pint of water, to be used as a lotion.

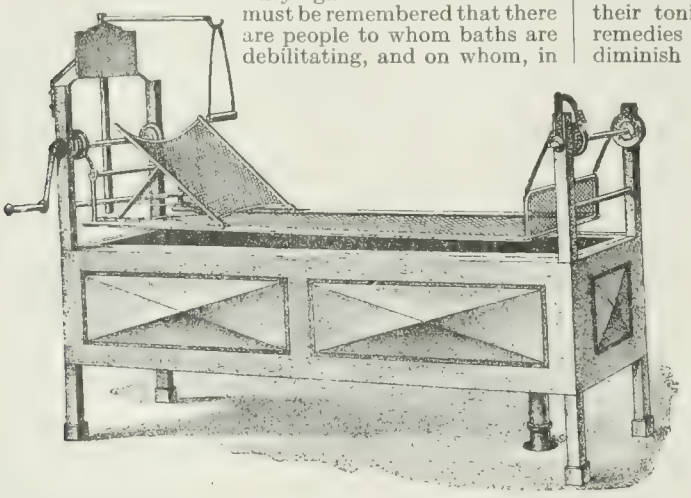

Fig. 4254.—Hebra's Contrivance for Administering a Continuous Bath. (From Jarisch's "Hautkrankheiten," in "Nothnagel's System.")

Other solutions to be used on compresses are those of acetate of aluminum, saturated solution of boric acid, and liquor plumbi subacetatis. Carron oil, made with equal parts of lime water and olive oil, with the addition of four per cent. of boric acid, is one of the best applications in pemphigus, and is especially useful in the dry scaly condition in pemphigus foliaceus.

Treatment of Pemphigus Vegetans.—Unna introduced a treatment of pemphigus vegetans which consisted of painting the lesions with tincture of iodine. This treatment is so painful that the patient must be anesthetized, and on awaking must receive full injections of morphine. Köbner first curetted away the vegetations or burnt them down with the thermocautery; then afterward he treated any vegetations that appeared with tincture of iodine.

Jarisch said he saw the lesion in a typical case of pemphigus vegetans clear up with wonderful celerity under a paste consisting of: ℞ Sulphur. præcip., zinc. ox., amyli, āā 10; vaselin. flav., 30. M. S.: Spread on linen and apply or rub into patches, and dust with some indifferent powder, such as oxide of zinc and starch.

In pemphigus vegetans, however, these measures for controlling the vegetations, no matter how successful locally, have no effect on the course of the disease. The general symptoms of sleeplessness and exhaustion go on unchecked. In fact, it is the rule for the vegetations spontaneously to cease appearing as the fatal termination approaches.

Neumann found solutions of salicylic acid applied on cotton an excellent deodorant for the foul odor present in pemphigus vegetans. A powder made of equal parts of talc and salicylic acid may also be used.

In looking over the literature of the drugs and applications used in pemphigus, one cannot fail to note everywhere a tone of helplessness, with perhaps a slight brightening up when the continuous bath is mentioned. The good effect of all the internal remedies may, in almost all instances, be reduced to their tonic or sedative action, and of the external remedies to their soothing effects, their power to diminish tension and burning, or to control the evil odors and the undue activities of the pyogenic bacteria. The treatment, it is true, is still far from our ideal of what effective treatment should be. Nevertheless, we have grounds for claiming that the actual advance made in the treatment of pemphigus is by no means so small as upon first thought it would seem to be. Thanks to Neumann's discovery of the true nature of pemphigus vegetans we are now able to save many a patient from the mental worry and humiliation of being thought to have a syphilitic disease, and from the physical suffering which he would have to undergo before it could be demonstrated by treatment that this diagnosis was incorrect. Douglass W. Montgomery.

Penis, Diseases, Injuries, and Malformations of the.—The most common inflammation of this organ, is gonorrhea, involving the urethral canal, which has already been discussed elsewhere. The penis proper, with its loose cellular tissue and unusually abundant blood supply and lymphatics, offers a frequent opportunity for the spread of inflammatory processes.

Cellulitis.—This usually results from the presence of chancroids, balanitis, or posthitis, or superficial wounds of the penis. It often occurs as a periurethral inflammation secondary to gonorrhea. In mild cases, it is confined to the penis, in severe cases it may spread to the scrotum, thighs and abdomen. Death may result from emboli being carried into the blood stream.

Treatment.—Rest in bed, and the local application of hot, soothing solutions, such as Thiersch solution, Liquor Burrowii, Creolin. The source of infection must be exposed and treated surgically.

Lymphangitis.—The etiology is practically the same as that of cellulitis. The dorsal vein is prominent above the surface, thick and reddened. When the infection is very virulent, perilymphangitis may supervene and the inguinal glands may suppurate.

Treatment.—The etiological factor must be treated. In addition, wet dressings locally, and flaxseed poultices over the inguinal glands, so as to stimulate phagocytosis. With the disappearance of the causa-

tive factor, the lymphangitis will gradually disappear likewise.

CAVERNOSITIS.—The *acute form* of inflammation of the corpora cavernosa or corpus spongiosum is due to infection of superficial wounds of these bodies or of adjacent bodies. When the corpus spongiosum is involved acutely, the condition is termed chordee, and is characterized by acute inflammatory symptoms, edema of the skin, and more or less prolonged and painful priapism.

Treatment.—Attention to the gonorrheal or other local infection, wet local applications, bromides, and sedatives for the priapism. If pus is present, incision and drainage.

The *chronic* form is usually termed "fibrous or indurated sclerosis of the corpora cavernosa." It is a rather uncommon condition; the author has seen but three cases, and very few are reported. It is a painless, progressive thickening of the fibrous tissue sheath of the corpus cavernosum. The etiology is unknown, but it is ascribed to gout, rheumatism, syphilis, gonorrhea, and other conditions. It occurs principally in men over fifty. The patient notices one or more hard nodules or plaques, varying in size from one-fourth to one inch in length, and half an inch in width. Erection is interfered with, coitus being painful and sometimes altogether impossible owing to excessive fantastic curvature of the organ. These plaques are not sensitive to touch; they do not respond to any known treatment, and excision merely substitutes scar tissue in place of the existing nodule. The prognosis is altogether unfavorable as to cure, but life is not endangered in any way.

DERMATOSES.—(*a*) *On the glans* and mucous surfaces of the foreskin, we find herpes, scabies, lichen planus, chancroid and syphilides (the last two are discussed elsewhere). Herpes progenitalis is very common; it is characterized by burning and itching. When seen early, grouped vesicles are found, implanted upon an erythematous base. The vesicles often become eroded and infected, confusing the diagnosis with chancroid.

Treatment.—Thorough cleansing, followed by a dusting powder, preferably thymol iodide.

Scabies is seen in the form of vesicles, pustules, and papules. The earliest lesion is the burrow, of minute length, which frequently enters the stages of vesicle and pustule when infected. The lesions are multiple in number, and may cover a wide area.

Treatment consists of the daily use of ten per cent. sulphur ointment for five days, and fifteen days later, a second course to destroy the parasite.

Lichen planus has been known to exist for months and years on the glans. Usually the lesion appears in the form of a reddish-violet patch made up of flat-topped papules. In the absence of a prepuce the surface is usually dry. Itching is not characteristic, but may be present. The condition may be mistaken for chronic eczema.

Treatment.—Arsenic (Donovan's solution) internally; externally the tar preparations, such as oil of cade (5 per cent.) in zinc-oxide ointment. In obstinate cases, radiotherapy has proved effective.

(*b*) *On the sheath of the penis* we find psoriasis, lichen planus, seborrhoic eczema, sebaceous cyst, fibroma, disturbances of pigmentation, and syphilis.

Psoriasis may be but a part of a general eruption or it may be localized on the penis and hairy regions. Tar and ammoniated mercury are most effective.

Seborrheal eczema attacks the penis and pubic area.

Sebaceous cysts and *fibroma* are not uncommon and are easily diagnosed. Loss of *pigmentation* is seen often in dark-skinned persons in the form of vitiligo; in the negro it is very striking. Excessive pigmentation, on the other hand, is far more common. There is no known treatment for these conditions.

ELEPHANTIASIS.—This is a rare disease in temperate climates, but not uncommon in the tropics. It may be limited to the penis, but more often the scrotum is the primary seat of the disease, the penis becoming involved later. An unusually interesting case is reported in a boy aged eleven years, by De los Terrores.[1] At the age of eight this boy had a phimosis with preputial excrescences accompanied by anasarca. Circumcision relieved him entirely and he remained well for three years when he developed lymphatic varices in the inguinal regions and genitalia. In a few months the external genitals, the entire left lower extremity and the lower abdomen presented a typical elephantiasis. No cause could be assigned for the disease.

GANGRENE.—Usually but a portion of the organ is involved—the glans, in connection with chancroidal ulceration or paraphimosis, or the sheath of the organ, in connection with extravasation of urine and diffuse phlegmon. In diabetes and occasionally in connection with disease of the dorsal artery of the penis, gangrene may occur as a secondary complication. Exposure to excessive heat or cold and irritating chemicals may produce this condition. The mortality ranges from fifteen to thirty per cent., according to the etiology.

Treatment.—Free incisions into the affected parts, excision of gangrenous tissue and wet dressings locally. In some cases the actual cautery has been useful in surrounding the necrotic area with a line of cauterization. Plastic surgery is seldom required as nature repairs the defect by granulation. Internally alcoholic stimulants and forced feeding are often of value in aiding the natural reparative process. In many of these cases the outcome depends not only on the strength of the patient, but chiefly on the virulence of the microorganisms which caused the gangrene.

PHIMOSIS.—This is a condition of the foreskin in which its orifice is too small to permit the glans to become uncovered. It is usually congenital, but may also be acquired as a result of irritation and inflammation of the preputial mucosa.

In the congenital form, adhesions very often form between the glans and the prepuce, which tend to increase any inflammatory condition which may develop later. In some cases, the preputial orifice is so small as to interfere materially with the passage of urine.

Phimosis itself is of no serious consequences, if the patient can keep the parts clean and free from secretion; it is the author's experience, however, that cleanliness of the foreskin is exceptional and not the rule. In some cases, men have often told him that they have never in all their lives retracted the prepuce or cleansed its cavity. When the phimosis is of moderate degree, when retraction is partially possible, the foreskin occasionally becomes relaxed spontaneously, thus bringing about a natural cure. However, the prepuce remains unusually long, and exposes the patient to additional risk of venereal infection.

In the acquired form, connective-tissue deposits, resulting from previous inflammations and ulcerations, are the underlying cause. The resulting difficulty of retraction is the same, however, as in the congenital form. Both these forms acquire their greatest importance when venereal infection or inflammatory conditions arise within the preputial cavity or on the glans. In these cases, it is impossible to make a diagnosis or attempt appropriate treatment while access to the glans is impossible. Complications are, therefore, rather common and considerable tissue destruction and other damage may result.

Symptoms.—These may be divided generally under two heads; namely, disturbances of the nervous system, and inflammatory conditions. The nervous symptoms are many and varied, but are most frequent

in early childhood. They include masturbation (due to irritation), enuresis, frequent erections, neuralgia, muscle spasm, and other neurotic manifestations.

Inflammatory symptoms deal with the retention of urine and smegma in the cavity of the prepuce, with the result that balanitis, posthitis, and calculi develop, and multitudes of organisms thrive.

Treatment.—Prophylaxis is secured by circumcision of every male infant during early infancy. These conditions, and others even more serious, are all avoided by the act of circumcision in infancy. When the conditions have already arisen, circumcision may and often *must* be resorted to, but the operation itself becomes a much more formidable procedure and infection of the wound is almost certain.

Inflammatory phimosis demands treatment for the cause of the inflammation, if it can be reached, by the injection into the preputial cavity and the application externally, of mild antiseptic solutions, such as weak bichloride, carbolic acid, peroxide of hydrogen, etc. If the condition persists, lateral incisions should be made, thus exposing the cavity and the glans; later on, when the circumstances permit, the circumcision may be completed by the removal of the "dog's ears," which remain after the lateral incisions.

In very mild forms, breaking up the adhesions with a probe, and cleansing the cavity, may be sufficient for all purposes. The prime indication, however, in all cases, is to remove the foreskin through circumcision, whenever and wherever circumstances permit. There is but one exception to this rule, and that is found in phimosis associated with diabetes. Operation in these cases may be followed by gangrene and sometimes death. Cleanliness and dry dusting powders, such as stearate of zinc, aristol, etc., will often suffice to keep the glans and preputial cavity in tolerably good condition.

Complications of Phimosis.—When phimosis masks the presence of venereal ulcerations, it is impossible to know what process is going on within the preputial cavity. When chancroidal or luetic ulcerations exist, more or less serious damage may be done to the glans, even to the point of complete destruction. This is especially true in cases of phagedena. The inguinal glands usually become inflamed and suppuration often follows. In some cases of phimosis, the dorsal lymphatics of the penis are involved, but do not suppurate as a rule.

A serious complication of phimosis, is found in the presence within the prepuce of a primary syphilitic chancre. Not only does the foreskin predispose to this infection, but by hiding the initial lesion from view by covering the glans, it makes an early diagnosis impossible. It is not unusual to find secondary manifestations in patients with phimosis, who are entirely unaware of the existence of a primary lesion in the preputial cavity. In such cases it is the practice of the writer, to urge immediate circumcision in the hope of getting rid of the phimosis and at the same time, of the primary focus of infection, as well, when the chancre is located on the prepuce. When chancroids are present, with the development of bubo and possibly of lymphangitis, it is often better to make a dorsal incision, thus exposing the glans and the preputial cavity, leaving the completion of the circumcision to be done later, when the inflammation will have passed off.

Paraphimosis.—In this condition, the foreskin has been drawn back of the corona, and cannot be drawn forward over the glans. It is the result of some cause acting to tighten the orifice of the foreskin while lying behind the corona. It usually occurs when the orifice is very tight and has become inflamed while lying in its retracted position. It is apt to occur when the foreskin is retracted in order to cleanse the glans, in the presence of gonorrhea, venereal ulcers, herpes, balanitis, etc., and the patient notices that it has become tightened above the corona, making it impossible to bring it forward. The first result is to cause swelling and infiltration of the glans, and other soft parts distal to the constriction. This, of course, makes retraction still more difficult, and the process proceeds until, if it is not checked, ulceration and gangrene supervene, thus breaking the constriction spontaneously. This leaves an ugly ulcerated area, which may be more or less resistant to treatment, depending on the primary character of the inflammation. There may be a serious hemorrhage resulting from the rupture and destruction of one or more blood-vessels. Erysipelas, cellulitis, lymphangitis, phlebitis, and inguinal bubo (adenitis) are all possible sequelæ of this condition.

Treatment.—Discoloration, swelling, coldness and numbness of the glans and adjacent tissue, indicate the existence of strangulation and impending gangrene. Palliative treatment is of no avail; heroic measures are demanded. The constricting band must be divided by passing a tenotomy knife through the ring upward and backward, the knife edge pointing upward against the band. Occasionally a small nick in the ring is enough to permit of retraction. In addition, it is often advisable to reduce the edema and swelling by making multiple punctures in the foreskin with a sharp-pointed bistoury. This will usually prove effective immediately and afford considerable relief in facilitating retraction.

In the mild cases, without evidence of strangulation, palliative measures are usually sufficient. Local wet dressings afford considerable relief, aided by manual attempts to retract the foreskin. This is done by pressing the glans backward through the constricting ring of the foreskin with the thumbs, while the other fingers act in pulling the foreskin forward over the glans. In this manner retraction is usually accomplished.

Neoplasms.—These are of two kinds, benign and malignant. In the benign class are included fibroma, lipoma, cysts, papilloma, horny growths, and excrescences. The malignant growths are carcinoma and sarcoma, the former occurring usually in the form of squamous-celled epithelioma.

Warts.—The most common of the benign growths is the papilloma the so-called venereal warts (verrucæ, condylomata acuminata, vegetations). These are not necessarily venereal in origin, but are usually associated with irritative or uncleanly conditions of the glans. They consist of highly vascular papillary outgrowths, containing epithelial and connective tissue. Their favorite site is at the junction of the skin and mucous membrane. When found on the skin, they are usually hard and firm; when on the mucosa, they are soft and yielding. Those of the soft variety are often found at the urinary meatus, and less often in the urethra itself; they may also be found on the scrotum, extending backward to the anus. They may be so profuse about the glans as to hide it completely, creating a cauliflower appearance. These warty bodies may fill the preputial space to such an extent, as to cause pressure on the glans with the possible development of gangrene and perforation of the prepuce. The question of their contagiousness is still a matter of discussion, but the preponderance of evidence is against that view.

Differential Diagnosis.—Condylomata lata and epithelioma are the two conditions which might be confused with papilloma. The former may be confused with warts only when changes have taken place in the warts so that they have become flat and fused together; in the early stages such an error would be quite impossible. Epithelioma occurring late in life, and associated with enlargement of adjacent glands, is usually differentiated from papilloma. The microscope will clear up any existing doubts.

Treatment.—The writer is a strong believer in that prophylaxis which is offered by circumcision of all

males early in life. Venereal warts in a circumcised individual are a rarity indeed. In the presence of a prepuce, however, cleanliness is the great desideratum, particularly when balanitis or gonorrhea have already supervened.

The treatment aims to remove the growths as thoroughly as possible. They may be removed with scissors, after local anesthesia with cocaine, alypin, etc. Great care should be exerted to control hemorrhage, which is often quite profuse and difficult to control. After excision, the base is cauterized with nitric acid. A simple and effective method is to ligate the base of the growths, retaining the ligature until the growth separates from its base; or after being tied, they may be cut above the ligature. Hemorrhage when profuse may be controlled by a dressing of adrenalin solution 1–1,000.

The growths may also be scraped off with a sharp curette, or may be destroyed by the application of the galvanocautery or the Oudin high frequency current. An application consisting of salicylic acid (1 dram) suspended in acetic acid (1 ounce) has been very effective in the author's practice. This makes a sort of paste which is applied rather thickly and permitted to remain twenty-four to forty-eight hours. At the end of that time, much if not all of the growth will have disappeared. A second application may be made if necessary.

The less important benign growths require but a word or two as they are of no practical importance. *Lipomata* are rarely found, and *cysts*, when they do occur, are small and not troublesome to the patient.

Malignant Growths.—These are of the greatest importance, as they endanger life to the same degree as when situated elsewhere in the body. Sarcoma is very rare. Carcinoma occurs as a squamous-celled epithelioma and is fairly common. Probably two to three per cent. of all carcinomata of the body are found in the penis. Most cases occur in middle life, and are rarely, if ever, seen among the circumcised. In 100 cases studied by Barney, the average age was fifty-six years. There is reason to believe that the Jewish race is immune to this affection. In sixty-nine per cent. of the cases Barney found the original lesion on the glans; in about thirty-six per cent. the original site was on the prepuce.

Epithelioma may first appear in a variety of ways, as follows: It may appear as a papilloma (wart), as a simple pimple located near the lymphatics, as a raw patch or superficial excoriation, as a true ulcer (very rare), and still more rarely, it may begin insidiously at the urinary meatus. The author has operated on a case in which the lesion consisted of a slight painful hardening of the tissue surrounding the meatus, the lesion strongly resembling a chancre of the meatus, except for the absence of redness and marked infiltration found in the latter. The diagnosis was made by the microscope.

The etiology is unknown, though many opinions have been rendered, even sexual contact with an epitheliomatous cervix being held responsible. Glandular involvement is the general rule, and metastasis takes place even after extensive resections. The duration of the disease, without operation, is from one to five years. It goes without saying that an early diagnosis followed by a wide and deep resection, involving glandular structures, constitutes the single hope of a cure.

Sarcoma of the penis occurs in the form of a nodular tumor, in the corpora of the organ, bilateral usually, and rapidly involving the inguinal glands. Metastasis is the rule. Operative interference is of no avail.

Injuries.—The penis may suffer injury as the result of accident or purpose, the latter as the outcome of attacks by the insane or during a fit of jealousy. Accidental injuries include wounds, lacerations, contusions, luxation, and fracture. Purposeful injuries are usually committed with a sharp knife or similar weapon, and consist usually of mutilation, more or less severe, and occasionally fatal in character.

Wounds may be punctured, lacerated or incised, and may be deep or superficial. The symptoms are hemorrhage, pain and deformity or distortion, all of these varying according to the extent of the trauma. When the corpora are involved seriously, the hemorrhage is inclined to be severe in character and difficult to check. Sepsis may set in, accompanied by phlegmon and gangrene, as a result of which fistula or deformity associated with painful and distorted erections may follow. In a punctured wound, the surface evidence may be comparatively slight, but there may be a deep seated hemorrhage of more or less severe type, causing swelling and discoloration of the organ. Incised wounds may be longitudinal, but are usually transverse, these being the results of depraved or insane minds acting in jealous rage. These cases are not rare in the annals of criminal law, such a case having been reported by Lydston of Chicago[2] in which a complete amputation of the penis followed an insanely jealous attack. It is a curious psychologic phenomenon that these attacks are usually the work of women seeking revenge on faithless husbands or paramours; occasionally, however, men have been known to commit these mutilations, the object in view being easily apparent.

Lacerations and punctured wounds are usually the result of accident, principally a fall, in which the patient strikes a sharp, projecting body. In warfare these injuries are not at all uncommon. When the superficial structure alone is involved, the damage is very slight; but when deep laceration takes place, profuse hemorrhage and severe reaction may follow. In these cases, the urethra may also be involved, thus adding a serious complication.

Treatment.—When the injury is superficial, a simple antiseptic dressing suffices to promote rapid healing. Hemorrhage and sepsis are the principal sequelæ of deep lacerations and require prompt and vigorous treatment. The wound may be sutured or packed, as the indications may require. Closure of the wound by suture is to be preferred because of the smaller connective tissue scar which remains, thus interfering to a slighter degree with the erectile function of the organ. It is important to avoid subcutaneous oozing or bleeding after suture. If erections supervene after the application of a tight penile bandage, it may be necessary to apply ice-bags outside of the bandages. Bromides, monobromate of camphor in fairly large doses, and similar sedatives may be useful in the prevention of erections.

Contusions.—The possible sequelæ of this form of injury are infection, localized swelling, and inflammation and gangrene. When there is no rupture of the fibrous sheath of the corpora, the injury may be termed contusion, but when the corpora have been torn, as the result of the trauma, the term fracture is applied. In contusion, the superficial blood-vessels are damaged, resulting in a subcutaneous hemorrhage into the lax areolar tissue. Unless suppuration takes place, the extravasation is absorbed, and the parts return to the normal. Suppuration often follows when infection takes place, terminating occasionally in gangrene.

Treatment.—For the milder cases, the application of cold, wet dressings, with even gentle pressure by bandage, will suffice. Perhaps the best wet dressings are aluminum acetate two per cent., dilute lead wash, Thiersch's solution, and Burow's solution. In severe cases, with much extravasation of blood, incision and drainage with the evacuation of the blood and pus, are demanded. The urethra may partake of the injury, even to the extent of suffering more or less complete rupture. In such cases, urinary infiltration should be prevented by the use of a retained catheter.

Luxation.—Dislocation of the penis is usually one of a number of injuries suffered by the patient on the occasion of a fall or a violent blow. As a result of the extreme trauma, the body of the penis proper is separated from the skin, and driven forcibly downward into the scrotum or perineum, and sometimes upward under the skin of the symphysis pubis, and over the pubic bone. It may even be forced outward upon the loin or thigh. The trauma may or may not rupture the urethra, depending upon the extent of the injury. The resulting displacement of the organ is easily recognized, making the diagnosis not a difficult matter. An extensive hematoma or extravasation under the skin usually accompanies this injury. Subjectively the principal symptom is urinary retention, which is associated with urinary extravasation, when the urethra has been ruptured. In the latter event, the extravasated urine adds considerably to the size of the mass formed by the hemorrhage. Dislocation of the penis does not usually take place unless the preputial mucous membrane has been severed from its attachment to the base of the glans, or from the orifice of the prepuce.

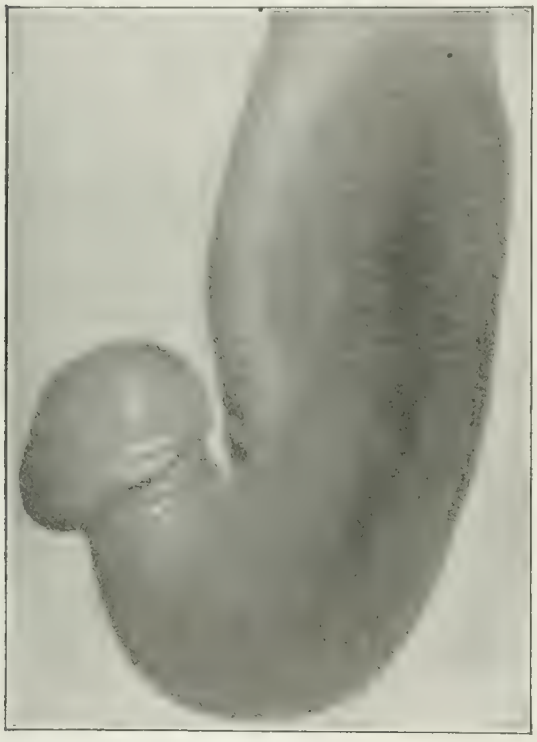

Fig. 4255.—Ecchymotic Infiltration and Swelling after Subcutaneous Rupture (Fracture) of the Penis. (After Wilensky, *Annals of Surgery*.)

Treatment.—As in the case of lacerations, the hemorrhage and extravasation are treated surgically by incision, irrigation and drainage. If the urethra has been torn, it should receive appropriate treatment. If the blood can be removed by breaking up the clot, this should be done; otherwise, the preputial orifice should be freely slit open and the organ replaced in its proper position. Extravasation and retention of urine are an indication for perineal section and bladder drainage. The prognosis is fair, except when the blood supply has been cut off, in which event gangrene will take place unless complete amputation of the penis is performed.

Fracture.—This is an injury which usually occurs while the organ is in the erect condition, and consists of a forcible rupture of the sheath of one or more of the corpora. It is difficult to imagine a fracture in the flaccid organ. A sudden direct blow on the erect organ, or a sudden bending of the organ in violent coitus, such as attempted rape, is the usual etiological factor. An attempt to "break a chordee" during the course of an acute gonorrhea may also be responsible for this condition. Rarely the injury occurs during normal coitus. Such a case is reported by Wilensky.[3] In this case the patient, aged thirty-six, suffered a sudden severe pain during intercourse; he quickly withdrew the organ, which swelled considerably and very quickly, assuming the appearance shown in the accompanying illustration (Fig. 4255). Urination was not interrupted, the urine being free from blood. It will be observed that the rupture occurred quite near the glans. It is probable that the rupture in such a case as this, without external trauma, is due to a weakening and thinning of the fibrous sheath at a given point, as a result of some obscure pathologic process, so that when erection takes place with its attendant stretching of the sheath, it gives way at its weakest point.

The symptoms of rupture or fracture are unmistakable. Acute pain is quickly followed by flaccidity of the organ, accompanied by more or less severe hemorrhage; extravasation of blood is marked by the development of a distinct hematoma, general swelling to an enormous extent and discoloration. If the tear involves the urethra, blood will appear at the urinary meatus. When the rupture is confined to the corpus spongiosum and the urethra, the corpora cavernosa being uninjured, there will be a urethral hemorrhage, with little or no swelling and discoloration, the reason being that all the blood is escaping into the urethra and out at the meatus. This is a very rare circumstance, inasmuch as the corpora cavernosa are almost always involved.

When the urethra is torn, urinary extravasation takes place as soon as the first urine is passed after the injury; this adds quite a serious complication, owing to the almost certain occurrence of septic infection.

The prognosis depends on the extent and character of the trauma. If the urethra has been injured and extravasation of urine has taken place, there may be a fatal result unless the condition is quickly relieved by an immediate perineal section and drainage. With the urethra undamaged (and this is determined by absence of blood in the urethra and normal urination) the extravasation gradually disappears and the organ slowly resumes its normal size and color. From a functional standpoint, however, the organ is rarely restored to the normal, owing to the formation of connective tissue at the site of the injury. This has the effect of preventing normal erection by interfering with the normal flow of blood into the corpora. When erection takes place, curvature or bending of the organ at an angle occurs, depending on the amount and location of the scar tissue. In some cases, erection takes place in two distinct stages: first, that portion of the organ proximal to the site of injury, and then the remainder. In those cases in which the urethra has been damaged, stricture inevitably follows, with greater or less interference with normal erection and urination.

Treatment.—When the injury is confined to the corpora, the urethra being unaffected, the treatment is expectant, wet dressings being applied, with the patient at rest in bed. Gentle pressure may be applied to the organ so as to prevent further bleeding and to assist in promoting absorption of the extravasation. Sometimes the hematoma may have to be incised and evacuated. Urethral hemorrhage may often be controlled by the introduction into the bladder of a firm catheter and applying a fairly tight bandage around the organ; in this manner, extravasation of urine might be avoided with all its consequent sequelæ and dangers. Some authors believe that satisfactory

functional results are obtained by incising the hematoma, evacuating the clots and closing the incision with sutures. They declare that by this procedure there is less connective tissue scar, with proportionately less interference with erectile power.

Persistent Priapism.—Strictly speaking this is not a disease of the penis, inasmuch as it is usually a symptom of disease elsewhere in the body; but in view of its being manifest in the penis, to the exclusion of symptoms elsewhere, a consideration of this subject may not be taken amiss.

By priapism we mean an erection without sexual desire, that is, involuntary. If it is but temporary and frequent, it may be merely a reflex manifestation of a local irritation somewhere in or near the genital tract. If it recurs nightly for an appreciable period, we are probably dealing with a lumbar hyperesthesia stimulated by a full bladder. In these circumstances sexual neurasthenia may and often does result, thus complicating an already difficult situation. Treatment should be applied to the nervous system, in the hope of restoring its normal tone and function. The prognosis is good, in the average case.

Persistent or prolonged priapism, however, is a much more serious matter. It may occur without evident cause, as in a case reported by Milenushkin.[4] The patient was thirty-seven years old. The affection lasted about two months and finally yield to treatment with morphine, *x*-rays, arsenic, and hydrotherapy. Leucemia has long been recognized as one of the causes of this condition. It is believed that the priapism is caused by the changes which take place in the corpuscular elements in leucemic blood, leading to leucocytosis, which in turn produces changes in the blood-vessels that are concerned in the mechanism of erection. It has also been suggested that the condition is due to mechanical pressure by enlarged glands along the course of nerves, or by pressure on certain veins resulting in continuous venous congestion.

Excessive sexual intercourse has frequently resulted in prolonged priapism. Such a case of unusual interest was reported by Billaud.[5] The patient was a farm servant aged twenty-six, who was married one month. There were no pathological antecedents, although the man was of nervous temperament. Up to the time of entry into the hospital, the priapism had lasted seventeen days. The condition began suddenly, without apparent reason, and the turgescence and rigidity extended to the spongy tissue of the organ and the corpora cavernosa. Medical treatment was of no avail. Cold and hot applications and leeches to the root of the penis and lumbar region, were equally useless. Narcotics and sedatives merely made him drowsy, without any local action. Coitus was impossible as introitus could not be effected owing to the size and wooden hardness of the organ. Masturbation resulted only in making the condition more severe. The weight of his clothing, the least movement, became intolerable. Urination was normal and painless, and constituted his only relief. An anesthetic having been administered, and a catheter placed in the urethra, two parallel incisions were made corresponding to the corpora cavernosa. A large quantity of black, viscid blood escaped and the organ became flaccid. On the following day, pain had entirely left the patient. The wound healed nicely, and at the end of twenty days no erection had taken place. The author was unable to say whether the man had any subsequent erections.

Malformations.—It has been stated, and with much truth, that there is no other organ in the body which is subject to so many changes in shape, size, and formation, as the penis. As to size, the range is considerable; the same may be said of the prepuce; and as for the meatus, it may be located anywhere from its normal position at the apex of the glans backward to the penoscrotal junction. Then the glans may be twisted about the shaft in various ways; the shaft itself may be twisted owing to malformation of the median raphé; and the writer has observed a case in which the glans occupied a position at a complete right angle to the shaft (Fig. 4256).

Extreme dwarfing of the penis, so that it may be taken for hermaphroditism, occasionally takes place, but usually in connection with hypospadias. Rarely

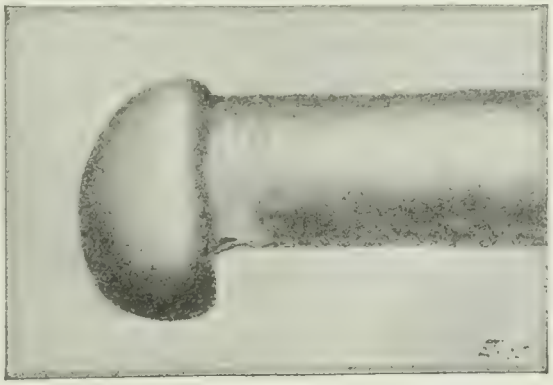

Fig. 4256.—Deformity of the Glans in a case of Hypospadias.

cases are met with in which the penis is buried amid the pubic fat, giving the appearance of a clitoris and mons. When encountered in children, relief may be obtained by liberating the organ from its bed of fatty tissue, as is well shown in the author's case (Figs. 4257 and 4258).

Unusual deformities have been encountered which are deserving of mention. Bilhaut[6] reported a case of a man aged fifty-one, in whom the proximal two-

Fig. 4257.—Burying of the Penis in the Pubic Fat; before operation.

thirds of the penis were permanently in a state of sharp curvature with the concavity directed upward. In the flaccid state the distal third hung down so that the organ assumed a sigmoid shape; and in erection, this dependent portion assumed the direction of the ascending arm of the permanently curved portion, so that the entire penis took the shape of the letter U. It was found that two little tumors of the corpora

cavernosa had caused some retraction of the dorsal aponeurosis of the organ, and when they were removed complete restoration of the normal shape and function took place.

Generally speaking, malformations follow four types, as follows: Hypospadias (glandular, penile, perineal), conditions allied to hypospadias (including epispadias), malformations of the raphé, and torsion of the shaft of the penis.

Hypospadias.—This is perhaps the most common of all penile malformations. It is the result of a congenital defect in which the urethra terminates somewhere on the under surface of the penis instead of the usual site at the apex of the glans. This defect is said to occur in 0.3 per cent. of all males. Many varieties have been described, but for practical purposes three classes may be named as follows: Glandular or balanic (balanitic), in which the urinary meatus is situated on the under surface of the glans or immediately behind it; penile, in which the meatus is located between the glans and the scrotal junction; perineal or scrotal, in which it is situated either at the penoscrotal junction in front, or at the junction of the scrotum with the perineum posteriorly. Most

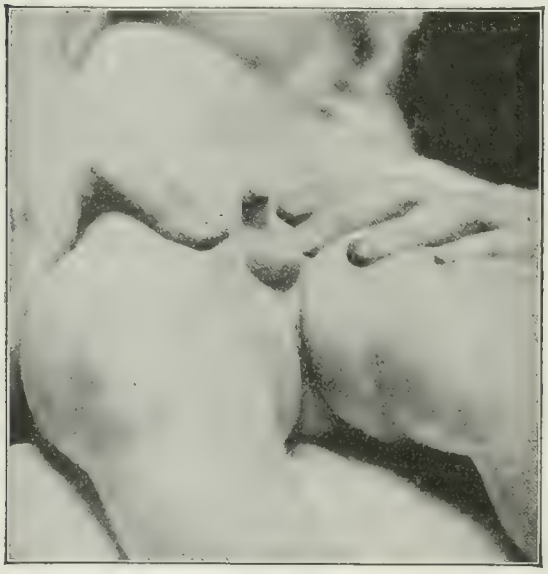

Fig. 4258.—Same Case as Shown in Fig. 4257; after operation.

commonly a deformity of the glans accompanies the balanic type, an extreme case of which is shown in Fig. 3.

To enter upon a lengthy discussion of these conditions would tax the limited space at our disposal, but it may be stated that these deformities are important in so far as they interfere with the proper erection of the organ, and cause an abnormal outflow of the urinary stream, so that it drops perpendicularly, causing wetting of the thighs and clothing; and lastly, because sterility is likely to follow, owing to the faulty deposit of seminal fluid in the vaginal canal during coitus. In the penile and scrotal types all of these disturbances are exaggerated to a more or less marked degree.

Epispadias.—This is a malformation of great rarity in which the defect is situated on the upper surface of the penis. One observer is said to have seen not a single case in 60,000 army conscripts. The disturbance of function produced by this type of defect is practically similar to that of hypospadias.

Treatment.—Many methods of surgical interference have been suggested, but with comparatively little success. A fairly successful method for hypospadias was devised by the late Carl Beck, of New York. This consists in dissecting the urethra from its natural bed, so that it may be put on the stretch, and then it is brought through the glans by a tunnel, and its ends sutured to the edges of the new glandular opening. The operation is simple enough, but the great liability to urinary infection, with consequent sloughing of the operative field, renders a successful outcome largely a matter of chance. Moreover, in all of the operations that have been suggested, a successful outcome is always accompanied by a deposit of scar tissue, which often renders the condition worse than in the beginning. The most satisfactory results are obtained when the operation is done in early childhood, between the third and eighth years; usually several operations are required before the results may be considered satisfactory.

Other Malformations.—It is sufficient merely to mention other malformations, which are of little or no importance except as curiosities. Among these are absence of the penis, a very rare condition associated with hermaphroditism or other defects of the genital system. Double penis has been mentioned in the literature. Hermaphroditism, true and false, has been much written about, but it is doubtful whether a case of true hermaphroditism has ever been encountered Abr. L. Wolbarst.

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Pennyroyal.—See *Hedeona.*

Penrose, Richard A. F.—Born in Carlisle, Pa., March 24, 1827. He studied medicine at the University of Pennsylvania, and graduated from that institution in 1849. He began the practice of his profession in his native city, in 1853. He devoted his attention chiefly to the diseases of women and children, and was one of the founders of the Children's Hospital of Philadelphia, and also of the Gynecian Hospital. In 1863 he was elected Professor of Obstetrics and Diseases of Women and Children in the University of Pennsylvania. He filled the chair for many years, and was most successful as a teacher. His death occurred in 1888. A. H. B.

Pental (*Tri-methyl-ethylene*), a purified amylene, introduced by Mering as an anesthetic. See *Amylene.*

Pentastoma.—*P. denticulatum* is a name given to the larva of *Linguatula serrata.* The worm-like adult lives in the nasal cavities and frontal sinuses of the dog, wolf, fox, horse, mule sheep, goat, man. The larva exists in the liver, lungs, or other organ of sheep, oxen, horses; rarely in cats, dogs, man. See *Arachnida.* A. S. P.

Pentosans.—Pentosans may be regarded as anhydrides of the five carbon sugars. They are not found in the animal kingdom but pentose sugars are found forming a part of the nucleic acid radical of the nucleoprotein molecule. In the vegetable kingdom the pentosans are widely distributed, occurring in all kinds of plants, and are not limited to any particular organ or tissue being present in roots, stems,

seeds, or leaves. The pentosans disappear from the alimentary tract of man to an extent seemingly proportional to their susceptibility to attacks of microorganisms and it is probable that they possess comparatively little value as sources of energy in nutrition. FRANK P. UNDERHILL.

Pentoses.—The pentoses are simple sugars containing five carbon atoms—hence their name. They are found for the most part in the vegetable kingdom but are produced from animal tissue by disintegration of nucleoproteins. See also *Aliment.*

F. P. U.

Penzance and the Scilly Islands.—These two localities on the extreme southwestern coast of England, although possessing no great value as health resorts, are taken as representatives of the mild winter marine climate of the south of England. "Penzance appears to be warmer in the winter than any other place on the mainland of England from which we have records" (Dickinson, "Climate and Baths of Great Britain"), and the temperature of the Scilly Islands for the same season is still higher. Mildness and equability of temperature is about all that can be said in favor of such resorts as the above, as well as of others in the same county of Cornwall and in the adjoining one of Devonshire, the most noteworthy of which is Torquay. Such a climate has been resorted to by consumptives and by patients having other inflammatory respiratory affections, notably by those patients with bronchitis who require a moist air. Chronic albuminuria, heart disease, insomnia, and scrofula are also said to be benefited in this climate.

As will be observed from the climatic chart of Penzance, the temperature range throughout the year is comparatively small. It is neither hot in summer nor cold in winter. Frost and snow are rare. The mean temperature for the three winter months is 43° F., while the mean of the coldest is 40° F. The relative humidity for Penzance is not obtainable, but it probably does not differ much from that at Falmouth, twenty-five miles to the East, which is eighty-two per cent. At the same place (Falmouth) the amount of sunshine is said to be greater than at any other place in England except Jersey and it is therefore a fair inference that Penzance is also similarly favored, although it is said to have more mist than Falmouth. Everywhere in England there is rain enough, and, Penzance, it is seen, has its share, the annual rainfall being 42.59 inches; the soil, however, dries quickly. The winds from the north and south are equally common, while those from the west are more prevalent than those from the east. Penzance has a southeastern exposure, and is sheltered from the prevalent west wind by the high country about the Land's End, and "very completely from the north by elevations of from five hundred to seven hundred feet within four miles. It is exposed, however, to the east, although some protection can be obtained by a choice of residence" (Dickinson, *loc. cit.*). With so many unfavorable climatic features—the large amount of rain; the high humidity; the wind and the relatively small number of sunny days, although large for England—such resorts as Penzance cannot compare with many other mild-winter marine ones except as regards equability; such, for example, as those on the Mediterranean coast, on the Pacific coast of Southern California, on the Gulf and Atlantic coasts of Florida, and many insular resorts. For the inhabitant of England, however, who desires for any reason a mild and equable winter climate, it offers an easily accessible retreat.

CLIMATE OF PENZANCE, ENGLAND, LATITUDE, 50° 8′ NORTH. TEN YEARS.

	January to March.	April to June.	July to September	October to December	Year
Temperature (degrees F.):					
Mean monthly average	43.2°	52.4°	59.8°	47.7°	50.7°
Mean daily range	6.0	9.7	9.5	6.1	7.8
Mean of warmest	46 3	57.4	64.6	50.6	54 7
Mean of coldest	40 2	47.5	55.0	44 5	46.8
Highest or maximum	58.0	77.0	76.0	64.0	77.0
Lowest or minimum	21.0	33.0	39.0	26.0	21.0
Precipitation:					
Average in inches	10 81	6.65	9.54	15.59	42.59
Wind:					
Prevailing direction	S. W.	N. W.	S. W.	N. W.	S. W.

The situation of Penzance is very picturesque, as indeed are so many of these seaside towns in Cornwall and Devonshire. There are also numerous attractive excursions in the neighborhood and in the adjacent district of Land's End.

The vegetation of Penzance and its neighborhood is very luxuriant and rich, and it seems quite extraordinary that in the latitude of 50°, that of Southern Labrador, one should find exotics flourishing in the open air, even in winter; geraniums and fuchsias attaining the dimensions of large shrubs; aloes flourishing, and hollyhocks, mignonettes, magnolias, and roses blooming, sometimes even in January. Potatoes are cultivated extensively, and sent to London and elsewhere during the winter months. A marked difference is noted between the north and south coasts, although only ten miles apart, not only in the vegetation, but also in the character of the climatic effects. On the north coast the vegetation is far less luxuriant and the climate is more bracing and exciting.

The *Scilly Islands*, although but little resorted to by invalids, represent an interesting phase of climate, and present many attractions from their picturesque situation, as well as from the fact that the Bishop lighthouse, which marks the group, is the first evidence of land which greets the Transatlantic voyager as he enters the English Channel. The group, consisting of forty islands, some only tiny specks, lies about forty miles southwest of Penzance, from which it is reached in four hours. But five islands are inhabited, and but one, St. Mary's, possesses any satisfactory accommodations. This island, which is the largest of the group, contains sixteen hundred acres, and no part of it is a mile from the sea. The scenery is of a peculiar and weird grandeur, great masses of granite cliffs standing out against the sea and storms. In this country the Isles of Shoals, off the New Hampshire coast, would appear to bear a close resemblance to the Scillies both in situation, in the open Atlantic, and in their granitic formation and bold rugged scenery. "The air here (Scilly) is as marine as on the deck of an Atlantic steamer. Every s ght and sound tells of the sea, the influence of which is here paramount in every shape" (Dickinson, "The Climate of Cornwall," in "Climates and Baths of Great Britain"). The exposed portion of the island of St. Mary's is treeless and bare; but in the valleys, and wherever artificial protection is afforded, the vegetation is luxuriant and almost tropical. Myrtles, fuchsias, geraniums, and aloes grow in great profusion, and palms and bamboo are abundant. "In the gardens of Tresco, unprotected except by the configuration of the ground, a mass of tropical vegetation presents itself which I suppose has no equal in Europe" (Dickinson, *loc. cit.*). The cultivation of the narcissus for Covent Garden is the chief industry of these islands. The climate is relaxing and soothing, a type of a mild, moist, marine one,

with great equability. From the chart the mean yearly temperature is seen to be 52.4°, the highest in England. The mean for the three months, January, February, and March is 45.3°. The relative humidity is high, and the rainfall large. The islands are fully exposed to the east and west winds. The former are especially felt in spring. Whatever value such a climate has must consist in its warmth, equability, and humidity, together with the marine influence. About the only conditions which appear to be favorably influenced by such a climatic combination are inflammatory affections of the respiratory organs other than phthisis, especially bronchitis, and scrofulous diseases—"children find the sands an unsurpassed playground." Chronic renal disease may also do well in such a climate, although the humidity is not a particularly favorable factor. A very charming description of the scenery of the Scilly Islands will be found in Sir Walter Besant's "Amorel of Lyonnesse."

Several other resorts in Cornwall and Devonshire, possessing somewhat similar climatic features, may be mentioned in this connection. On the south coast are Falmouth, Marazion, Torquay, Sidmouth, and other small resorts. On the north coast are St. Ives, Newquay, Tintagel, and Boscastle in Cornwall, and Ilfracombe, Lynmouth, and Lynton in Devonshire. The resorts on the north coast are frequented only in the spring, summer, and autumn.

Climate of the Scilly Islands, England, Ten Years.

	January to March.	April to June.	July to September.	October to December.	Year.
Temperature (degrees F.):					
Mean monthly average	45.3°	52.0°	62.9°	49.7°	52.4°
Mean daily range	6.4	8.0	8.0	6.3	7.1
Mean of warmest	48.7	55.9	63.4	53.0	55.2
Mean of coldest	41.8	47.9	55.4	46.7	47.9
Highest or maximum	57.0	73.0	75.0	65.0	75.0
Lowest or minimum	29.0	36.0	44.0	32.0	29.0
Humidity:					
Mean relative	87%	84%	85%	85%	85%
Precipitation:					
Average in inches	7.65	5.54	7.52	11.52	32.23
Wind:					
Prevailing direction	W.	N.	W.	W.	W.

Edward O. Otis.

Pepper, William.—Born Aug. 21, 1843, in Philadelphia. He received the degree of M. D. from the University of Pennsylvania, in 1864. From the time of graduation to 1887 he held the following hospital and teaching positions: Visiting Physician of the Philadelphia Infirmary; Resident Physician of the Pennsylvania Hospital; Curator and Pathologist of that institution; Visiting Physician to the Philadelphia Hospital; Lecturer on Morbid Anatomy in the University of Pennsylvania; Lecturer on, and afterward Professor of, Clinical Medicine, and, finally, Professor of Theory and Practice of Medicine and Clinical Medicine, in the same institution. In 1881 he was unanimously elected Provost of the University of Pennsylvania, and at the same time the dignity and powers of the office were materially increased. From that time to the date of his death, which occurred on July 28, 1898, the interests of the University were more rapidly advanced than at any previous period of its history.

Dr. Pepper's contributions to medical literature are quite numerous. His most important literary work, however, was the editing of the "System of Medicine by American Authors," 1886; 5 volumes.

A. H. B.

Pepo.—Pumpkin Seeds. *Semen Peponis.* The dried ripe seed of *Cucurbita pepo* L. (fam. *Cucurbitaceæ*).

The nativity of the pumpkin is not certainly known, though it was probably North American. It presents numerous varieties, and the squashes, at least some of them, have been regarded by some botanists as pertaining to the same species. Although squash seeds appear to possess similar properties, they are not included, as a drug, under the above title.

Pumpkin seeds are about two centimeters (¾ inch) long, broadly ovate, flat, white, or whitish, nearly smooth, having a shallow groove near to and parallel with the edge; containing a short conical radicle and two flat cotyledons; inodorous; taste, bland and oily.

The active constituent is supposed to be a small amount of a soft, green, acrid, and bitter resin, which possesses the same properties as the entire drug. With this there exists a yellow or somewhat reddish-yellow, bland fixed oil, to the extent of about thirty-five per cent., a little sugar, crystallizable albumin, and other unimportant constituents. The oil, which consists of glycerides of palmitic, myristic, and oleic acid, portions of which acids also exist in a free state, has been credited with the properties of the drug, but possibly, if pure, does not possess them.

Pumpkin seeds are markedly diuretic, but their medicinal use is as a pleasant and moderately certain tænicide. Only the kernel should be used, and it is commonly given in the form of an electuary or emulsion, the dose amounting to ʒvi–xii (25.0–50.0). It has been said that fifteen grains of the resin is an equally efficient dose, though not so pleasant, but of late this claim has been denied.

Throughout the West Indies, Mexico, Central America, and many other countries, pumpkin seeds, as well as squash seeds, are largely consumed as food.

Henry H. Rusby.

Peppermint.—See *Mentha Piperita.*

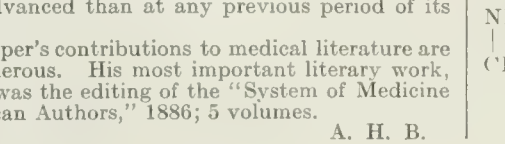
Pepsinum (U. S.).—Pepsin is a proteolytic ferment or enzyme obtained from the glandular layer of fresh stomach from healthy pigs; it should be capable of digesting not less than three thousand times its own weight of freshly coagulated and disintegrated egg-albumen. The Pharmacopœia prescribes that when any sample of pepsin is more powerful than stated above it may be diluted by sugar of milk to the standard strength.

The only known action of pepsin is its property of splitting protein into albumoses and peptoses in acid media (see under *Gastric Juice*). It is given in cases of acute or chronic gastric indigestion, usually in combination with dilute hydrochloric acid, in doses of gr. v.–xxx. (0.3–2.0).

Saccharated pepsin is a triturated mixture of one part of pepsin and nine parts of sugar of milk which is sometimes given in doses of gr. xv.–xxx. (1.0–2.0). There are various preparations of pepsin—aromatic pepsin, elixir of pepsin, wine of pepsin, etc.—in the National Formulary, the value of which (especially of those containing alcohol) is extremely problematical.

Henry H. Rusby.

Peptides.—Amino acids have the property of readily grouping together when water is split off and the amide group of one amino acid unites with the carboxyl group of the other. In accordance with this if two molecules of glycocoll, α-amino acetic acid are made to condense a new substance glycyl-glycocoll is formed in the following reaction.



Such a compound is called a peptid and is designated a di-, tri-, or tetra-peptid, according to whether two or more amino acids are united together. Collectively they are spoken of as polypeptides. It is assumed that the protein molecule is a huge polypeptid.

FRANK P. UNDERHILL.

Peptone.—Peptone is the name given to the product or products arising during a certain stage of the hydrolytic cleavage of protein, whether induced artificially or naturally in the alimentary canal through the agency of enzymes. Peptone is a member of that group of proteins designated Derived Proteins. As the name implies it is a derivative of the native proteins, and is not found in nature except as a decomposition product of protein. Peptone is a relatively simple protein which is regarded by some as a mixture of polypeptides (see Peptides) only and not a definite chemical individual. According to the older views there may be several peptones, their variety being determined by their varied precipitability. The peptones are very soluble, diffusible substances, which unlike all other proteins cannot be salted out by saturation of their solutions with ammonium or zinc sulphate. In strong alcohol they are insoluble. They are non-coagulable by heat. It has been assumed that in the cleavage of the protein molecule the peptones represent the final stage of cleavage where protein bodies are still present. They are formed after the proteoses (which see) and therefore are undoubtedly simpler molecules. Gastric digestion ceases at the peptone stage. FRANK P. UNDERHILL.

Percussion, Auscultatory.—By this method of physical diagnosis, an organ or pathologic formation of approximately uniform consistence, is located by the uniformity of conduction of sound vibrations. A preferable term is stethoscopic percussion and as vibrations are not necessarily induced by percussion, a still better general term is visceral transsonance. Any form of stethoscope may be employed, the best for most purposes being a flexible-tubed, binaural instrument with a chest-piece about three-fourths inch in diameter. This must be applied within the area in which the unit examined comes closely in contact with the body wall, as determined by general knowledge of regional anatomy and preliminary examination. By percussion or otherwise, vibrations are set up, the originator of vibrations being moved radially from the stethoscope and the points noted at which a sudden diminution of intensity occurs—indicating that the boundary of the vibrational unit has been reached. Unless in testing a long bone for continuity of structure as indicated by continuity of vibration, or in locating ascitic fluid which is equally in contact with the body wall in both flanks, the stethoscope must not be moved from the limited area of contact.

Heavy tuning-forks with vulcanite handles, electric buzzers fitted with a stem of hard rubber, dental pluggers with protecting discs, rubber pencil-ends, strips of rubber, various forms of pleximeters, etc., may be employed for inducing vibrations. The heart beating against a distended stomach occasionally serves as a percussor for this organ.

This method will locate the stomach, the liver up to about the fourth rib, normally, or for pathologic livers, up to a corresponding degree of departure from the body wall, a lung, the heart, a segment of intestine of approximately the same degree of inflation, the enlarged uterus or a tumor of fairly uniform consistence, a large pulmonary cavity, a consolidated pulmonary lobe, a collection of fluid in a body cavity, an enlarged spleen, or even the posterior projection of a normal spleen under proper circumstances. The method is not available for units too small to admit of the application of a stethoscope-end as well as of the application of percussion or some other means of inciting vibrations at an appreciable distance from the stethoscope. By varying the force of percussion or even by using an instrument of relatively fixed intensity of sound, as the tuning-fork or electric buzzer, vibrations may be set up in an organ at points where it is separated from the body wall by a moderate distance. As the mapping out of an organ, tumor, etc., is made upon the surface, the results are significant only when this surface approximates a plane of projection of the unit investigated, although information of value may be obtained even when the depth and irregularity of contour of the unit investigated and the relation of its curves to those of the body wall, do not admit of anything approaching a plane projection, as in the case of certain abdominal and pelvic tumors.

It should be borne in mind that the method does not name an organ or specify a pathologic state; it merely locates, to the degree that they can be brought into vibration through intervening media, certain areas of nearly uniform conduction of vibration and, therefore, presumably of approximately uniform structure. For instance, in transposition of viscera, very discordant results will be obtained, so long as the areas mapped out are named in accordance with the usual locations of the organs concerned. It may also happen that only part of the area of a liver, of the stomach, or of a pathologic new formation can be mapped out by this method, although by palpation and ordinary percussion—contrast of dulness or flatness with resonance—much larger areas are found. In such cases, it will be found that the limitation in extent and apparent failure of transsonance are due to marked differences in structure. For instance, approximately normal and almost entirely cancerous portions of the liver may appear as distinct areas, cystic and solid portions of ovarian tumors may be separated, a uniformly dull thoracic area may be resolved into two zones, one of fluid, the other of consolidated lung, as determined by auscultation of breathing and voice. On the other hand, a highly distended stomach and the transverse colon may vibrate so nearly in unison as to appear as one unit, though a distinction may usually be made by using different forms of vibration, as percussion, tuning-forks of different pitch, etc.

A. L. BENEDICT.

Perforating Ulcer of the Foot.—This is a rare affection, caused by pressure or injury where there is a degenerated nerve supply. It is found in leprosy, locomotor ataxia, lues, and alcoholic and diabetic neuritis. Gasquel studied 91 cases and found that in 69 there was a central nervous lesion, in 8 a peripheral neuritis, and 14 were diabetic. Of the 69 central nervous lesion cases, 32 had tabes, 17 general paresis, 8 symptoms of alcoholism, 4 traumatic cord lesions, and 8 various cord conditions. Of the 91 cases 84 were males. The most common location is where there is great pressure, as over the metatarso-phalangeal articulation of the great or little toe, or over the ball of the toes. Occasionally there are several lesions existing at the same time in one or both feet. A similar condition may also occur on the hands.

The process is very slow. It begins as a thickening of the skin resembling a corn, under which suppuration occurs; and later, when the horny plug is cast off, an ulcer is left. The destructive process extends downward until it reaches the bone, which may also become affected. The condition now is more that of a sinus than of an ulcer. The skin surrounding the opening is usually much thickened, and there may be granulations at the orifice. The diseased parts are generally painless and the neighboring parts are usually anesthetic. Distortion of the toes, as well as trophic changes in the nails, may occur later; they are usually accompanied by an increased growth of hair,

pigmentation, and hyperidrosis. The patients frequently complain of cold feet and neuralgic pains.

The prognosis is unfavorable, even if the lesions should heal, on account of the liability to recurrence, which in turn is due to permanent nerve lesions.

Perforating ulcer has to be differentiated only from a suppurating corn, which latter is painful and is accompanied by abnormal sensitiveness of the surrounding skin. In the case of a suppurating corn the results of surgical treatment are always satisfactory.

Prolonged rest will occasionally lead to healing of the lesion in the early stages, but exercise will cause the sore to recur. Packing the sinus with lint wet with a saturated solution of salicylic acid in glycerin, and the employment of mechanical devices to prevent pressure will frequently produce a temporary cure. Free opening of the sinus or stretching of the nerves which supply the part has been followed by good results in some cases. In the later stages excision of the ulcer is useless and amputation of the foot is necessary. Even then the ulcer may recur in the stump, unless the limb is removed at a point far from the lesion and above the line of anesthesia. HOWARD MORROW.

Pericardium, Diseases of the.—HISTORY.—Anatomical alterations in the pericardium were known long before diseases of the heart proper received careful study. Galen was familiar with pericardial effusion in animals, and suspected it in men.

The fables about the occurrence of hairy hearts in men of remarkable strength and daring are doubtless based upon the discovery of stringy fibrin deposited upon the heart. Rondelet described pericarditis as having symptoms of fever, dyspnea, pain under the sternum, and attacks of syncope.

In the eighteenth century the authors of works upon diseases of the heart made numerous anatomical observations upon diseases of the pericardium.

Vieussens often met with adhesion of the heart to the pericardium at autopsies, and assigned certain functional disturbances which occur during life to the existence of this condition. In earlier times it was thought to be a congenital defect. Albertini appreciated the difficulties of a symptomatological recognition of pericardial effusion. Morgagni believed that on account of the difficulty of diagnosis, the day was yet remote when we should have recourse to puncture of the pericardium as suggested by Riolan. Senac realized that it was impossible to make a diagnosis from the indefinite symptomatology, but thought that in hydropericardium he recognized an undulatory movement between the third and the fifth ribs. Corvisart believed that he could feel this. Both were in error. However, Corvisart first distinguished between inflammatory exudations and dropsical effusions, but could not lay down any fixed rules for differential diagnosis. Avenbrugger was the first to state any accurate physical signs; these were bulging of the precordium and increase in the area of percussion dulness. Laënnec, however, doubted the possibility of diagnosing pericarditis with certainty.

The discovery of the pericardial friction rub by Collin in 1824 made certain the recognition of dry pericarditis. Since this time our knowledge of the physical signs of all varieties of pericarditis has increased remarkably, but none are so pathognomonic or of so much assistance in diagnosis as this peculiar friction rub.

ANATOMY.—The pericardium is a fibroserous sac, somewhat conical in shape, surrounding the heart and the origin of the great vessels. Its base is directed downward, rests upon the diaphragm, and is firmly attached to its central tendon, and more loosely to its muscular structure. Its narrower portion is directed upward, and surrounds the great vessels. The fibrous layer is continued for some distance along the great vessels, in the form of prolongations, which gradually become incorporated in their coats. The inferior vena cava passes through the floor of the pericardium to reach the heart. The serous membrane lines the fibrous sac and is reflected over the surface of the heart, thus constituting its parietal and visceral surfaces. They are continuous along the great vessels, about an inch to an inch and a half above the base of the heart.

Externally, the pericardium is in contact anteriorly and laterally with the pleuræ covering the lungs, with the exception of a triangular space, behind the lower sternum. It is attached by fibrous bands to the manubrium and ensiform cartilage. Behind it are the esophagus, descending aorta, bifurcation of the trachea and left bronchus, and the other structures which form the root of the left lung. The phrenic nerves pass down, one on each side of the pericardium, on their way to the diaphragm.

In health the serous surfaces are kept moist by a secretion normal to serous membranes. The amount is always small, but varies from a few cubic centimeters to an ounce or two. As a result of the presence of this fluid the serous surfaces glide smoothly over each other during the various phases of the heart's action without producing audible or palpable signs.

The pericardium of an adult man with a healthy heart is capable of holding from fourteen to twenty-two ounces of fluid; that of a boy between six and nine years old, about six ounces when the sac is distended to the full by injecting water into it, by means of a syringe, through an opening made into the anterior part of the pericardium (Sibson).

The following are the important diseases of the pericardium:

1. Pericarditis: (*a*) dry or plastic (pericarditis sicca); (*b*) wet pericarditis, or pericarditis with effusion; (*c*) suppurative pericarditis; (*d*) chronic adhesive pericarditis.
2. Hydropericardium.
3. Hemopericardium.
4. Pneumopericardium.
5. New growths in the pericardium.

MORBID ANATOMY.—I. *Abnormal Conditions of the Pericardium* not of clinical interest, and which do not furnish physical signs.

(*a*) *Absence of the Pericardium.*—This occurs in ectopia cordis. It is usually only partial, there being a slit in the pericardium through which the heart protrudes. Very rarely the heart and the left lung lie in the same serous sac. The heart is covered by the visceral layer of the pericardium; at the origin of the great vessels there are usually found rudimentary portions of the parietal layer in the form of fringe-like reduplications.

(*b*) *Diverticula.*—Hernia-like pouches are rarely found. They are due to the pressure outward of fluid. This occurs in chronic conditions in which the fibrous layer has become weakened, and either yields or separates and allows the serous layer to be pushed through by the exudate.

Such pouches are usually small, but they have been known to contain as much as from three to four ounces. The opening into the pericardium may be wide or narrow. These conditions are not recognized during life.

(*c*) *Milk spots*, also called soldier's spots and tendinous spots.

By these terms are meant those circumscribed, whitish, slightly thickened spots which are so frequently found upon the pericardium. Some authorities look upon them as evidences of an old pericarditis, and as such they have influenced the statistics of pericarditis.

Most writers now believe them to be areas of chronic hyperplasia of connective tissue. Friedreich believed that they resulted from a continual mechan-

ical irritation of the surface of the heart, and were found most frequently on those parts of the heart which were continually brought into contact with the more resisting portion of the chest wall. These spots are nearly always found on the visceral pericardium on the anterior surface of the right ventricle along the coronary arteries. They are much more common in advanced age than in youth, and in men than in women. They are of no clinical importance and cannot be recognized during life.

(*d*) *Thinned Pericardium.*—The wall of the sac may be thinned as a result of distention from an enlarged heart or from the pressure of fluid.

(*e*) *Foreign Bodies.*—These have been found lying free in the sac, and have been regarded as polypi detached from the inner surface of the pericardium, or as results of fibrous or calcareous deposits about foreign substances.

(*f*) *Calcareous Deposits.*—In cases of prolonged pericarditis there may be more or less calcareous deposit in the pericardium.

II. *Acute Plastic Pericarditis.*—In this variety both layers of the pericardium present an inflammatory exudate of varying extent and character. There may be merely an absence of the usual glistening appearance or the exudate may be just thick enough to be lifted, showing an injected and possibly ecchymotic myocardium beneath. When the exudate is more extensive it may be thrown into folds by the action of the heart or on separating the pericardial layers the bread-and-butter appearance described by Laënnec may be presented. The myocardium may be pale or injected and usually will show inflammatory or degenerative changes to a depth of several millimeters. The involvement of the pericardium may be universal or only partial. If only partial it is more common at the base of the heart than elsewhere.

The various changes occurring in pericarditis are sometimes described as following a definite order of succession: (1) Increased vascularity; (2) fibrinous exudation; (3) fluid effusion; (4) absorption; (5) adhesion. It is very seldom, however, that these stages can be recognized, as there is likely to be a mixture of two or more—as, for instance, the association of a plastic exudate with fluid effusion, or even the combination of adhesions and fluid.

It is possible for resolution to take place, followed by absorption. Very often, however, especially in the pericarditis sicca, the plastic material becomes organized into firm adhesions which pass from parietal to visceral pericardium. In the early stages of an inflammation the adhesions may be very fine and delicate and easily broken with the fingers. Later on, however, they become exceedingly strong, and the pericardium cannot be separated from the heart without tearing the heart substance.

The presence of adhesions may be partial or universal. If universal, there will be entire obliteration of the pericardial cavity. Adhesions may also exist between the pericardium and pleura, or between the pericardium and chest wall, as a result of mediastinopericarditis (pericarditis externa).

Eichhorst applies the name *Zuckergussherz—frosted heart*—to cases in which the epicardium is thickened by chronic pericarditis, so that it gives the organ the appearance of being covered by a sugar icing, as in the case of a frosted cake.

Calcareous pericarditis has been referred to above. In chronic cases the heart may be completely invested by a calcareous coat which may in places be 1 to 1.5 centimeters thick (Osler).

Effusion.—As previously stated, there is present normally in the pericardial sac enough fluid (a few cubic centimeters) to keep the surfaces well lubricated. In diseased conditions this fluid may be enormously increased in quantity and greatly altered in character. Roberts says that the average quantity of fluid in pericarditis is from eight to twelve ounces, but it may range from an ounce or two to two or three pints or more. Balfour says several pints; Broadbent says that any large amount is exceptional.

Sibson states that the effusion is likely to be large in rheumatic pericarditis, while John Broadbent says that it is the exception to find a large effusion in this condition. There is no definite rule. Roberts states that the quantity is likely to be small in Bright's disease. However, Dr. Herman Allyn (*American Medicine*, October 18, 1902) reports a case of pericarditis which occurred as a terminal infection in Bright's disease, and in which he removed by paracentesis, on the day previous to death, forty-four ounces of bloody serum. At autopsy the pericardial sac was found to contain about 250 ounces of bloody serous exudate.

It is generally stated that the exudate is large in cases secondary to scurvy. In the Russian epidemic referred to later, the quantity amounted to from four to five pints.

Character of Fluid.—This varies much, depending on the nature of the inflammation. In the typical case of pericarditis it is a clear yellow, usually containing shreds of fibrin and leucocytes. In rheumatic pericarditis it is usually clear, but may be blood-tinged and may occasionally become purulent. In new growths and tuberculosis the fluid is likely to be blood-tinged, but not necessarily so. In scurvy the exudate is usually bloody; in fact, it may be almost clear blood.

The specific gravity of a pericardial exudate, like that of other serous cavities, is usually above 1.015.

Absorption.—The natural tendency in most cases of serous or serofibrous effusion is toward absorption sooner or later. This is especially true in rheumatic cases. In fact, after reaching the acme, in a day or so there may be a distinct diminution in amount, and in from four to six days the quantity may fall to normal. In rare cases an ordinary inflammatory exudate does not undergo absorption, but remains as a chronic collection, or may become hemorrhagic or purulent. Many authorities believe that even a fibrinous exudation may be absorbed, up to a certain amount, after undergoing a fatty change.

The fibrous patches left from pericarditis are larger, thicker, and have a more irregular distribution than the so-called milk spots, and as a rule are associated with adhesions.

Myocardium.—A consideration of the morbid anatomy of pericarditis would not be complete without reference to the changes which are produced in the heart. Broadbent says: "The heart is usually found to be dilated to a varying degree. In the subacute or chronic cases in which the pericardium has become adherent, the dilatation is often extreme, and the heart muscle soft and flabby, showing evidence, on microscopical examination, of well-marked, inflammatory changes. Dr. Poynton has shown by a series of sections of the heart wall, in cases of rheumatic pericarditis, that the cardiac muscle, as well as the pericardium, is almost invariably attacked by the inflammatory process, and that there are foci of small round-cell infiltration between the muscle fibers throughout the thickness of the heart wall. The myocarditis which accompanies pericarditis is therefore not simply an extension of the inflammation from the pericardium to the myocardium. There is granular and fatty degeneration of the cardiac muscle due to the toxic effects of the rheumatic poison, as well as actual destruction of muscle fibers by inflammatory exudation."

Etiology.—Pericarditis is almost always a secondary infection. Its etiology resembles very closely that of endocarditis. The more careful our examinations and the greater our bacteriological knowledge, the fewer will be the cases of idiopathic pericarditis discovered.

Rheumatism is by far the most common cause of

pericarditis. Roberts, in "Allbutt's System," states that pericardial inflammation is to be looked upon not as a mere complication of rheumatism, but as an essential part of the disease.

Sibson noted that in the large majority of cases of rheumatic pericarditis endocarditis was also present. Broadbent states that pericarditis must not be regarded as a separate entity, but as part of a general inflammation of the heart, the myocardium being almost invariably and the endocardium frequently affected.

There is no definite relation, when a large number of cases is considered, between the severity of the joint affection and the severity of the pericarditis. It may develop at any time during the attack, even preceding the joint affection, or appearing late in the disease.

Pneumonia, pleurisy, the various acute infectious diseases, especially scarlet fever—during the stage of desquamation or during nephritis—chorea, pyemia, purpura, scurvy, are all at times complicated by pericarditis. Especially interesting is its association with Bright's disease. Taylor found that pericarditis occurred in about ten per cent. of his cases of Bright's disease. Sibson, in an analysis of 1,691 cases of Bright's disease collected from various sources, found that pericarditis existed in 8.17 per cent. It is now generally accepted that the pericarditis of Bright's disease is usually an infection, often a terminal infection. Chronic disease lessens the resisting power of the tissues and invasion by microorganisms becomes easier. Tuberculosis, carcinoma, extension from contiguous tissues, traumatism, are also causes of pericarditis.

Aneurysm of the aorta occasionally is accompanied by pericarditis.

Scurvy is frequently accompanied by hemorrhagic pericarditis. Seidlitz and Kyber report an epidemic occurring in Russia in 1840, in which 30 out of 60 fatal cases showed hemorrhagic pericarditis. The fluid was dark, and amounted to four to five pints.

Sears, in a study of 100 cases at the Boston City Hospital, assigns rheumatism as a cause in 51 cases, pneumonia or infection with the pneumococcus in 18; in 7 chronic nephritis, and in 5 pleurisy was the primary disease.

Bacteriology.—The staphylococcus, streptococcus, pneumococcus, and tubercle bacillus are the organisms most commonly encountered. Isolated instances of infection by other infectious agents have occurred.

Symptomatology.—Developing as it usually does as a complication of a pre-existing disease, pericarditis may cause no symptoms attracting attention to it and may be entirely overlooked. Occasionally attention is first directed to the pericardium by the patient who complains of pain or a grating sensation under the sternum. In primary cases the symptoms may be so obscure as to leave one in doubt until the physical signs are well developed.

The following important symptoms may be mentioned:

Pain is present in many cases of pericarditis, especially early in their course, when friction sounds are heard, but it is not pathognomonic, and bears no special relation to the severity of the attack. It may be extremely severe in localized pericarditis and entirely absent in large effusions or extensive adhesions. When present it is usually in the precordial region. Children, however, are prone to refer the pain to the epigastrium. It varies much in its character, from a dull ache to a stabbing or tearing pain. It usually disappears with the advent of the effusion. There may be pain or tenderness in the epigastric region, especially when upward pressure is made at one or other of the costal angles. This pain usually comes on later than the precordial pain. The patient may complain of only a sensation of distress, a pressure or tightness about the heart, especially if a large effusion is present. There may be dyspnea and palpitation.

The *pulse* has no special characteristics. The heart action in the early stages is rapid and energetic. Subsequently, as a result of the mechanical embarrassment due to the presence of a large amount of fluid, and the involvement of the myocardium and its nerves, the heart action becomes weak and rapid, possibly irregular. In the early stages it may vary from 90 to 120; later, in rare cases it may reach 160. Occasionally there is very little alteration from the normal, and rarely the pulse rate is below normal. Ewart says that in many cases of effusion the pulse is quick, and resembles the Corrigan type. Pulsus paradoxus is said to be more marked in adherent pericardium than in any other known condition.

Friedreich's sign of collapse of the cervical veins during diastole is not considered important.

The *respiratory* symptoms vary greatly. Respirations are usually somewhat increased in frequency. If the effusion becomes large, dyspnea and even orthopnea may supervene. The patient usually prefers to lie on his back or on the left side. In large effusions there is often a short irritative cough, and in rare cases distressing hiccough due to involvement of the phrenic nerve.

There may be pain or difficulty in swallowing as a result of pressure of an effusion upon the esophagus, or due to nerve irritation.

When pericarditis is a secondary affection, there is present the fever of the primary disease. The pericarditis may cause a slight extra elevation of temperature. It may, however, be practically normal throughout, or only slightly elevated, to 100° or 101°; rarely to 103° F.

It must be remembered that the symptomatology of pericarditis may be altered by the associated primary disease. Thus, a case secondary to Bright's disease would differ from a case secondary to rheumatism.

Enormous effusion, by interfering with the action of the heart and aëration of the blood, may produce the most grave symptoms of dyspnea, cyanosis, very rapid and weak heart action, which if not relieved may eventuate in death.

The rapid heart action, the pulsus paradoxus, and the asymmetry in the size of the pulse of the radials, the irregular type of temperature, the paralysis of the recurrent laryngeal nerve, the unequal pupils, may all be important signs, if present.

Physical Signs.—*Acute Plastic or Dry Pericarditis.*—Fortunately the signs of this condition are very distinct; the danger is that they may disappear before the physician's attention is directed to the precordium. In some cases they are very evanescent, disappearing in a few hours; in others they persist for days.

Pericardial Friction Rub.—This is the pathognomonic sign of dry pericarditis. It is a superficial, dry, scraping or rubbing sound, distinctly dependent upon the heart movements. Frequently it is a to-and-fro friction corresponding to systole and diastole. It does not correspond exactly with the first and second sounds of the heart, but may occupy a place between them. At times it is only systolic. It is said to be first heard in most cases over the base of the heart, but may be heard first as a single systolic scratch at the apex. Great care must be exercised in interpreting a friction rub at the apex because of the not infrequent occurrence of pleuropericardial friction sounds in this area. The pericardial friction is usually heard best just to the left of the sternum, between the third and fifth ribs. As the inflammation progresses it may be present over most of the precordium, and even to the right of the sternum in children. It is due to the rubbing of the inflamed pericardial surfaces over each other.

Clinical experience has proven that the most com-

mon cause of the disappearance of the friction sound is the advent of an effusion which separates the pericardial surfaces. Another fairly common cause is the development of adhesions, uniting the pericardial surfaces. Again, there may be absorption with resolution. The friction sound may reappear after the absorption of the fluid. It must be borne in mind, however, that despite the presence of fluid the visceral and parietal layers of the pericardium may be practically in contact directly beneath the sternum. This may be understood by reference to Fig. 4259, a diagram representing a cross-section.

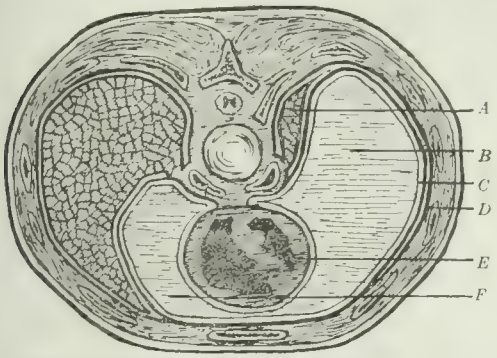


Fig. 4259. Cross-section (Diagrammatic) of the Chest in a Case of Extensive Pericardial Effusion. *A*, compressed left lung; *B, F*, exudation in the dilated left and right sides of the pericardium; *C*, pericardial wall; *D*, pleura; *E*, heart. (Curschmann.)

Palpation.—In well-marked cases a friction fremitus can be felt.

Differential Diagnosis.—A pericardial friction rub is usually so characteristic that little difficulty is experienced in its detection. It must be distinguished from organic and functional murmurs and from pleuritic friction sounds. Cardiac murmurs almost never have this superficial scraping, to-and-fro sound; they are likely to be more distinctly systolic or diastolic, and have special lines of transmission. They are not so much altered by changes in the patient's position and are more permanent.

Pleuritic friction sounds are very similar in their character, but are dependent on respiratory movements, and can be eliminated by causing the breath to be held.

Pleuropericardial Friction.—A friction sound resembling very closely the true pericardial friction is heard when there is inflammation of that part of the pleura which overlaps the pericardium. With each contraction of the heart the external surface of the pericardium is forced along the undersurface of the inflamed pleura, and a friction sound is produced. Forced expiration might tend to eliminate this sound.

Signs of Effusion.—The fact that a friction sound has been heard is of great assistance in diagnosing an effusion. It is fair to suppose that an increased area of cardiac dulness, which develops subsequently to the detection of a pericardial friction rub, is due to an effusion. But one always keeps in mind the fact that a cardiac dilatation must be reckoned with.

Percussion.—In an effusion of moderate degree the outline of dulness is quite characteristic, being of an irregular pear shape, or that of a triangle with rounded angles, whose base faces the diaphragm, and whose apex is above, to the left of the sternum.

More important is the fact that the dulness extends much farther to the left, beyond the apex beat, than it does in hypertrophy or dilatation.

Rotch has drawn special attention to the blunting of the cardiohepatic angle in the right fifth intercostal space in pericardial effusion. In health this cardiohepatic angle is usually less than a right angle. It may, however, be obtuse in cases of dilated heart and may be less than a right angle in cases of pericarditis with effusion. In pericardial effusion it is more obtuse. Rotch lays great stress upon the presence of absolute dulness in the fifth intercostal space, extending one and one-eighth to one and a half inches to the right of the sternum. In a case of advanced mitral insufficiency, however, it is a common experience to obtain dulness in this area, and a consequent blunting of the cardiohepatic angle. In fact, Broadbent speaks of two cases of dilated heart in which paracentesis was resorted to, because the signs seemed to point conclusively to pericardial effusion.

With a large effusion, signs of compression of the left lung develop. Above the line of dulness is an area of tympany or hyperresonance, with increased vesicular or bronchovesicular breathing. Attention must be called to the presence, in large effusions, of a circumscribed patch of dulness or impaired resonance usually just below the angle of the left scapula, over which there are increased vocal fremitus, bronchophony, and bronchial breathing. This may be at times mistaken for a pneumonic process. It will be readily understood that the compressed lung (*A* in Fig. 4259) will lack in resonance and give bronchial breathing. Broadbent, I believe, is correct in saying that these signs may also be present in any case of enormously enlarged heart.

Position of the Apex.—It has been held by some of the authorities that the apex is pushed upward and outward by the fluid. Others state that it is tilted upward and inward, that is, is floated by the effusion. It seems impossible for a fluid of a lighter specific gravity than the heart to float it upward.

Ludwig and Bowditch have observed that the impulse of the heart, as seen normally in the fifth left interspace, need not be caused by the heart's apex, but may be caused by a portion of the heart above the apex striking against the chest wall. The presence of a high pulsation could be accounted for by the tumultuous action of that portion of the right ventricle. It should also be remembered that in children the apex beat is normally in the fourth interspace.

A very important sign is the gradual weakening of the apex beat with the increase of fluid. It may be entirely obliterated. In pericardial effusions the pulse may be strong and the apex beat weak; in heart lesions the apex beat may be heaving and the pulse weak. The effusions may become enormous and thus hinder the heart's action.

The presence of adhesions may prevent a pericardial effusion from assuming the typical shape. Rotch speaks of a case in which dulness failed to appear in the fifth intercostal space (right side), because of the presence of adhesions binding the lung tightly to the right edge of the sternum.

Purulent Pericarditis.—This disease furnishes the same physical signs as the serous effusion. It might be suspected from the etiology, *i.e.*, if secondary to suppuration in the other parts of the body, especially of the lungs or pleura. The leucocyte count would very likely be higher than in the simple serous pericarditis. Paracentesis is the only positive means of determining the nature of the fluid. The temperature curve is of the septic type, resembling that of empyema. The process may come on insidiously. It is usually purulent from the outset, though a serous effusion occasionally becomes purulent.

Adherent Pericardium.—The *symptoms* are not at all characteristic, and cannot be distinguished from those of organic heart lesions.

The *physical signs* in marked cases may be quite distinctive. They depend upon whether the adhesions exist between only the parietal and visceral layers of the pericardium, or whether they include also adhesions between the external pericardium and the chest wall or pleura. The following are of some importance: (1) Fixation of the apex beat. Under

normal conditions the apex beat moves a considerable distance with change of position of the patient and forced inspiration. (2) Systolic retraction of one or more interspaces. This sign, however, is unreliable, especially if the retraction is present in only one interspace, and at the apex; for it is occasionally seen in greatly hypertrophied hearts.

If there be distinct dragging in of the costal cartilages at the lower end of the sternum, one can be almost certain of adhesions.

Broadbent's Sign.—"Systolic retraction of the posterior or lateral walls of the thorax may indicate the presence of a universally adherent pericardium. Such retraction may, however, be seen even when the pericardium is not adherent to the heart, but only to a larger extent than normal to the central tendon of the diaphragm, to the muscular substance on either side, and to the chest wall as well. In such cases the heart is usually greatly enlarged and hypertrophied from old valvular disease. The explanation seems to be that the portion of the diaphragm to which the pericardium is adherent is dragged upward at each systole of the heart, so that the points of attachment of the digitations of the diaphragm to the lower ribs and costal cartilages are dragged inward and retracted."

If pericardial adhesions are present between the heart and the diaphragm and the chest wall, the descent of the diaphragm may be much diminished. Fluoroscopic examination would be very useful in demonstrating this point. Litten's phenomenon would be diminished or absent.

Enlargement of the heart is common in adherent pericardium. There are both hypertrophy and dilatation. The hypertrophy results from the obstruction offered to the regular contraction of the heart.

Broadbent states that the heart becomes dilated during acute pericarditis, and before it regains its original size, becomes anchored in this position by adhesions.

Friedreich's sign of diastolic collapse of the cervical veins is not considered useful by the majority of modern observers.

The pulsus paradoxus has generally been held to be a sign of pericarditis. It is characterized by the disappearance of the radial pulse during inspiration. Kussmaul believes that it is of diagnostic importance in indurated mediastinopericarditis; it is due to the fibrous cord dragging on the aorta during inspiration. It may be present in pericarditis with effusion.

Most of these signs are dependent upon the presence of adhesions between the pericardium and the chest wall. When such adhesions are absent signs are very indefinite.

Signs and symptoms of incompensation may come on which cannot be distinguished from those of incompensated organic lesions.

An important condition is that of *pseudocirrhosis* of the liver due to obliterative pericarditis. In this condition there is an enlarged liver, associated with ascites, but without edema or enlarged spleen. Autopsies have shown, according to Becker, in all recorded cases, that ascites is due to a passive congestion of the liver, causing a connective-tissue formation with subsequent contraction and obstruction of the portal circulation, the result of obliterative pericarditis.

Differential Diagnosis.—The chief difficulty lies in distinguishing between dilatation of the heart and pericardial effusion, when, as occasionally happens, neither friction sound nor murmur can be heard. This may be better appreciated when it is remembered that on several occasions the right ventricle has been punctured by the paracentesis needle with serious results, the diagnosis of effusion having been made. In many cases in which the effusion is only of moderate degree it is difficult to be absolutely certain of a diagnosis.

Massive pericardial effusions, amounting to one and a half or two liters, have been mistaken for pleuritic effusions.

The following points, mentioned by Osler, may assist one in differentiating between dilatation of the heart and pericardial effusion:

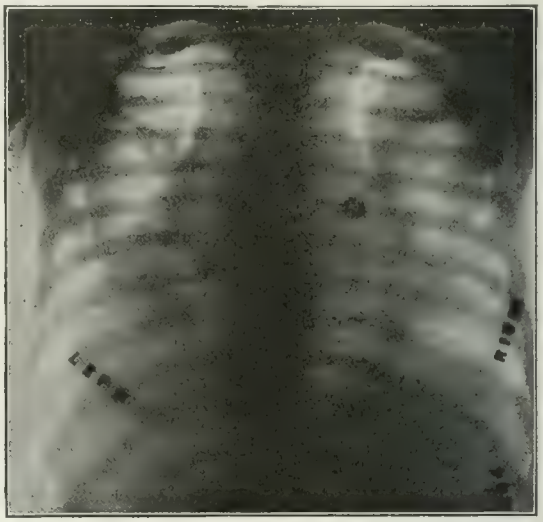


Fig. 4260.—Pericardial Effusion; note the great broadening at the base of the heart and the extension to the right of the sternum.

In dilatation the impulse in thin-chested people is usually visible and undulatory; the shock of the cardiac sound is more distinctly palpable in dilatation; the peculiar area of dulness in effusion, especially if the upper limit shifts with change of position of the patient.

In dilatation the heart sounds are clearer, often sharp, valvular or fetal in character; gallop rhythm

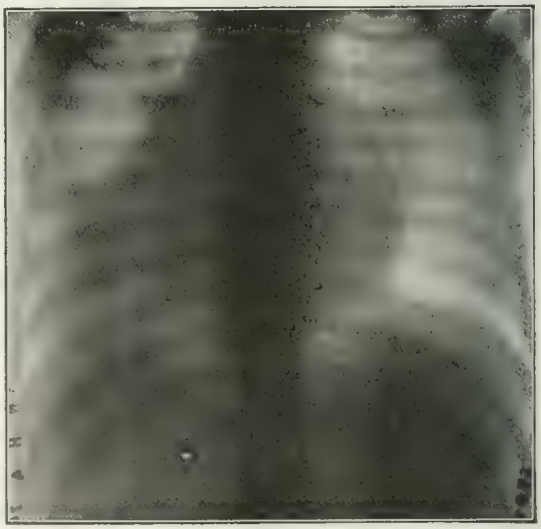


Fig. 4261.—Same Heart as Shown in Fig. 4260, but Two Years Later during Acute Decompensation.

is common, whereas in effusion the sounds are distant and muffled.

Rarely, in dilatation, is the distention sufficient to compress the lung and produce the tympanitic note in the axillary region.

Fluoroscopic examination and *x*-ray plates are extremely useful for differential diagnosis. The opaque

area does not pulsate as it does in enlarged heart or aneurysm. The upper level can be seen to move with changes of position. Figs. 4260, 4261, and 4262 show the value of *x*-ray plates in diagnosis. Fig. 4260 shows the typical pear shape with the broad base showing uniformly on each side. This child entered the N. Y. Hospital in extreme dyspnea and orthopnea; 175 c.c. were aspirated through fifth left interspace. Fluid was serous in character. Fig. 4261 shows same heart two years later during decompensation. Fig. 4262 is a picture of a heart in which the possibility of pericarditis with effusion was considered. It may be readily differentiated by comparison with Fig. 4260. The case is probably one of adherent pericarditis, the child having been seen during the attack of acute pericarditis and now (two years later) presenting the picture of Pick's disease.

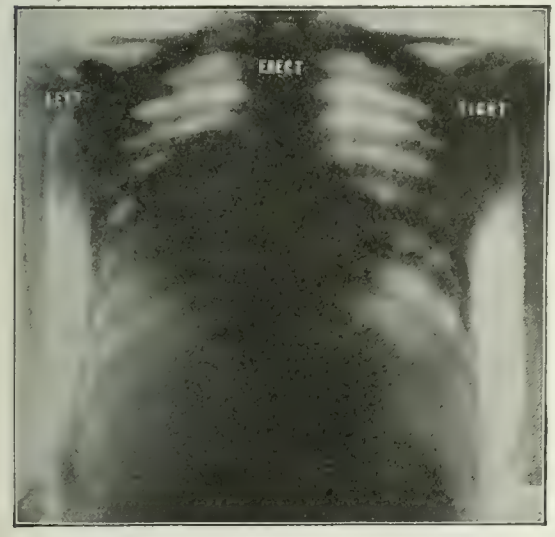


Fig. 4262.—Large Heart; Probably a Case of Adhesive Pericarditis.

Diseases of the Pericardium in Children.—Only a few special observations need be mentioned under this heading, as the signs of pericardial disease are practically the same at all ages. Rotch states that so far as he could determine by the dissection of sixteen infants of different ages the relation of the infant's pericardium does not differ from that of the adult. The amount of fluid normally present is of variable quantity, but is probably under 5 c.c. When pericardial friction sounds are absent, the diagnosis of pericarditis in a young child is attended with great difficulties. Owing to the greater flexibility of its thorax the child is much more likely than the adult to manifest a bulging of the precordium as a result of the pressure of the fluid. It must be kept in mind that on account of the smallness of the child's thorax the heart and pericardium are both brought nearer the surface than in the adult; and as a result the heart's impulse can be felt, and the heart sounds heard, in much larger effusions than would be possible in adults.

Pericarditis sicca is uncommon in early childhood. Exudation takes place more frequently than in the adult, and with greater rapidity, and is more likely to be purulent (Rotch). Exudation tinged with blood is not uncommon in early life, and is not so significant of tuberculosis as is a pronounced hemorrhagic exudation.

Holt states that pericarditis is rare in infancy and early childhood, only two cases having been seen in 726 consecutive autopsies at the New York Infant Asylum. In later childhood the disease is more frequent. According to Jacobi, Holt, and other authorities diseases of the lung and pleura, especially of the left side, take first rank as etiological factors in infancy and early childhood. After the fourth year rheumatism takes precedence and the pericarditis is then usually associated with endocarditis. Pericarditis may develop in the newborn as a result of infection of the cord. In rheumatism pericarditis may develop and become very pronounced, while the articular complaint is mild.

In young children pain seems to be generally absent.

Prognosis.—Pericarditis should always be looked upon as a serious disease, chiefly because of the myocardial degeneration which accompanies it. Death may take place in a few days in the acute cases associated with rheumatism and pneumonia, but this sequel is very uncommon. The immediate prognosis in these cases is generally good. The probability of repeated attacks, the likelihood that adhesions will form, and the presence of myocarditis render the prognosis for a long life unfavorable. When associated with Bright's disease the prognosis is bad.

Patients occasionally die from syncope as a result of embarrassment to the action of the heart from the pressure of a very large collection of fluid.

Suppurative pericarditis is nearly always fatal if associated with a general septicemia; if it is secondary to an empyema or other localized collection of pus, there may occasionally be recovery, with the adoption of early and proper surgical treatment.

In adherent pericardium the prognosis is serious if there are adhesions to the chest wall, if the heart is enlarged, or especially if these adhesions are associated with valvular lesions. Universal adhesion of the pericardium to the heart, provided the heart is not enlarged, does not necessarily tend to shorten life.

Treatment.—Pericarditis must always be considered a serious disease, even if the symptoms are slight. The patient should be put to bed. The diet should be chiefly liquid, milk forming the major part. The stomach should not be overloaded. In the milder cases soft articles of food may be given. Pain should be relieved chiefly by the application of the ice-bag. In children hot applications may be more satisfactory. Morphine may be required in some cases. Restlessness and sleeplessness should be controlled by suitable doses of bromide or trional. The heart action, pulse, respirations, and color of the patient should be closely watched, and heart tonics, such as caffeine and digitalis, given when indicated. The time may come when the heart is embarrassed by the obstacles presented by the enormous effusion; the pulse becomes extremely weak and rapid, marked dyspnea and cyanosis develop; then heart tonics are useless, and one must resort to paracentesis to save the patient.

Unless the symptoms are moderately urgent a serous effusion should not be evacuated, because many times the absorption is very rapid. If the effusion is large and has existed for many days, and shows no signs of resorption, it should be evacuated without hesitation.

Paracentesis Pericardii.—The pericardium is tapped with a trocar and cannula in the same way as is the pleura. The only difference is in the selection of the point of puncture. The proceeding is not free from danger and should not be made for the purpose of diagnosis but only to relieve symptoms. When the effusion is large enough to cause embarrassment to the heart, aspiration is preferably performed in the fifth left interspace about one inch inside the outer limit of absolute dulness. It is well to precede the aspiration by exploratory puncture with a small syringe and fine needle. Puncture may also be made to the right of and close to the sternum in the fourth interspace when the dulness extends well to the right of the sternum. The danger of injuring the heart is greater at this point. The fluid may also be reached by thrusting the needle upward and backward in the

left costoxiphoid angle, keeping fairly close to the sternum.* As much as possible should be removed. The aspiration may have to be repeated.

Purulent effusions should be treated like any other abscess, by early free incision and drainage. Irrigation of the sac is not advisable except in selected cases.

The treatment of adherent pericardium is practically that of organic heart lesions (myocardial and valvular). It is necessary to keep up bodily nutrition by proper exercise and diet, and at the same time guard against overtaxing the weak heart. If symptoms of incompensation develop they should be treated by rest, diet, and cardiac medicines, as indicated elsewhere. If it is possible to demonstrate adhesions between the heart and the chest wall as evidenced by systolic retraction the possibility of affording relief by cardiolysis as advocated by Brauer should be considered.

Hemopericardium and Hydropericardium have been considered in detail in vol. iv.

Pneumopericardium, because of its extreme rarity and hopeless prognosis, is of very little practical importance. By it is meant the presence of gas or air in the pericardial sac. As a matter of fact, gas is never present alone, but is in combination with fluid, usually pus, *i.e.* pyopneumopericardium. It is always secondary to some very serious destructive disease in which a communication is established between the pericardium and a cavity or tube containing air—as, for instance, perforation from the esophagus, especially in connection with cancer; rupture into the pericardium of a lung cavity, or pneumothorax, or perforation of a gastric ulcer. It may occur as a result of penetrating wounds, such as fractured ribs, concussion or crushing of the chest, or injury from the side of the esophagus. The gas in pneumopericardium varies in amount and in composition, and is generally offensive. It may be under so great pressure that when the pericardium is punctured the gas escapes with a hissing noise.

Symptoms.—These are very indefinite, and difficult to dissociate from the primary disease. If the gas is present in abundance there will be dyspnea, cyanosis, attacks of syncope, collapse, a feeble and irregular pulse, and occasionally dysphagia and precordial distress.

Physical Signs.—There may be bulging of the precordial region. The apex beat is weak or absent. The heart movements may produce a very peculiar crackling sensation due to the bursting of bubbles.

Percussion signs are very striking. A metallic tympanitic note is heard over the distended pericardium. Because of the presence of fluid and air a freely movable area of dulness is detected in the dependent part, upon change of position. The quality of the tympanitic note may also vary with the change of position.

Auscultation.—The heart sounds are unusually loud and may have a metallic ring. If murmurs are present they take on the same quality. The cardiac movements and deep breathing agitate the fluid and gas present in such a way as to produce unusual adventitious sounds. They have a metallic ringing quality, and have been likened to the sound of a water wheel.

Treatment is expectant and supportive. It may at times be wise to allow the gas to escape through a fine trocar, or even to incise and treat surgically. Little can be done in a medical way.

New Growths and Parasites.—Under this heading are included tuberculosis, carcinoma, and hydatids. Tuberculosis is much more common than the latter two. It is very unusual to find the tubercles of acute miliary tuberculosis on the pericardium. In most cases tuberculosis of the pericardium is chronic and secondary to tuberculosis in other parts of the body, especially of the lungs and mediastinal lymph glands. In many cases of pulmonary tuberculosis the complicating pericarditis is of the simple serous type. The exudate in tuberculosis and carcinoma of the pericardium is likely to be blood-tinged, and may be purulent or ichorous.

Carcinoma of the pericardium is extremely rare and is always secondary, the sac being involved by extension from neighboring organs.

Hydatids of the pericardium are extremely rare. Clinically we have no means of recognizing the presence of a new growth in the pericardium, except as we infer its presence from the detection of similar disease in neighboring tissues.

James Rae Arneill.
Joseph C. Roper.

Perihepatitis.—Perihepatitis, or inflammation of the capsule of the liver, may be acute or chronic. The acute form is usually a secondary affection. The instances of primary acute perihepatitis are rare, and are due to direct injury, or are associated with acute peritonitis or inflammations adjoining. A chronic perihepatitis is said to arise from the long-continued pressure produced by tight lacing, or by wearing a strap about the waist to support the trousers. Capsular cirrhosis is the term applied to the best-known form of primary chronic hepatitis. An hypertrophied heart may cause a similar inflammation on the blunt margin of the left lobe (Thierfelder). Secondary perihepatitis arises by extension of inflammatory processes seated in the neighboring structures. Affections of the diaphragmatic pleura and of the stomach, duodenum, or pancreas, causing local peritonitis, are attended by perihepatitis. It may be caused by disease of the ribs lying over the organ. All forms of general peritonitis involve the portion of the membrane that covers the liver. The larger number of cases arise by contiguity from some disease of the liver. It is seen in cirrhosis, cancer, and abscess and hydatid cysts lying near the surface. The presence of gallstones in the gall-bladder, cholecystitis, and the occurrence of attacks of hepatic colic, are very frequently attended by local peritonitis.

The investing capsule in perihepatitis is opaque and thickened from the formation of new connective tissue. The liver is intimately attached to adjacent structures. It is rendered more globular or rotund in those cases in which the capsule is the seat of chronic inflammation, and is tightly stretched over it. The adjacent hepatic tissue is not generally altered. Roller and Frerichs state that true cirrhosis may proceed from the chronic capsular inflammation. Sometimes processes of connective tissue are sent out into the parenchyma. Inflammation about the portal fissure leads to subsequent stricture of the hepatic ducts by contraction of the inflammatory new growth. The spleen is rarely enlarged, possibly in many cases owing to an existent perisplenitis. In many cases the disease is part of a chronic proliferative peritonitis; adhesive pleuritis and pericarditis may also be present. Under the title of "pericarditic pseudocirrhosis (hepatic)," Pick describes some of these cases; the tendency is, however, not to accept the perihepatitis and accompanying cirrhosis (sometimes seen) as due to or consequent upon the obliterative pericarditis, but as part of a general proliferative process.

Symptoms.—The symptoms of acute perihepatitis are often severe. Sudden, sharp, lancinating pain in the region of the liver, increased by movement, by respiration, or by pressure, is experienced. Some dyspnea is provoked by the interference with the breathing. Marked fever attends these phenomena during the first three or four days. The presence of a friction murmur may be detected by auscultation

* Drainage may be by syphon or aspiration.

in some rare instances. An acute pleurisy of the right side is very strongly simulated by perihepatitis. Chronic perihepatitis is attended by dull pain, and at times by friction sounds and fremitus. It may proceed without symptoms for years. After adhesions have formed the liver may not move upon deep inspiration. In some cases, in which owing to extreme contraction of the new-formed tissue the portal and lymphatic circulations are interfered with, ascites develops, which with a markedly diminished liver area gives a more or less suggestive picture of cirrhosis. The course of these cases is very chronic (up to fifteen years) and paracentesis abdominis may be performed an enormous number of times (three hundred and one in one instance).

Treatment.—The treatment is simple. Rest must be enjoined in the acute cases. Morphine will at times be necessary. Warm compresses or poultices to the right hypochondrium may give relief. In chronic perihepatitis prolonged counterirritation, as by iodine, is suggested. Collections of ascitic fluid must be removed. Otherwise the treatment must be directed to the cause.

It is not to be forgotten that the presence of old adhesions between the liver and the diaphragm is often a wise provision. The vessels that develop in the tissue are utilized for setting up a collateral circulation, when the normal hepatic vessels are occluded or compressed. Norman B. Gwyn.

Perinephritis and Perinephritic Abscess.—Perinephritis, also sometimes called paranephritis, is an inflammation of the fatty and cellular tissues around the kidney, and is met with in two forms: (1) as a productive or sclerosing inflammation, without demonstrable septic foci; and (2) as a suppurative process.

Etiology.—The productive form often occurs in mild or moderate degree in connection with excessive mobility of the kidney, with the chronic diffuse, chronic hemorrhagic, or chronic interstitial types of nephritis, occasionally with renal tumors, and with many cases of pyonephrosis and calculous or tuberculous nephritis, under these last three conditions sometimes reaching such an extreme degree that almost the entire fatty capsule is converted into a dense fibrous mass. The suppurative form undoubtedly occurs from hematogenous infection in occasional instances, but usually infection of the perirenal and retroperitoneal fatty tissues in general takes place through the lymphatics or by direct extension from neighboring structures.

Perinephritic abscesses occur most frequently in early adult and middle life, although cases have been reported from the age of five weeks to old age. They are at least twice as common in the male as in the female, and the right kidney region is more often affected than the left. Very rarely both sides are affected. Perinephritic abscesses have been referred to as *primary* and *secondary:* primary, when apparently originating in the perinephritic tissues; secondary, when the infection can be shown to be directly traceable to the kidney, liver, gall-bladder, appendix, or any other demonstrable septic focus.

Examples of apparently primary perinephritic abscesses are by no means uncommon, yet it is undoubtedly true that most of these cases are really secondary to undetected septic foci, some of which are more or less remote from the perinephritic tissues and whose connection with the abscess is thus unsuspected. We are easily led to this belief from the fact that the proportion of cases where a definite focus of infection is located in contiguous or anatomically related structures is gradually growing greater with the advances in diagnostic methods; and it is already plainly apparent that the kidney is the source of infection in a far larger percentage of the cases than was generally believed even a decade ago. Küster's 1902 statistics of 230 cases of perinephritic abscesses collected from the literature gave suppuration in the kidney as the cause in fifty-nine cases, or about twenty-five per cent. Albarran,[1] however, considered that in one-half of the cases the infection came from some kidney lesion. Guiteras,[2] in 1906, was still more impressed with the rôle of the kidney in the causation of perinephritic abscesses; for after stating that one would form the opinion from the textbooks that one-third of the cases were due to renal suppurative lesions, he announced it as his belief, from personal experience, that nearly all of the cases are due to renal disease, and that those due to disease of other organs are rare and not, properly speaking, perinephritic abscesses. Braasch,[3] in a review of 101 cases of abscess in the perinephritic tissues that had been operated upon at the Mayo Clinic up to January 1, 1914, found that sixty-seven could be properly classified as perinephritic abscesses and that thirty-four were secondary to lesions in the extrarenal tissues; and because of their situation these were termed subdiaphragmatic or retroperitoneal abscesses. Of the sixty-seven classified as perinephritic, forty-nine were directly traceable to renal infection and four to other structures, leaving fourteen with no data as to the source of infection. But he says, "in many of this group the more recent methods of examination were not employed. Doubtless with the aid of these methods, some evidence of renal infection would have been found in a considerable percentage of these cases." Braasch states that the existence of a primary perinephritic infection has never been definitely established either at operation or autopsy, and that it would be more logical to regard all perinephritic infection as secondary or metastatic; that a division may be made between an abscess of renal origin and one arising in other tissues; and that the former group should be termed true perinephritic abscesses, the latter subdiaphragmatic or retroperitoneal, thus in large measure agreeing with the beliefs stated by Guiteras ten years ago. Richardson,[4] in a study of all cases of perinephritic abscesses operated upon at the Massachusetts General Hospital during the fifteen years from 1899 to 1913, found a small number of cases in which perirenal suppuration was unaccompanied by demonstrable septic processes in the kidney or other adjacent structures, but where there had been a septic focus in a remote situation, such as furuncles, carbuncles, paronychiæ, etc.; and he concludes that in these cases there was a metastatic hematogenous infection of the perinephritic tissues. In none of his cases, however, was the kidney entirely exposed, hence the possibility of connection with a small cortical abscess cannot be excluded.

It is thus seen that through improvements in diagnostic methods and greater care in the studying of cases, suppurative lesions of the kidney, considered as the etiological factor in but twenty-five per cent. of the cases in Küster's 1902 statistics, have been found responsible for at least fifty per cent. of all cases in the most recent series reported (that from the Mayo Clinic) and for approximately eighty per cent. of those which were considered entitled to be properly classified as perinephritic abscesses; and that the remaining thirty-four cases in this series, discussed in detail by Judd,[5] proved at operation to have been secondary to lesions in the extraurinary tissues, and because of their situation were not termed perinephritic abscesses at all, but subdiaphragmatic or retroperitoneal. Nevertheless, an enumeration of the principal commonly accepted etiological factors should be made in a work of this kind, and is as follows: Suppurative diseases of the kidney; traumatism; abscesses of the liver, gall-bladder, spleen and pancreas; appendicitis; perforated gastric or duodenal ulcers; operations upon

or diseases of the intestines, especially the colon or rectum, fecal impaction; prostatic abscess; puerperal infection and inflammatory conditions in any part of the genito-urinary apparatus; pneumonia; abscess of the lung; empyema; and suppurative conditions of the ribs, vertebræ, or overlying soft parts. Perinephritic abscess may also develop during the course of certain of the exanthemata, especially typhoid, scarlet fever, smallpox and erysipelas. In every large series of cases there has remained a certain percentage in which the etiological factor was not and apparently could not be determined.

Pathology.—The productive, or sclerosing, type of perinephritis has been sufficiently discussed in connection with those diseases of the kidney in which it occurs in its most pronounced form and in the article on nephrectomy; hence will not be further commented upon here. Suppurative lesions, developing into perinephritic abscess, are usually found posterior to the kidney and the abscess is usually unilocular, although infection of the perinephritic tissues, such as that originating from a kidney having multiple cortical abscesses, may likewise occur at several points, and these may sometimes be demonstrated, especially when operation is done early. Usually, however, even if there are at first several foci these fuse later and as a general rule a single abscess cavity is encountered. The size of the mass varies within wide limits and the amount of contained pus ranges from a few cubic centimeters to several liters. Perinephritic abscesses may point in the upper lumbar region, in Petit's triangle, in the iliac or ischio-rectal fossæ, or, after burrowing through the sacrosciatic foramen, in the gluteal region; they may break through and empty into the colon or some other portion of the gastrointestinal tract, into the general peritoneal cavity, into the kidney, ureter, bladder or vagina; or they may develop upward and open into the pleural cavity or the lung itself. Very rarely, cases have been reported (Guiteras, Albarran) in which abscesses have been absorbed after being walled off by firm connective tissue. The staphylococcus is the most frequent infecting organism, but the colon bacillus, streptococci, and a number of other organisms are also sometimes found.

Symptoms.—The symptoms vary with the manner of infection and the virulence of the infecting organism. As a rule the process develops rather insidiously and may at first present but few symptoms—possibly merely malaise and slight gastrointestinal disturbances, a sense of soreness or dull ache in the loin, with little or no fever—so that the presence of a mass in the lumbar region may be the first thing to really call attention to the condition. Sometimes, however, the onset is acute and in these cases there is often an initial chill followed by high fever, which may be continuous or remittent in type, together with rapid pulse, headache, and disturbances of the gastrointestinal tract such as are the usual concomitants of acute septic processes generally. In addition there is pain in the affected side and this pain may be so severe and sharp as to suggest renal colic in occasional instances, though more frequently it is dull, deep-seated and perhaps boring in character. The pain may remain localized or be referred in various directions corresponding to the distribution of those lower thoracic and lumbar nerves which are irritated by the inflammatory process. In the early stages of the acute cases there may be no appreciable swelling in the loin, though tenderness on pressure can be elicited very early in most cases. There may be tenderness anteriorly as well as in the loin and tumefaction is almost sure to occur sooner or later, though this may not appear for some weeks. Fluctuation is rarely seen early, may appear late, but more often cannot be elicited at any stage. If the abscess points superficially, edema and redness of the skin gradually appear. In many instances the attitude of the patient is rather characteristic. As he lies on his back the leg on the affected side is kept somewhat flexed at the hip and knee; and when standing he inclines the body toward the affected side so as to relax the vertical muscles of that side, especially the psoas. In the acute cases particularly there is always marked leucocytosis, with a high percentage of polymorphonuclears. The urine may be normal but in a very considerable number of cases there are some changes to be noted in the catheterized specimens from the two ureters, such as the presence of a trace of albumin, a few blood and pus cells, and a few casts. It may be necessary to make a number of examinations before these abnormal constituents of the urine on the affected side can be found and, as pre-existing lesions in some part of the urinary tract cannot always be ruled out, the urinary evidence is of value only when taken in conjunction with other clinical signs and symptoms. In the cases developing secondarily to suppurative processes in the kidney there are seldom any changes in the urine of diagnostic significance.

Diagnosis.—This is often extremely difficult until well-marked focal symptoms develop. In cases secondary to a known suppurative process in the kidney, the presence of a slight febrile condition and mild evidences of septic absorption often go unnoticed until pain is experienced in the renal region or until the patient appreciates the fact that pain, which had previously been intermittent or remittent in type, has become practically continuous, or until there is a fairly well-marked mass in the loin. With pain and tumor developing under such conditions diagnosis usually presents but little difficulty. There will always be some degree of hyperleucocytosis and certainly at least some of the other symptoms noted above will be present. If the patient assumes the attitude previously referred to as rather characteristic, it must be determined that it is not due to disease of the spine or hip.

Cases developing without known pre-existing renal lesions present the greatest difficulty in diagnosis and often many days or even weeks elapse before a positive diagnosis is made. This applies not only to those developing insidiously but also to some of the acute cases ushered in by chill, high temperature, rapid pulse, marked leucocytosis, and other evidences of a severe septic infection, but at first without pain or other frank symptoms pointing to the kidney region. Under such conditions, the previous history, especially regarding infectious processes, is very important. A careful general physical examination must be made, in the course of which tenderness may be found sooner or later in one or the other lumbar region, while the urine will naturally receive attention and may possibly show signs of renal irritation. In this latter event both ureters should be catheterized and the separate urines examined chemically, microscopically, and bacteriologically, and estimation of the comparative renal function should be made, for a sufficient number of cases have already been reported to show that these measures are often of value in early diagnosis. In addition, much may often be learned by *x*-ray examination at the hands of an expert. As the disease progresses, dulness is sometimes found on percussion and palpation discloses a tender mass in the loin—a mass which is fixed, indistinct in outline, gradually causes an obliteration of the normal concavity under the ribs, and which is accompanied by pain localized or referred in various directions, and occasionally by edema of the lower extremity on the affected side.

Perinephritic abscess must be differentiated from acute septic nephritis, pyonephrosis and other purely renal conditions, lumbago, suppurative disease of the vertebræ, hip-joint, or sacroiliac synchondrosis, hematoma, or other conditions affecting the musculature of the lumbar region, empyema, and various sup-

purative conditions, such as liver abscess, developing in connection with organs in the upper portion of the abdominal cavity.

Treatment.—This is purely surgical. The abscess should be opened through a sufficiently extensive lumbar incision to allow easy access to all parts of the cavity and the carrying out of such measures regarding the kidney, if that is found to be the source of infection, as may seem advisable. With kidney involvement the general condition of the patient must, of course, be taken into consideration, also the functional value of the affected and the opposite kidney, and the character and extent of the infectious process, before deciding whether the kidney should be let alone, removed at once, or drained and perhaps removed later. Guiteras has well summed up the elements which make for success in the handling of perinephritic abscesses as follows: "(*a*) Early incision and evacuation before the pus has had time to burrow extensively. (*b*) Thorough exploration, without timidity, opening the kidney and exploring the ureter if need be. (*c*) Thorough drainage down to the deepest part of the sac by means of large soft rubber drains or gauze, the drain being kept in place until a well-formed sinus exists down to the deepest part of the cavity. (*d*) Nephrotomy, nephrostomy, or nephrectomy should be performed if indicated at the time of operation or later."

In emergency cases and in those where, for any reason, the patient is in poor condition, abscesses which are large and relatively superficial may be opened under local anesthesia. Usually, however, general anesthesia should be employed for one seldom knows how extensive an operation will be required until after a thorough exploration, and this can seldom be done satisfactorily under local anesthesia.

Prognosis in early operations is extremely good and depends more upon the nature of the underlying cause than upon the abscess itself. The prognosis in late cases is not so good but depends to a very considerable degree in the individual case upon the type of operation which is done; and this, in turn, depends upon the skill and surgical judgment of the operator. In the older statistics the mortality, including all classes of cases, was 30 to 40 per cent.; later, 20 per cent. The mortality for the Massachusetts General Hospital series was 10.2 per cent., while there were no deaths in the last group of thirty-four cases. Of the sixty-seven patients considered as having true perinephritic abscess and operated upon at the Mayo Clinic two died, a mortality of 3 per cent.

Wesley Grove Vincent.

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Perineum, Surgical Anatomy of the.—I. The Male Perineum.—In the skeleton the perineum corresponds to the outlet of the pelvis. It is a diamond- or lozenge-shaped space bounded in front by the pubis and subpubic ligament, behind by the coccyx, and on each side, from before backward, by the rami of the pubis and ischium, the great tuberosity of the ischium, and the great sacrosciatic ligament (l. sacrotuberosum).

The whole space measures about three inches and a half from side to side, and four inches anteroposteriorly. At the posterior part it is from two to three inches deep; anteriorly it only reaches the depth of one inch. The perineal space is separated from the pelvic cavity above by the recto-fascia and levatores ani muscles. A line drawn across from one ischial tuberosity to the other, and passing immediately in front of the anus, would divide the space into two parts (see Fig. 4263), the anterior of which is called the *urethral* triangle or true perineum, and the posterior the *anal* or rectal triangle. The anterior triangle contains the bulb and urethra, with the muscles of the perineum proper; the posterior triangle has in it the rectum and the two ischiorectal fossæ.

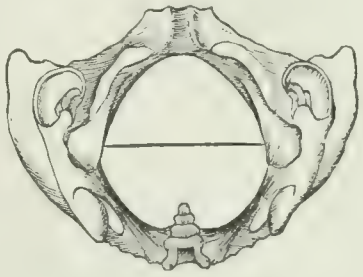

Fig. 4263.—Outlet of the Pelvis. Line dividing outlet into anterior or urethral triangle, and posterior or rectal triangle.

Surface Anatomy.—In the undissected subject the superficial area of the perineum is very limited, especially when the thighs are brought together; it then consists of a narrow space or groove reaching from the coccyx behind to the symphysis pubis in front. In the center of this groove is an elevation of the skin, called the median raphé, which runs from the front of the anus, over the scrotum, to the undersurface of the penis. No vessels cross this line, and in this situation incisions may be made without any fear of hemorrhage. The osseous boundaries of the perineum may be easily made out through the skin; the great sacrosciatic ligaments, however, being covered by the gluteal muscles, can be felt only by pressing in a line drawn from the coccyx to the ischial tuberosity. In thin subjects they can be more easily felt. The anus is situated at the midpoint between the tuberosities, and its center is about one inch and a half from the end of the coccyx. The central point of the perineum is a little more than an inch in front of the anus; this point corresponds to the middle of the free border of the triangular ligament. A knife introduced here, and given a slightly upward direction, would reach the membranous urethra. Immediately in front of the central point may be felt, in all but very fat persons and children, the bulb of the urethra and the corpus spongiosum. Abscesses point, and urethral fistulæ are often seen, in this region.

The membranous portion of the urethra perforates the triangular ligament one inch below the symphysis pubis, and one inch and a half in front of the anus. The skin of the perineum is thin and covered with hairs; about the anus it is of a brownish color and thrown into radiating wrinkles by the contraction of the external sphincter; these folds are much enlarged when the hemorrhoidal veins are swollen and inflamed. If the skin of the anus be everted, a fine white line is seen which marks the junction of the skin and mucous membrane, and corresponds exactly to the lower margin of the internal sphincter. There are a number of follicles about the margin of the anus, and small subcutaneous abscesses frequently occur in this situation. These must not be confounded with fistulæ. The usual incision in lateral lithotomy passes between the anus and ischial tuberosity, a third nearer the tuberosity than the anus.

If the finger be introduced through the anus into the rectum, many important landmarks may be felt. The finger for the first inch is grasped by the sphincter

muscles, principally the internal. Here the internal openings of fistulæ may be felt; these openings are rarely much above the upper border of the sphincter ani. One can easily feel ulcers and fissures in this situation, when they are present. In the front wall of the bowel the membranous portion of the urethra can be made out in the middle line, and when a catheter is introduced into the bladder it can be easily felt as it passes through the membranous portion; with the finger in the rectum a catheter can be guided into the bladder in cases of enlarged prostate, and if the instrument enters a false passage it can be detected and directed into the proper channel. The prostate gland can be felt one inch and a half from the anus, and its condition ascertained if it be enlarged or inflamed. Passing beyond the prostate the finger comes on the trigone of the bladder. When the bladder is distended it may be made out through the rectum as a soft fluctuating tumor. It is more easily felt when the other hand, placed above the pubis, passes the apex downward. The bladder, when distended, may be tapped through the trigone with a curved trocar, without there being any danger of wounding the peritoneum, which generally reaches only to within four inches of the anus. In rare cases the peritoneum passes down between the gut and the trigone. In such cases, of course, in this operation, it would inevitably be wounded.

The vesiculæ seminales can rarely be felt, unless affected by disease.

Stone in the bladder in children can often be diagnosed through the rectum. Above the trigone of the bladder transverse folds of mucous membrane in the rectum can be felt; these are soft and velvety when healthy, but when ulcerated or inflamed they feel thick and cause great pain on defecation. Many diseases are diagnosed by the finger in the rectum, viz., ulcers, polypi, hemorrhoids, stricture of the gut, diseases of the prostate, deep-seated abscess of the ischiorectal fossa, pelvic tumors, etc.

With the whole hand introduced into the rectum the entire pelvis may be explored, as well as the lower part of the abdomen.

Ischiorectal Fossa.—The ischiorectal fossa is the space which exists on each side between the rectum and ischial tuberosity. It is of a pyramidal shape, with the apex pointing upward to the pelvic cavity, and is from two to three inches in depth.

Boundaries.—Internally, the levator ani covered by the anal fascia; externally, the obturator internus muscle covered by the parietal layer of pelvic fascia; in front, the triangular ligament and transversus perinei muscle; behind, the lower edge of the gluteus maximus, the great sacrosciatic ligament, and the coccygeus muscle.

The space is filled with fat, and crossing the fossa obliquely are the inferior hemorrhoidal vessels and nerves. The anterior portion is crossed by the perineal vessels and nerves, and entering the fossa at its posterior part is the perineal branch of the fourth sacral nerve.

The tuberosities of the ischia have also a cushion of fat over them, and when this is removed several bursæ are seen. The apex of the space corresponds to the division of the pelvic fascia into parietal and visceral layers, or rather to the junction of the anal with the obturator fascia. When the anal fascia is removed the levator ani muscle is exposed, and internal to the levator ani is the visceral layer of pelvic fascia.

The lower end of the rectum is placed between the two fossæ, slung, as it were, by the meeting of the two levatores ani muscles, and held in place by the external sphincter and rectovesical fascia. The fibers of the levatores ani muscles at the lower end of the rectum are separated from one another, and in this situation the anal fascia is also very thin, so that little resistance is offered to the entrance of pus.

Ischiorectal Abscess and Fistula in Ano.—Abscess in the ischiorectal fossa is not an uncommon affection, and is often caused by the ulceration of foreign bodies, such as fish-bones, through the bowel into the fossa, and there setting up inflammation. Sitting on cold, damp seats after exercise is another, and perhaps the most common, cause of ischiorectal abscess.

When pus forms in the fossa it presents at the points of least resistance, viz., the internal wall of the fossa and the skin at the base. When the abscess breaks through the skin it will be found that after a time a sinus remains, which generally communicates with the bowel; this sinus is called a *fistula in ano*. The internal opening of the fistula is usually within half an inch of the margin of the anus, as at this point pus can more easily penetrate the rectum, because of the thinness of the fascia and the scantiness of the muscular fibers. The external opening may be anywhere in the region of the posterior part of the perineum. To prevent the formation of a fistula, the ischio rectal abscess should be opened early and freely.

Perineal Fasciæ.—The superficial fascia of the perineum consists of two layers, between which, in the rectal triangle, is a large amount of fat; in the urethral triangle there is less, and as the fascia reaches the scrotum the fat is replaced by the muscle or dartous tissue of that structure. The deep layer of fascia (fascia of Colles) is limited to the urethral triangle; it is attached to the base of the triangular ligament, to the anterior lips of the rami of the pubes and ischia laterally, and anteriorly it is continuous with the fascia of the scrotum. By its junction with the triangular ligament posteriorly it forms a pouch, which is divided into two portions by a median septum.

This pouch has an important influence on the direction which urine takes when extravasated, or pus when it forms, in this region. Owing to the attachment of the superficial fascia to the base of the triangular ligament and to the rami of the pubes and ischia, fluid cannot go back toward the anus or down the thighs, but, as the fascia is continuous anteriorly with the dartos of the scrotum, no resistance is offered to its progress forward and upward over the scrotum to the abdomen.

This is the course taken by urine when extravasated in front of the triangular ligament. When an abscess forms in the perineum, owing to the median septum, it is usually confined to one side of this pouch, and the swelling is triangular in shape. The pus, as it passes forward, on account of the deficiency of the septum in front, fills both sides of the pouch.

The anterior perineal pouch contains the superficial perineal muscles, vessels, nerves, and the root of the penis, which latter is made up of the two crura of the cavernous portions and the bulb of the spongy portion.

Muscles.—The muscles of the perineum bound the perineal triangle, in which the knife is entered in the operation of lateral lithotomy. The base of the triangle is formed by the transversus perinei muscle, the outer side by the ischiocavernosus (erector penis) muscle, and the inner side by the bulbocavernosus (accelerator urinæ); the triangular ligament forms the floor of the triangle.

The point of meeting of the two transverse perineal muscles, the sphincter ani, and bulbocavernosis muscles is called the tendinous or central point of the perineum. Along the lower border of the transverse muscles is seen the transverse artery, a branch of the internal pudic.

Diaphragma Urogenitale (Triangular Ligament).—This ligament divides the perineum into two portions—a deep and a superficial. It has very definite attachments to the subpubic ligament, the rami of the pubis and ischia, and the superficial fascia. It also blends with the central tendinous point of the perineum and completes the pelvic wall in front.

When the body is erect the lower surface of the triangular ligament looks downward and forward, and the deep surface upward and backward.

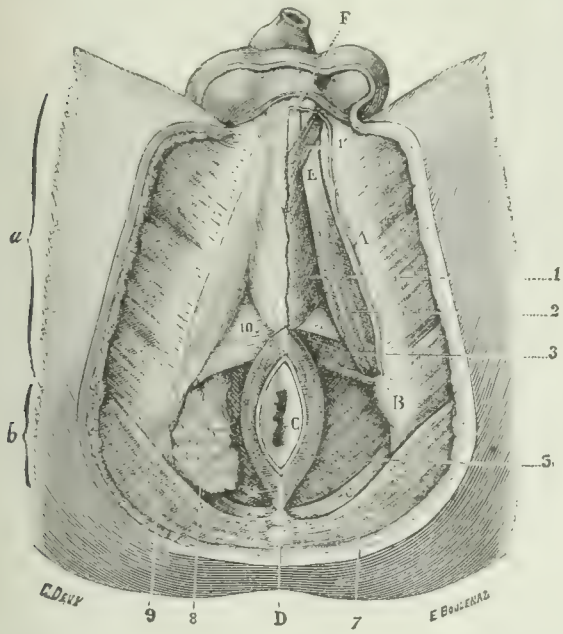

Fig. 4264.—Superficial Dissection of the Muscles of the Perineum. 1, Bulbocavernosus muscle; 2, ischiocavernosus; 3, transversus perinæi; 4, triangular ligament; 5, sphincter ani; 6, coccygeus; 7, great gluteus muscle; 8, cellular fatty tissue of the ischiorectal fossa; 9, sacrosciatic ligament; *A*, ischiopubic ramus; *B*, ischium; *C*, anus; *D*, coccyx; *E*, cavernous body.

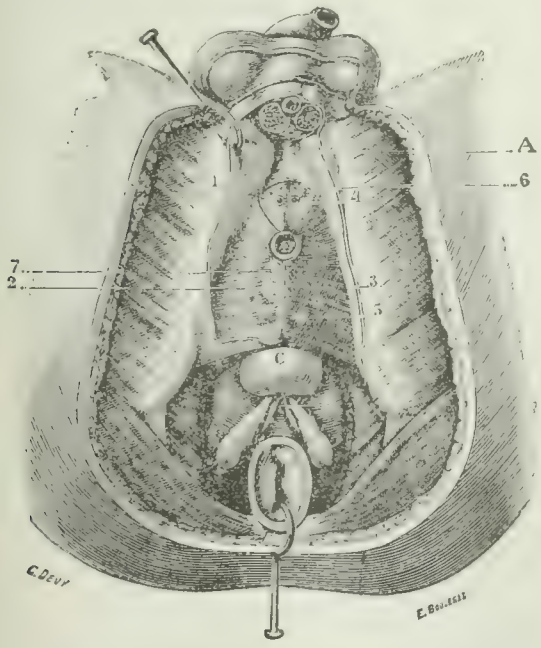

Fig. 4265.—The Muscles of the Perineum, Deep Dissection. *A*, Symphysis pubis; *B*, bladder; *C*, prostate; *D*, seminal vesicle; *E*, urethra cut transversely; 1, triangular ligament; 3, deep transverse perinei muscle; 5, Cowper's glands; 6, subpubic plexus of veins.

Structures in Relation with the Triangular Ligament.—In front are the structures named above as being contained in the perineal pouch.

The ligament is pierced by the urethra, and also by the dorsal vein and nerves of the penis and the internal pudic arteries. The urethra pierces the ligament one inch below the symphysis pubis, in the middle line. The parietal layer of pelvic fascia (posterior layer of the triangular ligament) is above and behind, and is attached to the ligament below, but as it proceeds upward the space between them widens. Between these two structures are the membranous portion of the urethra, the pudic vessels and nerves, with the artery of the bulb, the dorsal vein of the penis, the compressor urethræ muscle, which surrounds the membranous urethra, and Cowper's glands. These latter empty their secretion into the bulbous portion of the urethra; in inflammatory conditions of the urethra they may become inflamed and suppurate; they are the homologues of Bartholin's glands in the female.

The membranous portion is the least dilatable portion of the urethra, and is frequently the seat of *traumatic* strictures; it measures three-fourths of an inch in length.

Behind and above the pelvic fascia (posterior layer of the triangular ligament) is the apex of the prostate gland, covered by the levator ani muscle and by its own capsule. From this description it will be seen that the triangular ligament divides the perineum into two compartments, a superficial and a deep; the superficial contains the perineal muscles and root of the penis; the deep the membranous portion of the urethra, the pudic artery and nerves, the dorsal vein of the penis, the compressor urethræ muscle, and Cowper's glands. The base of the triangular ligament is the meeting-point of three fasciæ, viz., (1) perineal fascia; (2) triangular ligament; and (3) the parietal layer of the pelvic fascia (posterior layer of the triangular ligament).

The triangular ligament sometimes offers an obstacle to the introduction of a catheter; for if the instrument be not kept against the upper wall of the urethra, it is apt to sag in the lower wall, which is very distensible, and reach the triangular ligament below the opening of the membranous urethra. After the triangular ligament has been successfully passed, the point of the instrument may be arrested in the membranous urethra by the spasmodic contraction of the compressor urethræ muscle which encircles it; this obstruction may be overcome, without exercising any force, by merely keeping the end of the instrument pressed gently against the obstructing point; after a short time the muscle relaxes and the instrument slips into the bladder.

Kicks in the perineum, or injuries from falling astraddle of anything, may rupture the membranous portion of the urethra, and in these cases blood and urine will be extravasated between the triangular ligament and the parietal layer of the pelvic fascia (posterior layer of the triangular ligament). Should the injury tear the triangular ligament, then the extravasated fluid would take the ordinary course upward over the scrotum and abdomen. When extravasation has occurred, free incisions should be made in the perineum, and if the urethra be completely torn across, the perineum should be opened in the middle line and an instrument introduced into the bladder.

Cunningham has pointed out that in removing the various structures from the surface to the prostate gland, alternate layers of fascia and muscle are met with, viz., (1) Superficial fascia; (2) *superficial perineal muscles;* (3) triangular ligament; (4) *compressor urethræ muscle;* (5) parietal layer of pelvic fascia, or posterior layer of the triangular ligament; (6) *levator ani muscle;* (7) capsule of the prostate and pubo-prostatic ligament.

Arteria Pudenda Interna (Internal Pudic Artery).—The pudic artery is seen in the rectal triangle, enclosed within a sheath of pelvic fascia formed by the splitting

of the obturator fascia. It lies about one and a half inches above the level of the ischial tuberosity and is accompanied by the pudic nerve and the two pudic veins; proceeding forward, it passes between the triangular ligament and the parietal layer of pelvic fascia (posterior layer of the triangular ligament), and then, running under cover of the rami of the pubis and ischium, pierces the triangular ligament from behind,

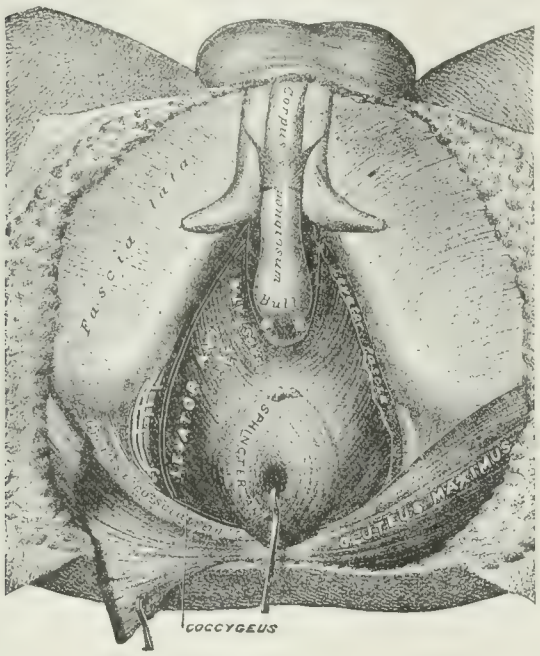

Fig. 4266.—The Male Perineum, Deeper Structures.

half an inch below the symphysis and a little to one side of the middle line. It then divides into its two terminal branches, the artery to the corpus cavernosum, and the artery to the dorsum of the penis. The pudic artery, while in the ischiorectal fossa, gives off the hemorrhoidal, and a little further forward the superficial and transverse perineal, arteries. While passing behind the triangular ligament, it gives off the artery of the bulb, the wounding of which was formerly so much dreaded by surgeons. The pudic artery itself is said to be in danger of being wounded in lateral lithotomy, but this accident could occur only to the most careless operators, when withdrawing the knife and sweeping it outward. It is possible to wound it only after it has left the protection of the pubic arch.

Exploration of the Bladder through the Perineum.—This operation is little more than a perineal section. According to Sir Henry Thompson, after introducing a grooved staff an incision should be made in the median line, commencing three-fourths of an inch in front of the anus, and the parts should be divided till the staff is reached in the membranous portion of the urethra; the finger is introduced into the bladder through this incision, the prostatic urethra dilating easily; the staff is now removed and the exploration of the bladder is made. Through this median incision tumors and stones of moderate size can be removed. There is little hemorrhage, even should the bulb be wounded, for this latter structure is not very vascular in the median line.

Parts Divided in Lateral Lithotomy.—The incision is commenced one inch and a half in front of the anus, and is carried downward and outward to a point between the anus and great tuberosity, a little nearer the tuberosity than the anus. In order to reach the staff in the membranous urethra the following structures must be cut:

In the first incision: Skin and superficial fascia; transverse perineal muscle and artery; base of the triangular ligament; the hemorrhoidal vessels and nerves.

Second incision: The knife is now guided by the forefinger, passed up behind the triangular ligament, its point placed in the groove of the staff, and the blade is lateralized and pushed along the groove into the bladder. In this incision the following parts are divided, viz., membranous portion of the urethra and compressor urethræ muscle; parietal layer of the pelvic fascia (posterior layer of the triangular ligament); anterior fibers of the levator ani and left lobe of the prostate.

Parts to be Avoided.—(1) Artery of the bulb, (2) rectum, (3) pudic artery.

1. The danger from a wound of the artery of the bulb is not great, and is somewhat traditional; with the modern methods of arresting hemorrhages no one need fear wounding the artery of the bulb. Very frequently it is abnormal in its distribution, and its division cannot be avoided.

2. The rectum may be cut, especially in children, if the bowel is not emptied previous to operation, or if the incision be carried down too vertically.

3. The pudic artery need never be wounded in a properly performed operation. It can be cut only by lateralizing the knife too much in withdrawing it. If wounded, it may be secured with the modern artery forceps without great difficulty.

In the withdrawal of the knife a too vertical incision may cut through the prostate, and so divide

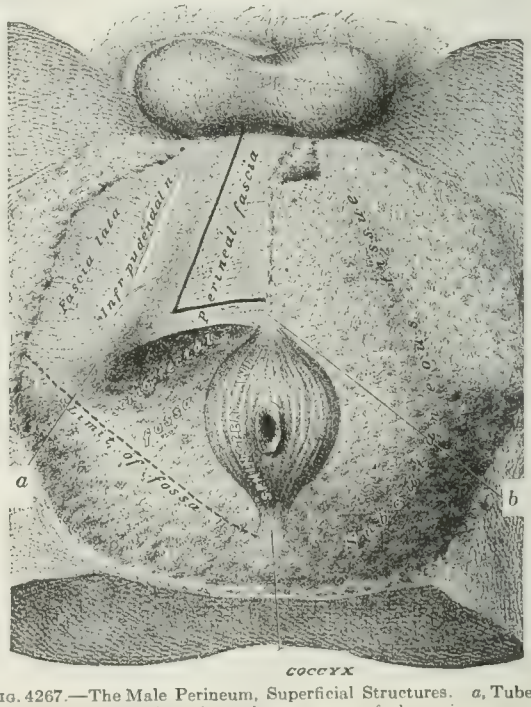

Fig. 4267.—The Male Perineum, Superficial Structures. *a*, Tuberosity of the ischium; *b*, tendinous center of the perineum.

the visceral layer of pelvic fascia. Should this accident happen, no ill results will follow if the wound be kept sweet and be thoroughly drained. Wounding of the visceral layer of the pelvic fascia is a danger much dwelt on by the older lithotomists, and surgeons of the present day still have a traditional fear of this accident happening. In children, lateral lithotomy can scarcely be performed without cutting

through the prostate gland, and at the same time the visceral layer of pelvic fascia; yet no ill results follow; on the contrary, the operation is safer in children than in adults. The real danger in adults is not from wounding the pelvic fascia, but from wounding the prostatic plexus of veins and the ejaculatory ducts. The prostate gland when enlarged can be removed through a perineal incision either transverse or vertical. Also the seminal vesicles can be reached through the same route. When affected with tuberculous disease it is sometimes necessary to remove them. The ureter as it enters the bladder can be reached through the perineum, and stones which have become lodged there successfully extracted.

Testicle in Perineum.—During the descent of the testicle, and after it has passed through the external abdominal ring, it may, instead of entering the scrotum, pass down into the perineum (ectopia perinealis). In these cases it may be felt slightly movable under the skin, about an inch and a half in front of the anus. The scrotum of the side in which the testicle is lodged in the perineum is deficient if the affection be congenital; if the case is of traumatic origin the scrotum of that side is present. The displacement has no evil effect on the testicle, which is always of a good size. The abnormal position of the testicle renders it liable to injury, and patients apply to the surgeon for relief. An operation has been devised for restoring the misplaced testicle to its proper position in the scrotum, but its success has been only moderate. Excision is sometimes demanded to rid the patient of his trouble.

II. The Female Perineum.—The space occupied by the female perineum, owing to the wider pubic arch, is somewhat larger than that of the male. It

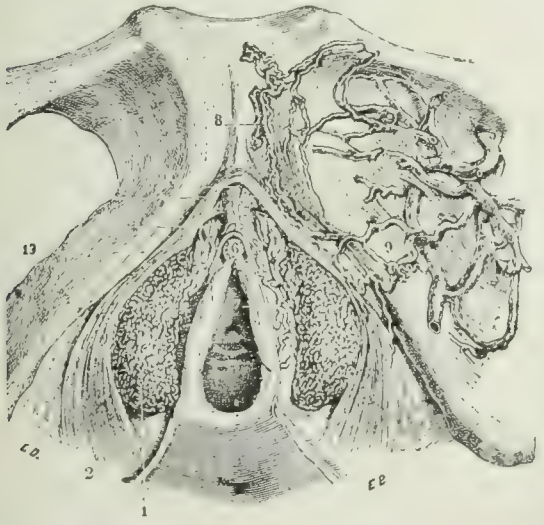

Fig. 4268.—The Bulb of the Vagina with the Venous System of the Clitoris, Viewed from in front. (After Kobelt.) 1, Bulb; 2 constrictor muscle; 6, glans of clitoris; 9, communication with the obturator veins; 13, cavernous body.

differs from the male perineum in being perforated in the median line by the vulvovaginal opening. This opening occupies the place in the female which in the male is the situation of the bulb. In the female this bulb is, as it were, divided into two halves, as is also the muscle covering it. The space between the divided bulb is the opening of the vagina. The *vagina* extends upward and backward between the bladder and rectum, its upper part being covered by peritoneum, and thus it is in close relation with the peritoneal cavity.

The *triangular ligament* is also divided into two halves, and on this divided ligament rests the divided bulb, the vagina passing between. So we have a bulb which is called the "vestibular bulb" on each side of the vagina, and these bulbs are joined above by a small plexus of vessels called the "pars intermedia." The bulbs are covered by the sphincter vaginæ muscle (bulbocavernosus). This is the homologue of the fused *bulbocavernosus* muscle in the male. We also see the anterior fibers of the levator ani muscle embracing the vagina as they do the prostate gland in the male.

The *superficial fascia* and *Colles' fascia* have the same attachments as in the male, but differ in being perforated by the vagina.

The glands of Bartholin and Duverney are situated on each side of the commencement of the vagina behind the triangular ligament, and correspond to Cowper's glands in the male. Their ducts open on each side between the hymen and labium minus. It is not uncommon to have abscesses connected with these glands, to cure which they have to be dissected out.

The *clitoris* and nymphæ correspond to the penis in the male. The clitoris is composed of two corpora cavernosa and a rudimentary glans. It is much smaller than the penis, and is not perforated by the urethra. The corpora cavernosa are attached to the inner side of the pubic arch in front of the triangular ligament, and, as in the male, are covered by a muscle, the ischiocavernosus (erector clitoridis). The glans is surrounded by a membranous fold, which is the homologue of the prepuce in the male.

The *vulvar cleft* opens on the surface between the two labia majora; anteriorly opening into this cleft is the urethra, and posteriorly is a recess called the fossa navicularis, and in the center is the vagina. The space anteriorly between the clitoris and the urethra is called the vestibule, and this is bounded on each side by a labium minus.

The *labia majora* are two thick folds of skin covered with hair and united in front to form the mons veneris. In each labium are blood-vessels and dartous tissue as in the scrotum of the male, of which they are the homologue. The vestibule corresponds to the lower prostatic and membranous portion of the urethra in the male.

On separating the labia majora the nymphæ or labia minora are seen. These are folds of skin which are continuous above with the prepuce of the clitoris and below join the *labia majora* about the center. As a rule, they do not project beyond the labia majora, but in the dark races they are of larger size and project considerably beyond the vulvar cleft. In old age they are also more prominent.

The *hymen* is a thin fold of mucous membrane of various forms, which partially occludes the vaginal orifice; in some cases the vaginal orifice is completely closed, and then we have what is called an *imperforate hymen.* Occasionally the hymen is absent or has been destroyed by inflammatory action in childhood. Its presence is not necessarily a proof of virginity nor is its absence significant of the loss of the same. When the hymen has been ruptured, and in women who have borne children, the remnants are seen as small rounded elevations called "carunculæ myrtiformes."

The vessels and nerves of the female perineum do not differ essentially from those of the male; the pudic artery is smaller, while the superficial perineal artery going to the labia is larger. Owing to the small size of the clitoris as compared with the penis, the nerves and blood-vessels supplying it are much smaller.

The perineal body, or the so-called perineum of the obstetrician, fills in the space between the vagina and the rectum; in section it is triangular in shape, with the base of the triangle downward, corresponding to the skin between the posterior part of the vagina and the anterior border of the anus. Anteriorly is the

fossa navicularis, and posteriorly is the rectum. The perineal body measures at its base about one and one-quarter inches from before backward, and laterally extends from one tuberosity to the other; in this space is the tendinous point of the perineum, to which are attached several muscles, such as the levator ani, sphincter ani, transversus perinei, and sphincter vaginæ. Laterally we have the ischiocavernosi muscles. Running across the perineal body we have

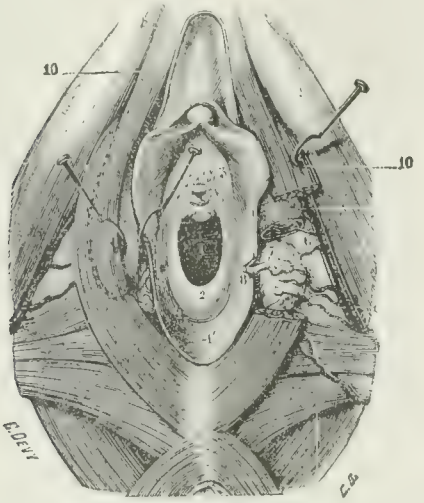

FIG. 4269.—Dissection of the Vulvovaginal Orifice with the Glands of Bartholin. 1, Orifice of vagina; 2, hymen; 3, meatus urinarius; 4, navicular fossa; 5, bulb of vagina; 6, vulvovaginal or Bartholin's glands; 7, 8, duct with opening cut through orifice of vagina; 10, constrictor vaginæ partly resected on left side to show the glands of Bartholin; 11, transversus perinei muscle.

a transverse septum which, in the female, is very strong and consists of connective tissue, yellow elastic tissue, and involuntary muscular fibers; it can be felt as a hard body when examined through the posterior commissure of the vagina. The "perineum" is a highly distensible body as is well seen in childbirth, when it is almost obliterated. Above the perineal body the vaginal and rectal walls are in apposition, loosely connected with areolar tissue. This so-called perineum is frequently torn in first labors, and if the rent be not sewed up immediately so as to enable-union by first intention to take place, the vaginal orifice will be much enlarged and the support of the perineal body be lost. Occasionally these rents extend into the rectum, and a very miserable condition results, there being partial or complete incontinence of feces. Operations undertaken for the repair of this condition are most successful even when of old standing. It is, however, much better to repair the rent as soon as possible after its occurrence.

Tearing of the perineum with general relaxation of the pelvic floor and increase in the intraabdominal pressure predispose to prolapse of the uterus. This condition is rarely seen in the nullipara or in well-to-do multipara. It is the hard-working woman, who gets up to work too soon after childbirth, in whom this condition is most frequently seen.

FRANCIS J. SHEPHERD.

Periosteum, Actinomycosis of.—Actinomycosis is rarely primary in the periosteum; but the periosteum is not infrequently involved by direct extension from actinomycotic processes in neighboring structures. Actinomycosis usually begins in soft organs or tissues, and then shows a great tendency to spread in the parosteal tissues along the jawbone, ribs, vertebræ, base of the skull, pelvic bones, etc., the bones being attacked from the outside. In primary actinomycosis of the mouth the periosteum of the jawbone is first involved, later the bone; in actinomycosis of the lungs the process may extend to the pleura and thence to the periosteum of the ribs and vertebræ. In these cases of secondary extension there occurs first an *actinomycotic periostitis* with formation of granulation tissue. This granulation tissue becomes purulent, and the bone comes to lie in a cavity filled with pus. As a result of this a superficial caries is produced and the interior of the bone becomes involved. Here the process develops more rapidly, the bone becomes rarefied and filled with granulation tissue, and expands into a honeycombed shell. Over this the periosteum may develop irregular masses or spicules of bone or thick layers of fibrous tissue but in many cases no new formation of bone occurs, in contrast to syphilis. The process is markedly destructive; in some cases a prevertebral phlegmon may extend along the entire anterior side of the spine producing extensive necrosis of the bodies of the vertebræ transverse processes and heads of the ribs. The clinical picture may be that of tuberculosis; in one case of this kind autopsied by the writer the clinical diagnosis was Pott's disease. The microscopical picture is that of a strong reactive inflammation; numerous mast and plasma cells are present. The clinical and diagnostic features are given under the head of *Actinomycosis*.

ALDRED SCOTT WARTHIN.

Periosteum, Neoplasms of.—The primary tumors of the periosteum belong wholly to the connective-tissue growths. They are both benign and malignant; the former, usually arising from the inner osteogenetic layer of the periosteum, are covered by its outer fibrous layer and cause only pressure—erosion of the bone; the latter break through the fibrous layer and invade the neighboring tissues and destructively infiltrate the bone. Occasionally both benign and malignant forms may arise from the outer layer.

Benign Neoplasms.—The *osteoma* is the most common benign growth of the periosteum, occurring usually as a circumscribed bony growth, termed an exostosis. The periosteal osteomata are classed by some writers under the general term *osteophyte;* but by others the latter term is used to indicate a very small bony growth of the periosteum. Larger, more diffuse periosteal osteomata are known as *hyperostoses*. A *circumscribed hyperostosis* differs from an exostosis in being less circumscribed and more superficial. According to their structure the periosteal osteomata may be classed as: *exostosis eburnea*, composed of hard compact bone without marrow spaces; *exostosis spongiosa*, composed of spongy bone about equally made up of bone tissue and marrow spaces; and *exostosis medullaris*, containing very large marrow spaces. The marrow in the exostoses presents the same general appearance as the bone marrow proper. According to histogenesis the periosteal exostoses may be divided into two classes: those arising from the connective tissue of the periosteum (*exostosis fibrosa*), and those of cartilaginous origin (*exostosis cartilaginea*). The former may arise either from the inner or from the outer layer of the periosteum; in the first case they are immovable (*immovable periosteal exostosis*), in the latter they are movable (*movable periosteal exostosis*). The cartilaginous exostoses may arise from a proliferation of the periost-perichondrium, usually from the epiphyseal cartilages. They occur most frequently in young children and are usually multiple. In other cases cartilage may first form from the periosteum, and this may later develop into bone. Exostoses are found most frequently on the cranial bones, the bones of the trunk, and the long bones of the lower extremities. Many of them are

not neoplasms strictly, but are hyperplasias of inflammatory origin.

Chondroma of the periosteum is of less frequent occurrence. It may develop from the inner layer (*immovable periosteal chondroma*) or from the outer layer (*movable periosteal chondroma*). They form nodular or pedunculated growths, often reaching a large size. They occur usually in the young, and are often hereditary. The cartilage may be formed from pre-existing cartilage (*epiphyseal*), or from periosteal connective tissue, or from embryonal inclusions of cartilage anlage. They occur most frequently upon the short bones of the extremities, the shoulder blades, the ribs, and the femur. They are very likely to undergo secondary changes: myxomatous degeneration, calcification, etc. They show a marked tendency toward malignancy. *Osteochondroma* of the periosteum sometimes occurs; and there is also a peculiar growth, the *osteoid chondroma*, which may reach an enormous size. It is found chiefly on the long bones of young individuals and shows a tendency to become malignant. The surface of the growth is usually smooth, the cut surface partly hyaline and transparent, partly lamellated and reticular.

Fibroma of the periosteum is rare. It occurs most frequently in the periosteum of the bones of the mouth and nose (fibroid epulis and fibroid polyps). Through excessive development of blood-vessels the growth may assume the character of a telangiectatic fibroma. It is also very likely to become calcified (*fibroma ossificans*) or to undergo myxomatous change. Malignant changes may develop.

Myxomata arise rarely from the periosteum. They are seldom pure myxomata, but present the appearance of myxochondroma, myxofibroma, myxosarcoma, etc. They form round or oval masses covered on the outside by a dense layer of fibrous tissue.

Lipomata of the periosteum are known as parosteal lipomata. They are very rare, and are nearly always congenital. They usually contain areas of striped muscle fibers. The exact nature of these growths is not yet known. They have been reported as occurring on the anterior surface of the cervical vertebræ, body of the pubis, frontal bone, scapula, etc.

Angiomata of the periosteum are very rare. They have been observed on the cranium and sternum. An ectatic condition of the blood-vessels is very common in all of the tumors arising from the periosteum.

Pseudo-cysts may be formed beneath the periosteum as the result of the liquefaction of the contents of subperiosteal hematomata or of subperiosteal tubercles or gummata.

Malignant Neoplasms.—*Sarcoma* is the most important of the primary growths of the periosteum and—next to the periosteal exostosis—of most frequent occurrence. It may occur at any age, and is quite frequent in the young, and it often arises after trauma. The periosteal sarcomata may occur in any part of the skeleton, but are more frequently seen near the ends of the long bones, particularly of the lower extremities, the lower end of the femur, and the upper end of the tibia. They may be divided into the *hard* and the *soft* forms. The soft growths show a variegated surface, and usually contain areas of softening and extravasation; the firmer whitish portions of the growth may be homogeneous or fibrous. The harder growths are usually whitish, and present a more or less fibrous, radiating surface. As a rule, the growths are more or less nodular. Originating in the majority of cases from the inner layer of the periosteum, the growth assumes a more or less spindle shape and tends to extend transversely and to surround the bone. Later, it breaks through the periosteum and invades the soft tissues adjacent.

Microscopically, the periosteal sarcomata represent nearly every form of sarcoma; round cell, spindle cell, polymorphous cell, giant cell, alveolar forms, fibrosarcoma, osteosarcoma, osteoid sarcoma, chondrosarcoma, osteochondrosarcoma, myxosarcoma, angiosarcoma, and numerous combination forms. The most common variety is the spindle-cell form containing bone or osteoid tissue. The most cellular, and consequently the softest forms, are the most malignant. The malignancy of the different varieties varies somewhat with the location. The giant-cell epulis of the jaw is of relatively slight malignancy, but a growth of the same structure on the long bones is much more malignant. The hard fibrosarcoma, and the osteo-, chondro-, and osteoid sarcoma, often show relatively slow growth and but little tendency to set up metastases; but under certain conditions any one of these forms may take on an increased malignancy. Metastases of periosteal sarcomata usually appear first in the lungs, later in the lymph glands, and finally in any part of the body. The metastases are frequently of a softer and more cellular nature than the primary, but may develop bone or osteoid tissue or even cartilage.

As the result of the growth of the periosteal tumor the bone may become infiltrated and rarefied, and in some cases undergo spontaneous fracture; or in other cases there is set up, in the neighborhood of the tumor, an ossifying osteomyelitis which leads to the most marked sclerosis of the bone. New bone is very frequently formed in the sarcoma, particularly next to the old bone upon which the tumor rests, so that the latter seems to spring from an osseous base. In other cases trabeculæ or delicate spicules of bone may be formed in a radiating manner through the tumor mass, or irregular bony masses or spicules may be scattered through it (ossifying sarcoma or osteosarcoma). The degeneration of portions of the growth, as is commonly seen in the softer varieties, may lead to cyst formation, or to ulceration, abscess formation or gangrene, as the result of secondary infection. Large hematomata may result from hemorrhage into the tumor. With the exception of the epulis and the hardest forms, sarcoma of the periosteum usually runs a malignant course. The growths show a great tendency to recur after operation, and as a rule they give rise to metastases. The latter usually do not take place as long as the neoplasm is confined to the periosteum; but when this is broken through and the muscle infiltrated the lungs and lymph nodes soon become the seat of metastatic nodules.

Chloroma.—Leucemic and chloromatous hyperplasias of the bone marrow may invade the periosteum and parosteal tissues forming flattened whitish or greenish lymphoid or myeloid thickenings. The periosteum and parosteal tissues of the orbital bones, vertebræ and underside of the sternum are most frequently the seat of such leucemic infiltrations. The bones are rarefied, and the leucemic marrow breaks through the cortical portion into the periosteum and thence infiltrates the parosteal tissues.

Secondary tumors of the periosteum are not infrequent; both sarcoma and carcinoma may invade the periosteum from primary growths of neighboring structures or flattened, circumscribed periosteal metastases of either may be found in advanced cases with more or less general metastasis. Secondary carcinoma is the more frequent. Caries and secondary involvement of the bone may result. An ossifying periostitis is almost always set up, so that the secondary tumors come to be more or less surrounded by newly formed bone, or contain irregular bony masses or spicules.

ALDRED SCOTT WARTHIN.

Periosteum, Tuberculosis of.—Primary tuberculosis of the periosteum is regarded by most writers as a very rare condition; but it probably is of not infrequent occurrence. Though the majority of cases of primary tuberculosis of the bones are of myelogenous origin, there can be little doubt that numerous cases begin as a *tuberculous periostitis* (*periostitis tuberculosa*).

The ribs are most frequently involved; next to these the bones of the face, wrist, and ankle. The process begins with the formation of a granulation tissue beneath the inner layer of the periosteum. This often shows but little tendency to caseate, but often becomes ossified. In other cases the tuberculous granulation tissue quickly caseates and becomes purulent, destroying the inner layer of the periosteum so that no new bone is formed. Under the tuberculous area there is a peripheral caries of the bone, leading to roughening of the surface of the bone and ultimately to involvement of the subperiosteal marrow spaces. Small tubercles are found in the early stages, but the process shows a great tendency to self-healing through the formation of bone (ossifying periostitis). As a result of such healing, exostoses or hyperostoses are formed. In other cases the process may break through the periosteum and a tuberculous sinus or a "cold abscess" may be formed; or in some cases the bone becomes extensively involved, and the clinical picture becomes that of a bone tuberculosis. Superficial caries occurs as the result of a pure tuberculous periostitis rather frequently upon the zygoma and lower margin of the orbit, owing to the rapid suppuration of the tuberculous granulation tissue. As in the case of gummatous periostitis, pseudo-cysts may be formed by the liquefaction of encapsulated caseous areas. The cyst wall may be bony. Secondary tuberculosis of the periosteum is very common in connection with bone or joint tuberculosis.

ALDRED SCOTT WARTHIN.

Peritoneum, New Growths of.—Primary tumors of the peritoneum are relatively rare; secondary involvement by malignant tumors, which are primary in some one of the abdominal or pelvic organs, is on the other hand of very frequent occurrence. Further, tumors which are primary in the retroperitoneal tissues are to be placed in a separate class from those which are primary in the tissues of the peritoneum proper, that is, which develop either from the endothelium or from its basement membrane.

Primary Peritoneal Growths.—These are of slight clinical importance owing to their rarity. The most important of the primary growths of the peritoneum is the so-called *endothelioma*, often called *endothelioma carcinomatosum* or *endothelial cancer*. The nature of this neoplasm is not yet settled. By some writers it is spoken of as *primary carcinoma* of the peritoneum, but the latter usage is confusing and should be avoided. The designation primary carcinoma of the peritoneum should be applied only to those rare carcinomata of the peritoneum which arise from the columnar epithelial cells of embryonal inclusions of intestinal anlage. Some writers believe it to arise from the endothelium of the lymphatics; others hold that it takes its origin from the surface mesothelium of the peritoneum. The presence of mucous cells in some cases has been taken as evidence of its epithelial origin. It forms multiple flat plaques or flattened nodules, which are more or less confluent or bound together by flattened cords or strands. Rarely the nodules may be larger and more elevated. About the larger plaques there are often seen numerous minute flattened nodules, solitary or becoming confluent into little groups. The color is usually white and the consistency soft; in some cases it is hard and firm (endothelioma fibrosum). The peritoneum about the plaques is more or less thickened. In many of the nodules a yellowish caseous center is present, the appearances closely resembling small caseating tubercles. A serous or serofibrinous exudate, usually hemorrhagic, is often present in the early stages; in the advanced stages it is invariably so. Microscopically the flattened tumors are found to consist of a firm connective-tissue stroma enclosing cords and strands of cells, which are often low columnar, and arranged upon a basement membrane after the manner of gland cells; so that the tumor possesses a distinctly *tubular* character. In many of the tubule-like cords an apparent lumen may be seen. The surface endothelium is usually absent over the larger plaques and nodules, but over the small ones it may be greatly thickened, forming a layer consisting of many strata of cells. Simple necrosis and caseous necrosis are found throughout the larger growths, and occasionally there is a mucoid change. The vascular supply is usually rich. The cells of the tumor appear to rise both from the surface endothelium and from the endothelium of the lymph spaces and vessels (*endothelioma lymphangiomatosum*). The anastomosing cords and strands follow the lymphatics. Metastasis into the solid organs is rare; secondaries when found occur in the pleura, dura mater, or other serous membranes. The pleura may be involved by direct extension. The growth is identical in structure with the flat tubular endothelioma of the other serous membranes; and it should be borne in mind that the peritoneal growths may be the result of direct extension from the pleura or they may be metastatic. The writer has seen one case in which the peritoneum, pleura, and dura seemed equally involved; and the only apparent reason for assigning the primary origin to the peritoneum was the greater area involved in the case of this membrane.

Primary angiosarcoma of the peritoneum occurs very rarely. It may develop as a plexiform angiosarcoma, consisting of newly formed blood-vessels, whose walls proliferate and form cylindrical masses of cells. Myxomatous change is not infrequent in these growths (*myxoangiosarcoma*), and under such conditions the tumor may be mistaken for a colloid carcinoma. In other cases the sarcoma may show the structure of a *perithelioma*. Kaufmann describes a case in which the entire peritoneum was covered with small warty or flattened nodules of grayish-red color and very vascular. Ascites was present, and the surface of the growths was covered with a thick fibrinous exudate.

Primary carcinoma of the peritoneum is of very rare occurrence and the reported cases have not been clearly differentiated from the so-called endothelioma. It is, therefore, a dubious class of neoplasm. The cases observed have been of a cylindrical-cell variety, with mucoid change (colloid carcinoma), and the growth advanced diffusely over the peritoneum. According to Birch-Hirschfeld the origin of these growths is from the epithelium of embryonal "rests" of intestinal anlage.

Primary benign tumors of the peritoneum are rare. *Lipoma, fibroma, neurofibroma, myxoma,* and *chylangioma* have been observed. The lipomata arise chiefly as tumor-like hyperplasias of the epiploic appendices or from the omentum. The cases of fibromata and myxomata reported as arising in the peritoneum are of somewhat doubtful nature. Inflammatory hyperplasias of connective tissue may have been mistaken for neoplasms. The majority of the benign growths undoubtedly arise in the retroperitoneal tissues. Polypoid lipomata of the peritoneum may become freed through tearing of their pedicles; as free bodies they are likely to become calcified.

Mesenterial cysts (*chyle cysts, cystic lymphangiomata*) are of rare occurrence. They form bladder-like, thin-walled cysts, which often reach a large size, holding several liters of fluid. The intestines may be adherent to the anterior surface of the cyst, and thus give rise to percussion signs of an area of tympanitic dulness passing over an area of absolute dulness.

Enterocystomata arising from remains of the omphalomesenteric duct are of very rare occurrence. They may be of large size, and are lined with columnar cells. *Mesothelial cysts* are common in the broad ligament and in connection with tubes and ovaries. Other peritoneal cysts may arise from snared-off

portions of the peritoneal cavity, from intraperitoneal lung anlage, or from retroperitoneal cystic teratomata related in origin to those of the ovary and testis.

Decidua-like proliferations of the peritoneum occur during pregnancy. They are usually confined to the pelvis, but may spread over a larger part of the peritoneum. After delivery they undergo resolution and become calcified.

Secondary Growths.—Secondary carcinoma of the peritoneum is of very frequent occurrence. The primary is most often located in the stomach, pancreas, gall-bladder, intestine, testis, ovary, or uterus. The peritoneum may be involved *by contiguity, by continuity,* or *by metastasis.* In the latter case a *dissemination* or *implantation metastasis* may occur over the entire peritoneum; the deeper parts, the pelvis, flanks, and root of mesentery, showing the most extensive growth. The dissemination of the growth is aided by the accompanying ascites, which is often very great. This may be secondary to the development of the carcinoma, or it may occur before the latter. It is usually hemorrhagic in character. In some cases the development of the peritoneal secondaries is very rapid, partaking of the nature of an inflammatory process, and giving the clinical picture of a peritonitis (*peritonitis carcinomatosa*); or in other cases the secondaries may form scattered or confluent nodules (*carcinosis peritonei*). When many cancer cells enter the peritoneal cavity in a short time and grow quickly, the peritoneum may present the appearances of a miliary carcinomatosis, which may closely resemble miliary tuberculosis of the peritoneum except for the absence of caseation. In the latter case ascites may or may not be present; in the former it is always present to a greater or less extent. The nodular and the diffuse forms pass into each other without sharply defining lines. The omentum and root of mesentery are often changed into a thick, hard mass which may show marked contractions.

The general characteristics of secondary carcinoma of the peritoneum depend upon the nature of the primary growth. *Adenocarcinoma* forms usually nodular peritoneal metastases; they are chiefly located on the undersurface of the diaphragm, in the flanks, pelvis, and omentum. The nodules are white, soft, often showing mucoid change. The arrangement along the lymphatics is often very striking. Confluence of the nodules gives rise to flattened warty masses. *Medullary* carcinoma forms soft nodules of large size, showing necrosis, umbilication, hemorrhage, etc. The metastases of this variety into the peritoneum are less common than are those of the other forms. *Scirrhous* carcinoma forms a diffuse fibroid thickening of the entire peritoneum, accompanied by peritonitis which often covers up the appearances belonging to the new growth. The small intestines may be contracted into a hard mass not larger than the fist. The appearances are those of a chronic fibroid peritonitis rather than of a new growth, and the condition is often mistaken for the same. On section the thickened serosa is hyaline, hard, and tendon-like. In all cases in which such fibroid change of the peritoneum is found, the lymph glands should be carefully examined for metastases, secondary scirrhus being more easily recognized in the lymph glands than in other structures. The pylorus, gall-bladder, and prostate should be thoroughly examined for the primary, which may be of insignificant size. The diffuse *mucoid* or *colloid carcinoma,* which is usually primary in the stomach, gall-bladder, or testis, produces very marked and characteristic appearances in the peritoneal cavity—particularly in the omentum and in the neighborhood of the stomach. The entire peritoneum may be infiltrated. The serosa, in particular of the omentum, is greatly thickened, covered with glassy, translucent, yellowish or yellowish-red masses containing mucin. The omentum may be changed into a thick, homogeneous mass, through which run strands and fibers of connective tissue enclosing the colloid substance (honeycomb appearance). The smaller, younger nodules may be white, opaque, and firmer. The *cystocarcinoma* of the ovary or testis may give rise to extensive peritoneal metastases, the entire surface of the membrane being sometimes composed of cysts filled with a mucoid substance. The peritoneal cavity may become entirely filled with a colloid-like mass. *Psammocarcinoma* of the ovary may give rise to peritoneal metastases, containing calcareous masses.

Secondary sarcoma of the peritoneum is more rare; melanotic sarcoma, myxosarcoma, lymphosarcoma, osteosarcoma, chondrosarcoma, spindle-cell sarcoma, and angiosarcoma have been reported. In metastatic melanosarcoma of the peritoneum the metastases may be so numerous as to give it a chocolate color.

Primary cystadenoma of the ovary may give rise to implantation metastases or may involve the peritoneum by continuity, spreading first over the broad ligament and then over the peritoneum. In the case of the *papilliferous cystadenoma* or *surface papilloma* of the ovary, portions of papillæ may be broken off and transported by gravity, peristalsis, or movement of ascitic fluid, and may develop over the peritoneum, wherever they may lodge. Rupture of an ovarian cystadenoma may lead to the covering of the peritoneum with mucoid or colloid material, which, becoming partially organized, gives rise to the condition known as *pseudo-myxoma peritonei.* This is not of the nature of a neoplasm, but represents a reaction on the part of the peritoneum, tending to organize the foreign substance spread over its surface. If in the colloid or mucoid substance living epithelium or portions of papillæ are transported, these may grow and form benign growths which later may become malignant. As a rule, such transported epithelium usually dies or forms small cysts which remain stationary after reaching a certain size.

Transplantation Metastasis.—In puncture for the relief of ascites or in operations for the removal of malignant tumors, abdominal metastases may be set up in the puncture or in the seat of surgical wounds (*inoculation metastases*).

Dermoid cysts and *teratomata* occur in the peritoneum of the pelvis, in the mesentery, and in the omentum. In the latter case a primary tumor of the ovary may become adherent to the omentum and later lose its connection with the former organ.

Pseudo-cysts arise from collections of exudate between peritoneal adhesions.

Primary retroperitoneal tumors are much more frequent than those primary in the peritoneum. *Lipomata* of large size (sixty-three pounds) have been reported. They may be mistaken for ovarian cysts. It is important to note that the retroperitoneal lipoma forms an elastic, fluctuating tumor, from which on aspiration no fluid can be drawn (pseudo-fluctuation). *Myxolipoma, fibroma, myxoma, fibrosarcoma, myxosarcoma,* and *angiosarcoma* of the retroperitoneal region have been described. The writer has seen a round-cell sarcoma, apparently primary in the retroperitoneal tissue, weighing eighty pounds. The retroperitoneal organs were not directly involved and showed only changes due to pressure. Secondary malignant tumors in the retroperitoneal lymph glands are of frequent occurrence in carcinoma of the uterus, etc. (See also *Omentum.*)

Pseudomyxoma.—The occurrence of free mucoid or colloid-like material within the peritoneal cavity, as the result of the rupture of an ovarian cyst or cystadenoma, or of the direct secretion of a neoplasm into the cavity, gives rise to a reactive proliferation of the peritoneal surfaces covered by such substance and the more or less complete organization of the latter. As a result of such partial organization the peritoneal surface is found

to be covered with a jelly-like layer containing blood-vessels and strands of connective tissue, closely resembling myxomatous tissue.

The gross appearances vary with the amount of colloid or mucoid material lying on the peritoneal surfaces, and with the degree of organization. In the very early stages the surfaces of the peritoneum are covered with a jelly-like substance of varying thickness, which is easily scraped off, or may even be scooped out of the peritoneal cavity owing to the fact that it lies free therein. If organization has begun, the portion of the colloid material lying next to the peritoneum is not so easily scraped away, appears more opaque, and contains minute vessels, as shown by the fine red lines running through it. The peritoneal surface has therefore a reddish, roughened appearance, and is covered with fine whitish or reddish strands enclosing jelly-like colloid substance. As organization progresses there is developed above the peritoneal surface a zone of fibroblastic tissue which in time becomes changed into fibrous connective tissue, so that the peritoneum becomes greatly thickened, the condition resembling that of a chronic fibroid peritonitis. If the amount of colloid material scattered over the peritoneum is small, it may be completely organized and the peritoneum become more or less thickened. On the other hand, a thick layer of colloid (several inches) is but slowly absorbed and organized, and may remain in the abdomen for a long time with but little change except where it comes into contact with the peritoneal surfaces. The reaction on the part of the peritoneum appears to vary greatly; in some cases it occurs immediately, in others it may be delayed for a long time.

Microscopically, sections cut through the peritoneum and the overlying mass of colloid show a fibroblastic proliferation of the subendothelial layer of the peritoneum, a wandering of fibroblasts into the colloid, and the formation of new blood-vessels which run out into the colloid substance. As organization progresses interlacing strands of connective tissue supporting blood-vessels are formed throughout the colloid substance, enclosing between them masses of the jelly material which have not yet been absorbed. These give the tissue an appearance resembling myxomatous tissue, even under the microscope. It is easily seen, however, that the structure is not that of a true myxomatous tissue, but represents an organization of a jelly-like foreign substance. All stages of organization may sometimes be seen in the same case.

Localized pseudomyxoma occurs when, from the rupture of a small ovarian cyst or cystoma, a small mass of mucoid substance is distributed in small portions over the peritoneal surface. These show the same stages of organization, hyaline change, etc., and finally come to represent localized thickenings of the peritoneum. This condition occurs most frequently in the pelvis.

Small cysts lined with hypertrophic endothelium may also be found in the pseudomyxomatous tissue of the peritoneal covering. These are probably derived from the remains of the surface endothelium. It is also within the range of possibility that these may form centers for the formation of a new growth of malignant character.

Pseudo-myxoma of the peritoneum is not in all cases formed by the rupture and discharge into the peritoneal cavity of an ovarian tumor containing mucoid or colloid material. Surface papillomata of the ovary may secrete such material directly into the peritoneal cavity; further, cystic carcinomata of the stomach, intestines, or testicles may give rise to the presence of mucoid or colloid substance in the peritoneal cavity, either from rupture of the primary or from secondaries located in the peritoneum. In the great majority of cases, however, the mucoid or colloid substance comes from the rupture of a large ovarian multilocular cystoma, in which one chamber has been developed at the expense of the others; or from a primary unilocular cystoma. If the cyst contents are of a thin serous character they may be absorbed by the peritoneum without the production of peritoneal proliferation. The more jelly-like or colloid the contents the more likely the occurrence of pseudomyxoma. In order to excite peritoneal proliferation the substance must be of a fairly firm consistency and not easily absorbed. Pseudo-mucin may or may not be present in the cyst contents, but in the majority of cases it is a pseudo-mucin cyst that ruptures. The jelly-like material of the pseudomyxomatous tissue may give both mucin and pseudomucin reactions.

The *prognosis* in pseudo-myxoma is not necessarily bad. Large masses of colloid material may be kept within the peritoneal cavity for a long time without especial symptoms. Small amounts may be completely absorbed and organized, and the resulting condition of the peritoneum may give rise to the same sequelæ as those which follow chronic adhesive peritonitis. Recurrence following operation takes place when the primary tumor or the metastases which produce the mucoid or colloid are not removed; or when the implantation metastases become active, and either burst or secrete into the cavity. Recurrence is much more likely to take place in the case of papilliferous growths.

Treatment.—In operations for the relief of pseudomyxoma after the rupture of ovarian cysts, it should be borne in mind that the peritoneum, after the removal of the overlying colloid material, represents a more or less denuded, hyperemic surface, through which infection may easily take place, giving rise to a fibrinopurulent peritonitis. The general resistance of the peritoneum appears to be lowered as the result of the presence of the foreign substance in the cavity. The danger that a malignant growth will arise from the implantation metastases is not very great in the case of a simple multilocular cystoma, but in the case of a papilliferous cystoma the danger of such an occurrence is much greater. Such metastases may occur in the operation wound. On the whole, the safest procedure is to operate as soon as possible after the rupture of the cyst, before organization has begun. A more or less marked ascites, which complicates the diagnosis, is often associated with pseudomyxoma; this is particularly true in the case of associated infection. It may occur, however, as the result of the irritation produced by the presence of the foreign body. ALDRED SCOTT WARTHIN.

Peritonitis.—The peritoneum is a thin membrane of connective tissue extremely rich in blood-vessels and lymphatics, and is covered by a single layer of flattened endothelial (mesothelial) cells (often called epithelial). Over the ovaries and about the mouths of the tubes they are more cuboidal in shape. These cells are chiefly polygonal, but the cell outlines are often very irregular, serrate, or wavy. By treatment with silver nitrate or by *intra vitam* staining with methylene blue, the cement lines between the cells can be made out; and by especial methods of technique the so-called intercellular protoplasmic bridges connecting the cells may be demonstrated. The connective-tissue layer consists of an interlacing network of fibrous connective-tissue bundles, fat cells, numerous elastic fibers, and connective-tissue cells. Unstriped muscle cells are found in the region of the pelvis and female adnexa. Through this there runs a very abundant capillary and lymphatic network having a free anastomosis. Some writers regard the endothelial lining of the lymph spaces of the peritoneal basement membrane as continuous with the lining of the peritoneal cavity. This is not the case, however,

and the mesothelial cells form an unbroken layer over both the blood and the lymphatic vessels, the processes of absorption and secretion being carried on through the two layers of cells, endothelial and mesothelial. The peritoneal surfaces are normally moist, shining and translucent; the amount of fluid normally in the cavity varies from a few drops to 1 to 3 c.c. The absorption capacity of the peritoneal surface is very great, being fully equal, in the case of experiments with certain poisons, to that of direct intravenous injections. Gases, fluids, and even morphological elements may be quickly removed from the peritoneal cavity, chiefly through the lymphatics of the diaphragm and omentum to the anterior mediastinal glands, and through the portal veins. On the other hand, the secretory activity of the immense vascular surface of the peritoneum is very great, and in disturbances of the vascular secretion an immense amount of exudate may pass through the peritoneum into the peritoneal cavity. The endothelial and connective-tissue cells of the basement membrane respond very quickly to "irritation" of any kind, and fibroblastic activity is set up more quickly in the peritoneum than anywhere else in the body. The movements of suspended particles in peritoneal fluids are essentially toward the diaphragm, although gravity plays an important part in determining the sinking of such particles, so that a large proportion of such particles (bacteria, tumor cells, etc.) may drop upon the pelvic surface. The course of peritoneal inflammations is considerably modified by these factors.

Postmortem changes in the peritoneum are frequently mistaken for evidences of disease. One of the most common mistakes of this kind is the misinterpretation of the postmortem or agonal increase of the peritoneal fluid which occurs especially in the new-born. Several hours after death postmortal maceration of the peritoneal epithelium occurs, the fluid becomes cloudy, and gelatinous translucent flocculi may be formed. Later diffusion of bile from the gall-bladder and of blood pigment from the hypostatic vessels gives the fluid and peritoneal surface a yellowish, rusty, green, gray, or black color.

The peritoneum lines the entire abdominal cavity, and is reflected over the organs contained within it. Over the organs it forms the serous coat or capsule (*tunica serosa*). Its superficial area is but little less than that of the skin. The membrane is attached to the underlying parts by a subserous coat of adipose tissue, connective-tissue bands and elastic fibers. Over the organs the subserosa is but slightly developed. The anatomical relations of the peritoneum to the abdominal wall, its investiture of the abdominal organs, the intimate relations of the peritoneal cavity to the female genital tract, etc., in connection with its very vascular structure, peculiarly predispose this membrane to the occurrence of inflammatory processes. Such a predisposition is shown by the fact that peritonitis is one of the most common and important clinical conditions. It is also one of the most serious. The high mortality of acute general peritonitis makes it one of the most dreaded affections. Even in these days of aseptic surgery when so many operative procedures have been divested of their chief dangers, peritonitis still remains to the abdominal surgeon and gynecologist one of the complications most feared and most carefully to be avoided.

The occurrence of peritonitis is not dependent upon climatic, seasonal, or meterorological influences. Females are more frequently affected than males, this fact being dependent upon the important rôle which diseases of the female genital tract play in the causation of peritonitis. It is therefore seen more often during the years of sexual activity, but may occur at any age. It is of not infrequent occurrence in young children. The relation of peritonitis as a complication to many of the acute infections makes its occurrence to a certain degree associated with epidemics of these diseases. Alcohol is regarded as a predisposing factor.

Etiology.—Peritonitis may be *primary* or *secondary*. *Primary* peritonitis is, if we except the surgical form, of much more rare occurrence than the secondary. It is usually *traumatic*, more rarely, *idiopathic*, *spontaneous*, or *rheumatic*.

Traumatic peritonitis is most commonly due to perforating wounds of the abdomen. Abdominal injuries in which the wall is not penetrated rarely, if ever, directly cause peritonitis. Nevertheless, blows, kicks, falls, etc., are often adduced as causes of peritonitis. The more severe the injury, the more likely is the occurrence of peritonitis. Hemorrhage into the peritoneal cavity is usually followed by inflammation of the peritoneum. Likewise, trauma may indirectly cause peritonitis through the perforation, laceration, tearing, or bruising of the stomach or intestines, rupture of the gall-bladder, pancreatic duct, urinary bladder, etc., these lesions permitting the entrance of microorganisms into the peritoneal cavity. The perforation of the esophagus or stomach by the careless passage of a sound or stomach tube may also be a causal factor in the production of peritonitis.

Operative or *surgical* peritonitis may be mentioned in this connection. Before the days of antisepsis and asepsis a large proportion of laparotomies were fatal from the peritonitis following the operation. The vast improvement in surgical technique has, however, greatly reduced the number of cases of postoperative peritonitis, and in certain operations in which there is, with proper methods, no opportunity for infection the peritoneal cavity is opened with a certain degree of impunity. Surgical peritonitis is due to the introduction of bacteria into the peritoneal cavity. But not all bacteria which gain an entrance into the peritoneal cavity set up an inflammation there. It has been shown experimentally that rather large quantities even of pus cocci, may be introduced into the peritoneal cavity of animals without causing peritonitis, the bacteria entirely disappearing after a short time. The presence of a tissue lesion, even though very slight, or the simultaneous introduction into the cavity of irritating substances, furnishes the conditions requisite for the growth of the bacteria and for the production of an inflammation. The peritoneum therefore when uninjured must possess a certain protective power against bacteria. This resistance is found to be lowered in the case of hemorrhage into the cavity, trauma, drying of the peritoneal surface, excessive heat, cold, after the removal of ascitic fluid, and in cases of pseudomyxoma peritonei. The general condition of the body, conditions of intoxication, cachexia, etc., also play a rôle of importance. Fatal peritonitis may follow the tapping of the abdomen in ascites, the small number of bacteria introduced by means of a septic trocar being sufficient to overcome the lessened resistance. When modern methods of asepsis are properly carried out the dangers of surgical peritonitis are relatively slight in all cases in which the contamination of the peritoneum with septic material can be avoided. Even when this contamination does occur, the modern procedures of thorough irrigation have greatly reduced the chances of infection.

The existence of a *peritonitis rheumatica* (*refrigeratoria*) has been denied by many writers. While the effects of cold as a factor in the etiology of peritonitis were formerly greatly exaggerated, there can be no doubt, from the large number of observations made by reputable clinicians, that attacks of peritonitis may follow the sudden chilling of the overheated body, prolonged exposure to cold or wet, lying upon the cold damp ground, etc. The effects of such chilling of the body are especially noticeable when

the abdominal vessels are overfilled with blood (*physiological congestion*). In women, particularly in girls at the time of puberty, a wetting or chilling of the body at the menstrual period is not infrequently followed by peritonitis. In all of these cases the effect of the refrigeration is not directly to excite the peritonitis, but to render the membrane less resistant to infection. The chilling plays the same rôle here as in the case of the mucous membranes. Diplococci have been demonstrated in the exudate of cases of so-called rheumatic peritonitis; and it is very probable that all such cases are infections following and dependent upon a lessened resistance of the body.

Cases of *idiopathic* or *spontaneous* peritonitis have also been reported clinically. The autopsy findings in such cases show the presence of an infection proceeding from the female genital tract, the appendix, or some other of the abdominal organs. Such cases occur most frequently in females and in very young persons. In the former the infection is nearly always secondary to some unsuspected condition of the internal genitals. The gonococcus plays an important rôle in such cases, particularly in young girls. In young boys cases of apparent spontaneous peritonitis are usually found to be due to appendicitis. Further, spontaneous cases of peritonitis have been found at autopsy to be ambulatory typhoid, acute tuberculosis of the peritoneum, etc. On the whole it may be said that the existence of a true idiopathic peritonitis, while probable, has not yet been definitely demonstrated. A *cryptogenic hematogenous* infection of the peritoneum is of course possible and certainly occurs in tuberculous peritonitis, but is of much less frequent occurrence in the case of the pyogenic organisms.

Likewise the existence of a toxic peritonitis, though assumed by some writers, has not been demonstrated. The injection of poisons (turpentine, croton oil, silver nitrate, etc.) into the peritoneal cavity will cause an acute peritonitis, but the occurrence of a peritonitis in man due to the action of irritant poisons is of very rare occurrence (perforation of stomach or intestine, operative accidents, etc.). The occurrence of so-called *nephritic* or *uremic* peritonitis seen in the late stages of Bright's disease, arteriosclerosis, cancer, chronic valvular lesions, etc., is to be regarded as of the nature of a terminal infection, and similar to the pericarditis and pleuritis occurring in the same disease. The occurrence of peritonitis in association with or following various forms of intoxication is to be explained in the same way as the rheumatic—the lessened resistance of the body tissues and the pathological alterations of the body juices predispose to infection.

Since primary inflammations of the pericardium and pleura are of relatively more frequent occurrence, the greater rarity of primary peritonitis may be explained by the assumption that the peritoneum possesses a greater resistance and protective power than the other serous membranes. This relative greater immunity of the peritoneal cavity has been demonstrated experimentally.

Secondary Peritonitis.—Writers upon the subject of peritonitis are not agreed in their conceptions of primary and secondary peritonitis. In a very broad sense the term primary may be applied to those forms which are not secondary to, or do not occur in association with, any other acute or chronic disease, hence not metastatic; and, further, which do not arise by contiguity from any of the organs of structures covered by the peritoneum. Terminal infections should then be classed as secondary rather than as primary. A number of writers, however, make a much narrower application of the term *secondary* as applying to peritonitis. According to Flexner, by *secondary* peritonitis we should understand those conditions which follow operations upon the peritoneum or the contiguous viscera, and those in which the peritoneum becomes inflamed through the mediation of disease-contained viscera. By *primary* peritonitis should be understood an inflammation, usually diffuse, of the serous cavity, occurring without the mediation of any of the contained organs and independently of any surgical operation upon these parts. The microorganisms causing the inflammation may be brought by the blood or lymph current or may pass through the intact intestinal wall. Flexner would therefore class as primary not only the terminal infections of the peritoneum occurring in the course of chronic diseases, but also those forms of metastatic peritonitis in which the microorganisms come through the blood or lymph without the mediation of some diseased organ or part. Since such a classification may be confusing, the writer has preferred to adhere to the more commonly accepted use of the terms as given above. Inasmuch as cases of primary peritonitis are rare, and as the peritoneum possesses a normal resistance against pathogenic microorganisms, the great majority of cases of peritonitis are secondary to infectious processes in the organs which it covers and protects. In the great number of cases secondary peritonitis arises through an *extension* of an inflammatory process from some contiguous viscus or part.

Perforative Peritonitis.—This is the most common form of secondary peritonitis. It may result from the perforation into the peritoneal cavity of an infected wound of the abdominal wall or of a viscus (traumatic or operative), or from the perforation, as the result of inflammatory processes, of the wall of the stomach, intestine, gall-bladder, pancreatic duct, urinary bladder, uterus, tubes, blood-vessels, lymph vessels, etc. Abscesses of the abdominal viscera, echinococcus cysts, tumors, burrowing suppurative processes in the retroperitoneal tissues, etc., may also give rise to perforative peritonitis.

In the case of perforative peritonitis there will be found in the peritoneal cavity, in addition to the inflammatory exudate, various substances of very different nature according to the location of the perforation and the character of the contents of the cavity communicating with the peritoneal sac. According to the character and amount of the substances thus entering the cavity, and according to the character and amount of the peritoneal exudate the appearances seen at operation or autopsy will differ greatly.

Some writers distinguish a *secondary perforative peritonitis*, grouping under this head those conditions in which the exudate of a purulent peritonitis, originally not perforative, gains entrance to some neighboring organ, and through it finds an exit, as, for example, through the stomach, intestine, pleura, abdominal wall, etc. Such cases should more properly be styled *perforating peritonitis.*

Peritonitis Arising by Contiguity.—Peritonitis may arise secondarily by the direct extension of inflammation caused primarily by wounds (operative or traumatic) of the abdominal or pelvic wall, gastric ulcer, or cancer, phlegmonous or toxic gastritis, intestinal ulceration, new growths of the intestine, coprostasis, etc. In the case of inflammatory processes in the pleural cavity (tuberculosis, empyema, etc.) the peritoneum is not infrequently involved, inasmuch as the lymph vessels of the diaphragm form a direct connection between the pleural and peritoneal cavities.

Next to the gastrointestinal tract the *female genital tract* is the most frequent source of peritoneal infection. In women genital peritonitis is by far the most common form of the affection. During the puerperium or as the result of attempts at abortion, operative procedures, intrauterine injections, etc., the genital tract may be directly infected; less frequently the infection occurs at other times, as for instance at the menstrual period. Gonorrhea of

the female genital tract is also an important factor in the production of peritonitis (see below). It must be noted further that in many cases of septic puerperal peritonitis the uterus and tubes serve as avenues of entrance to the agents of infection while remaining themselves in a normal condition.

An especial factor of the female genital tract in the production of peritonitis is that offered by the twisting of the pedicles of ovarian cystomata or of subserous uterine myofibromata. As a result of the shutting off of the circulation from the tumor, the tissues of the latter undergo necrosis, and the necrotic material offers a most favorable field for infection, particularly from the intestine. Such infections are very likely to result in a gangrenous peritonitis. In case infection of the dead tumor tissue does not occur a non-infectious peritonitis may result, the dead tumor acting as an irritating foreign body. A very virulent peritonitis may be thus excited, the exudate as well as the necrotic tumor containing no micro-organisms. Dermoid cysts appear to be especially susceptible to infection after twisting of their pedicles.

The rupture of an uninfected ovarian cystoma and the discharge of a thin serous fluid into the peritoneal cavity rarely excite a peritonitis, the fluid being quickly absorbed. The absorption power of the peritoneum under such circumstances is very great. Only those cystomata containing a firm jelly-like substance (mucin, pseudo-mucin, colloid) are dangerous, since the cyst contents cannot be easily absorbed and act upon the peritoneum as foreign bodies, leading to an organization and vascularization of the material (aseptic peritonitis, pseudo-myxoma peritonei). In the case of the rupture of cysts containing chemically irritating material (*pancreatic cysts, chyle cysts*), a non-infectious, acute, and very virulent peritonitis may be set up. Secondary peritonitis is also not infrequently associated with metastatic carcinoma (*peritonitis carcinomatosa*) and tuberculosis of the peritoneum (*peritonitis tuberculosa*). These conditions will be discussed below.

In the *acute infections* peritonitis is occasionally met with as a complication. Pneumonia seems to be particularly associated with peritonitis, and the pneumococcus has been found in the peritoneal exudate of a number of cases. The peritonitis may be secondary to the pulmonary symptoms or may appear to be the primary condition, the peritonitis manifesting itself before the pulmonary affection. It is probable that such cases represent a general infection by the pneumococcus, the localization varying in different cases. They may therefore be classed as *peritonitic pneumonia*, in analogy to the types known as cerebral and gastric. According to Bednar peritonitis may develop after vaccination.

Tuberculosis of the Peritoneum.—Tuberculous disease of the peritoneum is of especial interest because of its peculiar clinical course and the fact that the condition may undergo spontaneous healing after laparotomy. A distinction is drawn by some writers between pure tuberculosis of the peritoneum and a tuberculous peritonitis; but such a distinction, while based upon pathological grounds, has but little practical value, the first condition rarely presenting clinical signs.

Simple tuberculosis of the peritoneum without accompanying inflammation or exudation is usually secondary to an acute miliary or chronic pulmonary tuberculosis. It may be secondary also to tuberculosis of the bronchial or subperitoneal lymph glands, genito-urinary tuberculosis, tuberculosis of the pleura, adrenal bodies, etc. In the great majority of cases the infection of the peritoneum proceeds from tuberculous ulcers of the intestine or caseating mesenteric glands. In rare cases it may be primary. Small grayish tubercles are found scattered over the peritoneum. On microscopical examination they are seen to consist of epithelioid cells and numerous giant cells containing tubercle bacilli. Caseating centers may be seen in the larger ones; but inflammatory changes in the neighboring peritoneum are usually wanting. The tubercles are almost always more numerous in the omentum. When very small the tubercles may not be recognized at operation or autopsy; the larger ones are recognized by their grayish color and yellowish centers. Though often very numerous the tubercles are usually circumscribed. There are no symptoms, the condition usually being discovered at autopsy, or in the event of a laparotomy.

Tuberculous peritonitis occurs at all ages, but is most common in middle adult life. The majority of cases appear to occur in females, although many statistics show a majority of males affected. Children are not infrequently affected. According to Osler the condition, in America, is more frequently found in negroes than in the white race. In the female, tuberculous peritonitis is more frequently associated with tuberculosis of the tubes; in children the infection usually comes from the intestines. The condition not infrequently occurs as a terminal infection in hepatic cirrhosis.

Metastatic peritonitis occurs in malignant endocarditis and in pyemia. The primary focus may occur in any part of the body, and may be of very slight extent. Peritonitis has followed the infection of a circumcision wound, and very slight lesions in other parts of the body have led to the same fatal termination. It is not uncommon in such cases to find all the serous membranes involved—an acute panserositis; meningitis, pleuritis, pericarditis, and arthritis as well as peritonitis. Peritonitis may also develop during the course of acute articular rheumatism. The exact relation of the two conditions is unknown; the peritoneal inflammation is either metastatic or dependent upon a lessened resistance of the membrane to cryptogenic infections. Likewise acute peritonitis is sometimes associated with *acute nephritis*. It is possible that in these cases the intoxication plays some part in the development of the process, most probably by lowering the resistance of the membrane. The exudate in these cases is usually serous, and bacteria cannot always be obtained from it by culture methods; hence some writers regard these forms of peritonitis as of chemical origin and primary.

Terminal Peritonitis.—Peritonitis also occurs not infrequently as a terminal infection in chronic valvular disease, arteriosclerosis, chronic nephritis, cirrhosis of the liver, amyloid disease, tumor cachexia, scorbutus, etc. The peritoneum alone of the serous membranes may be affected, or the pericardium and the pleura may also become inflamed. Microorganisms are usually present in the exudate. In those cases in which they are not found it is possible that they were present earlier in the disease, and later disappeared. It is of course possible that the peritonitis in some of these cases may be toxic or chemical, but it is more likely that the general intoxication has lowered the resistance of the membrane and cryptogenic infection has occurred.

There is also a close relationship between *syphilis* and peritonitis. Acute peritonitis not infrequently develops in the early stages of acquired syphilis, but is usually a secondary infection. It is not known whether an actual syphilitic peritonitis exists, though it is very probable that it does, inasmuch as a so-called idiopathic peritonitis is of common occurrence in syphilitic new-born. Spirochetes in enormous numbers may be found in the peritoneal fluid of such cases, and also in such fluid of infants showing congenital syphilis when the peritoneum presents no macro- or microscopical changes. In the tertiary stage of acquired syphilis evidences of local peritonitis are common enough at autopsy. Chronic perihepatitis and chronic perisplenitis are more common in syphilitics than in non-syphilitics.

Foreign bodies (concretions, forceps, needles, hairs, etc.) when aseptic produce a local encapsulating peritonitis. When septic they may excite a diffuse purulent or fibrinous process. Free bodies, such as fat tissue, blood clots, pieces of fibroid tumors, etc., may become calcified or encapsulated, setting up a local adhesive peritonitis. In *extrauterine pregnancy* hemorrhage into the peritoneal cavity following the rupture of the sac may excite an intense peritoneal irritation even in the absence of infection. In such cases the blood itself must exert a chemical irritation upon the peritoneum, or irritating toxins are contained or developed within it.

Finally, during *intrauterine injections* irritating substances may be forced through the tubes into the peritoneal cavity and excite a toxic inflammation.

Parasites.—A number of observers have noted at autopsy the presence, in the peritoneal cavity, of intestinal worms in association with a perforative peritonitis. In some cases the perforation has been regarded as caused by the parasite (usually the common round worm), the peritonitis following the perforation. Some of the reported cases are very doubtful.

Bacteriology.—Inasmuch as the great majority of cases of peritonitis are caused by bacteria the bacteriology of peritonitis becomes a matter of very great importance. In recent years a number of important investigations have been carried out along this line, but much work yet remains to be done before we shall possess a fully satisfactory knowledge of the subject. It has been demonstrated that very different forms of bacteria may be found in the exudate of peritonitis. In the majority of cases there is a mixed infection, several varieties of pathogenic bacteria being present, or a number of varieties of pathogenic and non-pathogenic bacteria may be found together. According to Tavel and Lanz the hematogenous cases of peritonitis are monoinfections, while those arising by contiguity from a neighboring diseased organ are usually polyinfections. It is probable that in some at least of the cases of monoinfection the single variety found may have crowded out other varieties which were originally present. This is particularly likely to have been the case in those instances in which the only microorganism present is a harmless saprophyte. In those cases in which the exudate is sterile there is also the possibility that the original pathogenic bacteria causing the inflammation have died out.

The pathogenic bacteria most frequently found in peritonitis are the *Streptococcus pyogenes, Staphylococcus aureus* and *albus, B. coli, Diplococcus pneumoniæ, B. pyocyaneus,* and the gonococcus. Less frequently found are the *B. typhosus, B. aërogenes capsulatus, B. proteus, B. lactis aërogenes, Micrococcus tetragenus, B. influenzæ, B. anthracis,* spirillum of Vincent's angina, and a number of unidentified pathogenic and non-pathogenic bacteria.

In perforative peritonitis the *Bacillus coli communis* usually predominates; in puerperal peritonitis the chief rôle is played by the *Streptococcus pyogenes;* while in those cases of peritonitis which apparently arise spontaneously the pneumococcus or the gonococcus is the chief exciting factor. In all those cases of peritonitis in which the infection comes from without the flora resembles that of ordinary surgical infections, except for the prominent part played by the colon bacillus. In those cases which arise by contiguity from some one of the neighboring organs the staphylococcus plays a chief rôle, except in the case of intestinal infection in which the colon bacillus alone or combined with the former is usually found.

Much discussion has taken place as to the pathogenic rôle of the colon bacillus in peritonitis. The pyogenic properties of this organism have been quite generally accepted, and there can be no doubt of the existence of a primary colon-bacillus peritonitis. In the majority of cases in which the colon bacillus is found pyogenic cocci are also present, and it is probable that in some of the instances in which this organism alone was found in the exudate it had overgrown the cocci.

Pathology.—The pathological changes found in the peritoneum in inflammation of this membrane are essentially the same as those occurring in inflammatory processes of the pleura and pericardium. According to the duration of the inflammation there may be distinguished an *acute, subacute,* or *chronic* peritonitis. According to the extent of the membrane involved a peritonitis may be *local* or *circumscribed, general* or *diffuse.* A localization of the inflammation in the pelvis is generally spoken of as a *pelvic* peritonitis, in the neighborhood of the appendix as *periappendical,* over the spleen and liver as *perisplenitis, perihepatitis,* etc. According to the nature of the exudate there may be distinguished a *serous, fibrinous, purulent, hemorrhagic,* and a *putrid* or *gangrenous* peritonitis. Besides these pure types a variety of combinations, such as serofibrinous, seropurulent, fibrinopurulent, serohemorrhagic, etc., occur.

Acute Diffuse Peritonitis.—Within certain limits the anatomical picture presented in all cases of peritonitis is essentially the same, but the appearances seen at autopsy or operation may vary greatly according to the chronicity, severity, and extent of the inflammation, the amount and character of the exudate, etc. The picture of a severe *acute general peritonitis* is, however, very characteristic. The abdomen is distended and tympanitic over the dome and dull over the flanks. When the cavity is opened the distended coils of intestine rise up through the opening, and an escape of gas may take place, even in non-perforative peritonitis. The serous surfaces are cloudy, in slight cases having the appearance of glass which has been breathed upon. Both the parietal peritoneum and the outer surface of the coils may be more or less reddened, injected, or even show ecchymoses. When the coils are lifted up and separated the reddened areas appear to be arranged in bands along the intestine. As a rule, these reddened bands correspond to the spaces between the coils at those places at which the sides of the coils do not touch. The vessels of the serosa of these spaces are usually markedly hyperemic, while at those points at which the coils do touch the vessels are less congested. According to Wilks and Moxon these spaces, which are triangular on cross-section, form a system of communicating tubes through which the exudate may spread; and because of the lower resistance over these free surfaces absorption of the exudate is carried on here to a greater extent than elsewhere over the peritoneal surface. The loss of luster and the cloudiness of the serous surfaces are due partly to the degeneration and desquamation of the endothelium, and partly to a layer of fibrin which is deposited over the surface. The latter may vary greatly in amount; in some cases the fibrin film may be so thin that it can be seen only as a slight cloudiness when examined by oblique light, or it may be made evident by rubbing off the delicate coating with a damp cloth or by scratching the serosa with the edge of the knife. In other cases the serosa may be covered with a thick, grayish, yellowish, yellowish-gray or reddish-gray exudate which may extend over the coils in a sheet, or in strings or bands of varying size, or appear as flakes scattered over the dull, lusterless surface. The fibrin may bind the coils more or less firmly together; in acute cases such adhesions are easily separated by the fingers, but in older cases the adhesions become organized to a greater or less extent, and so firm that they cannot be torn. The spleen and liver may become entirely covered by fibrinous sheets, or tags and flakes of fibrin may be scattered over their capsules. The

amount of fibrin may be much greater in some parts of the cavity than in others, and by causing adhesions between neighboring structures may shut off portions of the cavity and confine the fluid exudate to certain regions.

Free fluid is usually present in the dependent portions of the cavity, in the flanks, pelvis, and the pockets between the coils. The amount varies greatly, sometimes many liters (twenty to forty) causing a great distention of the abdomen, while at other times only a small amount is present. The fluid is always more or less cloudy or opaque, but varies in character according to the nature of the exudate, the character of the infection, the occurrence of perforation, etc. It may be serous, purulent, hemorrhagic, fibrinous, putrid, etc. In the great majority of cases it is fibrinopurulent, a pure purulent character rarely occurring, although a purulent character usually predominates. Rarely is it serous or seropurulent. It is very often putrid (perforative peritonitis), and is then sanious, greenish, or grayish, having a gangrenous odor, and may contain gas bubbles. Except in the case of tuberculosis or carcinoma a hemorrhagic exudate is very rare. In severe streptococcus peritonitis the fluid may be thin and odorless, in less severe the exudate may be serofibrinous or fibrinopurulent. Staphylococcus exudates may be serous, purulent, or fibrinopurulent without odor. The presence of *B. coli* increases the purulent character and gives a fecal odor to the exudate. In gonorrheal peritonitis there may be a dry fibrinous exudate with little serum. In pneumococcal peritonitis the exudate is fibrinous or serofibrinous. Gas and odors of putrefaction give evidence of the presence of putrefactive bacteria. The distribution of the exudate is generally very irregular owing to fibrinous adhesions. It usually collects in greatest amounts in the pelvis, flanks, splenic and hepatic regions, and in the deeper parts of the two hypochondriac regions. It often becomes encapsulated by fibrinous adhesions between the coils themselves, or between these and the abdominal wall or some one of the abdominal organs. The omentum often plays an important part in the encapsulation of exudates of small size in the appendix region and in the neighborhood of perforating ulcers of the intestine. Large collections of exudate are often found between the liver and the diaphragm; when of a purulent character and encapsulated from the other portions of the cavity the condition is often spoken of as a *subdiaphragmatic abscess*. Gas is particularly likely to collect in this region. In some cases the liver may be pressed tightly against the diaphragm, its diaphragmatic surface flattened and dry. The exudate often follows along the tubular spaces between the coils, so that the exudate from a pelvic peritonitis may pass under the lower coils of the ileum into the cecal region and upward along the ascending colon to the right hypochondrium, then along the lesser curvature of the stomach to the cardiac end. In these regions the exudate may collect in large amounts, while elsewhere in the cavity there may be scarcely a trace of peritonitis. Not infrequently the exudate may become completely shut off from the cavity by fibrinous adhesions, which, becoming organized, finally form a fibrous connective-tissue capsule enclosing the exudate, which is either absorbed, organized, or undergoes inspissation or calcification. As mentioned above, the omentum plays an important rôle in such encapsulations, which are most often seen in the neighborhood of the appendix and the female pelvic organs. In the case of a perforative peritonitis the exudate may contain, in addition to the purely inflammatory products, also stomach or intestinal contents, bile, urine, etc.

In the more severe cases the entire intestinal wall may be involved, becoming swollen, edematous, and easily torn. Even in the light cases the subserosa is edematously swollen and may be easily stripped off from the muscularis. The muscle coats may be completely paralyzed; hence the occurrence of marked tympanites, general or local. On opening the stomach and intestines the mucosa is usually found to be pale, swollen, and edematous. Likewise the superficial portions of the liver, spleen, gall-bladder, etc., are edematous and swollen, often appearing as if macerated. The gall-bladder and the lower edge of the liver in particular may show an extreme edema. The tissues of the mesentery are swollen, moist, and more easily torn than normally. The mesenteric and retroperitoneal glands are usually pale, soft, and enlarged. Even the muscles of the abdominal wall may be pale and edematous, and the parietal peritoneum can be easily stripped from its attachments. The omentum is swollen, injected, and edematous. It is very frequently rolled up into a thick mass, but in the case of surgical or perforative peritonitis it is usually more or less adherent to the site of injury. It may be covered with a thick layer of fibrin and may aid in the encapsulation of the exudate. The diaphragm is usually pushed up to the third or even second rib; the lungs show partial atelectasis, particularly the lower lobes; and the heart is pushed upward and more or less to one side.

Although the changes just described apply to the great majority of cases of peritonitis, yet the limit of variation is great, in so far as the appearances presented by individual cases are concerned. A pure *serous peritonitis* (*peritonitis serosa*) is relatively infrequent. Some fibrin is almost always present, so that the exudate should be more properly termed serofibrinous. The fluid exudate is yellowish, slightly cloudy, and contains few cells, but fibrin flakes are found floating in it. Over the peritoneum there is usually a delicate film of fibrin. A pure *fibrinous peritonitis* is not common as a general process, but is often seen as a local peritonitis. The serosa is cloudy, dry (*peritonitis sicca*) and covered with sticky fibrin.

When the number of cells in the exudate is so great as to cause a turbidity, the peritonitis may be styled *purulent* (*peritonitis purulenta*). A pure purulent peritonitis is also rare, the character of the exudate being usually that of a *fibrinopurulent* inflammation. The coils are usually fastened together by masses of fibrin, while in the pockets between them a relatively pure purulent exudate is found, usually in large amounts (twenty to thirty liters). The so-called *peritonitis ulcerosa* is a misnomer, the appearances of ulceration over the surfaces of the abdominal organs and the parietal layer of the peritoneum being due to a loss of substance through erosion and pressure. In such cases the purulent exudate may perforate into the stomach, intestine, ureter, bladder, uterus, or through the diaphragm or abdominal wall (*secondary perforative peritonitis*). In the last-named case the perforation is usually located at the navel. This event happens more frequently in children than in adults.

In the case of *putrid peritonitis* the exudate has a foul odor and is irritating to the skin of the operator or prosector. In color it varies from dirty green to brownish. The fibrin of the exudate and the serosa itself may be likewise dark colored. Gas may be present in the cavity, and the odor of hydrogen sulphide is often very pronounced even when no perforation has occurred. In the case of a perforation of stomach or intestine food remains or feces may be found in the exudate. Brownish masses are also sometimes present; on microscopical examination they are found to consist of colonies of bacteria.

An acute *hemorrhagic peritonitis* is rare. It is usually associated with carcinoma or tuberculosis, but occurs also in morbus maculosus Werlhofii and in scurvy. Through the presence of hydrogen sulphide in the exudate the blood pigment may become converted into a hydrogen-sulphide compound, giving a gray or slate color to the exudate and serosa (*pseudo-*

melanosis). Friedreich has described an especial form of hemorrhagic peritonitis under the name of *hæmatoma peritonei*. In such cases the peritoneal surface is covered with layers of blood clot which are becoming organized, the condition being analogous to the subdural hematoma.

Circumscribed Peritonitis.—This presents practically the same appearances as the general form, except in being localized through the rapid formation of firm adhesions which prevent the inflammation from spreading (*peritonitis adhæsiva*). These adhesions may quickly become organized. Circumscribed peritonitis occurs most often as a perityphlitis (periappendical) dependent upon perforation of the appendix, and as a pelvic peritonitis pelveoperitonitis) due to diseased conditions of the uterus and its appendages. It may be caused also by perforative processes (ulcer, new growths, etc.) of stomach, intestine, gall-bladder, etc., by splenic infarction, hepatic abscess, and other local inflammations of the intraperitoneal organs. The so-called subdiaphragmatic abscess is an encapsulated purulent peritonitis. Similar encysted collections of exudate may be found in any part of the peritoneal cavity, but are more frequent in the regions named. Gonococcic peritonitis is usually circumscribed in the pelvis. The part which the omentum plays in the encapsulation of a local peritonitis has been mentioned above. Through its aid many cases of perforation peritonitis, particularly in the case of the appendix, are restricted to a narrow area. The frequency with which omental adhesions are formed about the appendix, tubes, perforating ulcers, new growths, etc., is evidence of its very great service in limiting peritonitis.

Microscopical Appearances.—Sections through an acutely inflamed peritoneum present changes which are analogous to those of inflammations of other serous membranes. The surface of the membrane is covered with a more or less thick layer of fibrin containing a varying number of leucocytes. The latter usually show karyorrhexis, the diffusion of the chromatin throughout the fibrin causing the latter to stain bluish. Beneath the exudate the endothelium is degenerated, necrotic, or desquamated. Numerous macrophages and eosinophiles are often seen in the early stages. The connective tissue of the basement membrane is edematous and infiltrated with leucocytes. The lymphatics are greatly dilated and contain fibrin and large numbers of leucocytes. The blood-vessels are also greatly congested and filled with leucocytes. The endothelial cells of both lymph and blood-vessels are usually somewhat swollen. Scattered hemorrhages of small size may also be found. The subserosa is usually actively involved, the connective tissue being edematous and infiltrated with leucocytes; the vessels are congested and small hemorrhages may occur. Fibrin threads may be found in the intercellular spaces of both serosa and subserosa. The muscularis is involved to a much less extent. Its vessels are congested and the intermuscular connective tissue is more or less edematous and contains an increased number of leucocytes. In severe cases the nerve cells of the intestinal wall may present various changes, such as vacuolation, hydropic degeneration, chromatolysis, etc. In the later stages of the inflammation evidences of proliferation are found in the endothelial cells of the blood- and lymph vessels and in the connective-tissue cells of the serosa and subserosa. Fibroblasts wander out into the fibrin of the exudate and a new formation of capillaries takes place. Even in attacks of peritonitis lasting but five to seven days the organization of the exudate may have advanced considerably. In the further progress of the disease connective-tissue adhesions and false membranes may be formed, or marked thickenings of the peritoneal surfaces may result. Should complete healing take place the newly formed connective tissue becomes scar-like and hyaline, and marked retractions of the omentum and mesentery may be caused. The remains of old organized fibrinous exudates are most frequently seen in the form of tendinous patches or small pearly nodules over the surface of the spleen, liver, or intestine. Extensive thickening of the pelvic peritoneum may result from the healing of circumscribed peritonitis in this region. During the stage of active fibroblastic proliferation such a large mass of granulation tissue may be formed that in the case of a circumscribed periappendiceal peritonitis a tumor may be produced which may be mistaken clinically for a malignant neoplasm, and even when examined microscopically might be mistaken for a sarcoma. Such tumor-like masses may also be found in the omentum. Should healing take place the tumor may gradually contract and finally entirely disappear ("disappearing tumor"). The presence of exudate not yet organized, the large number of polymorphonuclear leucocytes showing karyorrhexis, the hypertrophic character of the endothelium of the numerous capillaries, the presence of many plasma cells and phagocytes, the development in areas of a fibrous intercellular substance, etc., are among the points to be considered in making a microscopical diagnosis of tissue removed from such tumor-like formation.

Subacute Peritonitis.—In cases running a slower course the amount of exudate is usually less than in the acute forms, although in some cases in which it is more serous in character the amount may be very large. The adhesions are firmer, organization having progressed to a greater extent. The serosa is thickened, roughened, and wholly lusterless, and is often grayish or slate colored. The injection of the blood-vessels is much less, and there is also less edema of the subserosa. Exacerbations, which are very likely to occur, give the appearances of an acute inflammation. Microscopically the exudate covering the serosa is found to be partly organized, and there is a fibroblastic increase of tissue. The cells of the exudate may show fatty or hydropic degeneration.

Chronic Peritonitis.—Chronic peritonitis may follow an acute process or it may develop insidiously. The changes seen in chronic peritonitis are essentially the same as in the acute process, the chief difference being in the more advanced organization of the exudate with resulting firm adhesions and formation of false membranes, tendinous patches, etc. When numerous adhesions are formed the condition is termed *peritonitis chronica adhæsiva*. The capsule of the liver and spleen may be greatly thickened and hyaline (chronic perihepatitis, chronic perisplenitis). Scar-like thickenings and retractions of the omentum and mesentery may be found (*peritonitis chronica retrahens*), and in the former there may be produced tumor-like masses of granulation tissue. It is usually rolled up above the level of the umbilicus. Marked deformities of the intestine and intraperitoneal organs may be produced by the contraction of the new-formed connective tissue (*peritonitis deformans*). Partial or complete stenosis of the intestine, common duct, ureters, tubes, etc., may result from the contraction or pull of band-like adhesions. Incarceration of portions of the intestinal coils in hernia-like sacs formed by adhesions may also occur. Inasmuch as exacerbations are not infrequently seen in chronic peritonitis the picture of a recent exudation may be added to that of an older process. The *hæmatoma peritonei* of Friedreich mentioned above is associated particularly with a rare form of chronic hemorrhagic peritonitis. Chronic peritonitis may be local or general; the former is the more common. The inflammation may be dry, or a serofibrinous exudate may be present; less frequently the exudate is hemorrhagic or purulent.

Local chronic peritonitis is seen most often in the hepatic region (cirrhosis, gallstones, syphilis, etc.),

in the splenic region (perisplenitis), and in the pelvis of the female. In prostitutes a local chronic pelveoperitonitis is nearly always present in the form of adhesions. The appendix region, the neighborhood of gastric and intestinal ulcers, hernial sacs, etc., are also frequent seats of chronic peritonitis.

Mention may be made of the condition designated *"chronic multiple serositis"* or *"multiple progressive hyaloserositis"* which is characterized by a slowly progressive hyperplasia of the serous membranes with secondary hyaline changes. (See *Hyaloserositis.*)

Peritonitis Carcinomatosa.—Scirrhous carcinoma of the stomach or gall-bladder may give rise to secondaries scattered diffusely throughout the peritoneum. The membrane at the same time presents the appearance of a chronic hyaloperitonitis, the entire serosa, intestinal and parietal, as well as the hepatic and splenic capsules, being greatly thickened, dense, and hyaline. Such a condition may very easily be mistaken for a simple chronic peritonitis, inasmuch as appearances suggesting malignancy may not be visible to the naked eye. The diagnosis in some cases can be made only on microscopical examination, since the primary growth may consist only of a dense thickening of the pyloric end of the stomach or of the gall-bladder wall and may not be recognized from the gross appearances. Microscopically the hyaline connective tissue of the thickened peritoneum is seen to contain small nests and cords of epithelial cells, corresponding to those of the carcinomatous infiltration at the primary seat. It is well to bear in mind the fact that the mesenteric and retroperitoneal lymph glands may contain large nests of cancer cells, so that the diagnosis of scirrhous carcinoma may be more easily arrived at by the examination of these glands. The peritoneal condition may therefore be regarded as of the nature of a diffuse carcinomatosis with secondary inflammatory changes. More or less fibrinous exudate may be present over the surface of the thickened membrane, and some free fluid may be present in the cavity.

Tuberculous peritonitis—tuberculosis with inflammation and exudation—exists in a great variety of forms which have been variously classified by different authors. The most common forms are: *acute miliary tuberculosis* with serofibrinous or serohemorrhagic exudation; *chronic tuberculous ascites* with small tubercles which show little caseation; *chronic fibrocaseous tuberculous peritonitis* with purulent or fibrinopurulent exudate; *chronic hyperplastic tuberculous peritonitis; chronic fibroid tuberculosis* with little or no exudation, the serous surfaces being fastened together by adhesions.

The appearances at autopsy or operation may vary greatly. In the majority of cases two types predominate; the *adhesive* form and that with *free fluid exudate.* The former is the more common. The coils and the abdominal organs are matted together and to the parietal peritoneum by numerous firm adhesions, in which there are found numerous tubercles or caseous masses. The spaces between the adhesions are filled with a purulent, fibrinopurulent, or hemorrhagic exudate, or, if perforation into the bowel has occurred, with exudate containing fecal material. Such perforation is not uncommon and fecal fistulæ may be formed. The adhesions between the liver and spleen and the diaphragm are usually very firm. The omentum is thickened and rolled up, and its boundaries are lost in the general adhesions. In many cases it is almost impossible to orient the abdominal organs, everything being so densely bound together by adhesions, all free surfaces being covered with a thick yellowish or grayish layer of fibrinopurulent exudate. In the second type the peritoneal surface is covered or strewn with numerous tubercles which are more or less confluent. Caseation is usually advanced to a greater or less extent. In the later stages the entire peritoneum becomes covered with a layer of tuberculous granulation tissue containing caseous centers. Adhesions are not numerous, and the peritoneal cavity contains a large amount of serous or serofibrinous exudate.

In the chronic fibroid form the peritoneum is thickened and hyaline; adhesions are numerous, but there is little or no fluid exudate. The surface of the thickened peritoneum is usually covered with a fibrinous layer. Circumscribed tubercles may be entirely absent, likewise caseation. The spleen and liver may be covered with a thick hyaline layer, the appearances in general resembling those of hyaloserositis, as mentioned above, or the condition may be mistaken for scirrhous carcinoma. On microscopical examination tubercles are found embedded in the masses of fibroid tissue. These usually contain but few bacilli. In the chronic fibrocaseous form large caseating masses may be found in the adhesions or in the peritoneal surface. The chronic hyperplastic form is characterized by the formation of tumor-like masses of tuberculous granulation tissue. The mesentery may become enormously thickened, and the condition may be mistaken for a new growth. A hyperplastic tuberculosis of the intestinal wall is usually found in association with such cases. Such tumor-like masses are encountered most frequently in the right iliac region. Tuberculous tumor-like masses may also be found in the omentum.

Complications.—The complications of acute peritonitis are many and important. Perforation of the peritoneal exudate into some viscus or through the abdominal walls has been mentioned. Occasionally the pus may break through into two neighboring coils of intestine at the same time, giving rise to the so-called *fistulæ bimucosæ.* Fatal hemorrhage may follow perforation into an abdominal blood-vessel. Metastasis may occur and a general pyemia may result. It is not uncommon in the case of a severe acute general peritonitis to find at autopsy a beginning pleuritis, pericarditis, or meningitis. Sometimes all the serous membranes may be equally involved (panserositis). Such pathological findings are seen most frequently in puerperal peritonitis.

Symptoms.—*Acute General Peritonitis.*—Peritonitis in the great majority of cases being a secondary disease the symptoms are modified to a greater or less extent by the original trouble. The onset in particular is modified. Perforative peritonitis may occur suddenly in a person apparently in perfect health. Not infrequently the first intimation of the existence of a gastric or intestinal ulcer is the peritonitis following a perforation. In the case of perforative appendicitis the onset may be equally sudden. On the other hand, the symptoms of perforative peritonitis may be obscured in the case of intestinal tuberculosis, typhoid fever, intestinal obstruction, etc., by the severe local or general symptoms. A circumscribed peritonitis may also become gradually changed into a general condition, the change in symptoms not being so pronounced as to be noted. For example, a localized purulent perityphlitis or a purulent puerperal pelveoperitonitis may become generalized. A pneumococcic peritonitis occurring in association with pneumonia or meningitis may have its onset obscured by the general symptoms.

In spite of these exceptions nearly every case of acute general peritonitis runs a clinical course so typical and characteristic that the recognition of the condition becomes a matter attended by little or no difficulty.

Prodromal symptoms may or may not occur. In the former case they consist of chills, prolonged and repeated chilly sensations, fever, loss of appetite, nausea, vomiting, thirst, diarrhea or constipation, flatulence, etc.

Pain is the earliest definite symptom, and few cases of acute peritonitis exist without it. In patients who

are extremely weak or whose minds are clouded, no complaint of pain may be made, and the condition may in this way escape notice. In nearly every case, however, the pain becomes the most marked and important symptom. It may be local, often referred to the region of the umbilicus, but later usually extends over the entire abdomen. The localization of the pain at the onset of the disease may have some diagnostic value in indicating the possible source of the inflammation, as, for example, in the case of gastric ulcer or a perforating appendicitis. The pain is usually excruciating in character, and may be constant, or it may occur with short remissions followed by exacerbations. Colic-like paroxysms sometimes occur. The abdomen is extremely sensitive, so that even gentle palpation, or even the weight of the bed clothes can hardly be borne. The patient assumes a position which relieves the tension of the abdominal muscles, lying on the back with thighs drawn up and shoulders elevated. Such a position may be maintained for days and weeks as long as the condition lasts. The pain is increased by deep inspirations, voluntary movements, and probably also by intestinal peristalsis. The patient fears particularly such movements as vomiting, coughing, sneezing, defecation and urination, etc. The character of the pain is sometimes described as burning, boring, tearing, lancinating, etc., without much light being thrown upon the conditions causing the especial character. The passage of gas through the coils probably plays an important part in producing the painful attacks. Though in the majority of cases the pain is most severe below the umbilicus, in cases of perforation of the stomach the pain may be referred to the shoulders, back, or chest. In the earlier stages of peritonitis following appendicitis the pain may sometimes be referred to the testicle or the penis. Mackenzie believes that the pain which is caused by pressure over the abdomen is entirely due to muscular and cutaneous hyperesthesia, the peritoneum itself being devoid of sensory nerves. The board-like hardness of the abdominal muscles in peritonitis he holds to be the result of a violent stimulation passing from the affected organs of the peritoneal cavity to the spinal cord, where the irritation spreads, affecting not only the centers of the sensory nerves, but also those of the muscular nerves. When the patient is at perfect rest the pain may be slight or may even entirely disappear.

The *respiration* is very superficial, rapid, and wholly costal in type. The speech usually becomes an almost imperceptible whisper, occasionally hoarse and high pitched, resembling the so-called vox cholerica. When the attack is fully established the patient presents a very characteristic appearance, the expression is anxious, the face pinched and the eyes are sunken, the Hippocratic facies being seen in this affection more often than in any other disease except cholera. The severity of the pain is usually expressed by the patient's face; in severe cases the eyes are glassy and staring. Consciousness remains preserved usually until the last; rarely there is delirium, coma, or convulsion at the end.

The abdomen quickly becomes distended, the distention becoming gradually more and more marked, and sometimes reaches such an extent that it seems that the abdominal wall must give way. The skin over the abdomen is smooth, shining, thinned, the superficial veins appearing as blue lines. Fresh lineæ albicantiæ may be seen over the surface. The abdominal muscles are stretched and often of a board-like hardness. The distention is due to the intestinal tympanites, which is sometimes so great that complete paralysis of the intestinal musculature results. The distended coils of intestine can sometimes be traced through the abdominal wall. The more lax the abdominal wall before the beginning of the peritonitis the greater will be the distention; hence the distention is most marked in the puerperal cases. When the abdominal muscles are well developed and the abdominal wall is tense, the convexity may not be great. In some cases the wall may be as hard as a board and flat or even somewhat concave. In the latter case the diagnosis may be very difficult. In the later stages the abdominal distention is increased by the fluid exudate.

Vomiting is an almost constant symptom in peritonitis. It usually begins early in the disease and causes great pain. At first the vomitus consists of food remains, later it consists chiefly of a yellowish bile-stained fluid, and finally becomes greenish. Occasionally the vomitus is brownish black and possesses a slight fecal odor. The attacks may be spontaneous or follow the taking of food. In the former case the vomitus consists usually of greenish mucus. Eructations of gas usually accompany the vomiting. The frequency and intensity of the vomiting vary. In some cases nothing can be retained upon the stomach, and the patient's strength is very quickly lost. The cause of the vomiting is not clear; it is probably partly reflex and partly due to pressure upon the stomach. In those cases in which the vomitus has a fecal character the autopsy usually discloses no intestinal obstruction. It is therefore probable that the condition is due to the paralysis of the intestinal musculature and to the pressure upon the intestine. Toward the close of the attack the vomiting may be replaced by painful *hiccoughs*, which are a source of great torture to the patient. It is probable that this is due to the involvement of the peritoneal surface of the diaphragm. In those cases in which the vomiting is kept up to the end some of the vomitus usually enters the respiratory tract and may give rise to an aspiration pneumonia or gangrene of the lung.

Peritonitis not infrequently begins with *diarrhea*, which in some cases is associated with tenesmus, or assumes a dysenteric character. The paralysis of the intestinal musculature soon leads to *constipation*, so that this condition becomes an almost constant feature of the disease.

The *tongue* is usually coated, grayish white or brown; in cases of obstinate vomiting it may be clean and red or fissured. A very disagreeable fetor is usually present, sometimes almost fecal in character.

After the chill the body temperature usually rises, reaching 104° to 105° F. or higher, but later usually falls. Rigors are not common after the prodromal chill. The type of the *fever* is very varied; it may be continuous, intermittent, or remittent. The skin may be cool, while the rectal temperature is high. In the case of collapse (perforative peritonitis) the temperature may fall even to subnormal, and the body may be covered with an abundant cold perspiration. Just before death the temperature may rise again and reach a very high point.

The *pulse* is usually very frequent, the increase in rate being out of proportion to the fever, 120 to 140 per minute not being uncommon. The pulse is at the same time small, hard, and wiry in the early stages but later becomes small and soft, and in very severe cases may become imperceptible.

The number of *respirations* is increased, thirty to forty per minute. The increased rate is due partly to the fever, partly to the high position of the diaphragm, and partly to the pain attending abdominal breathing. As mentioned above, the type is costal and the breathing superficial. The cessation of movement of the diaphragm is regarded as a bad sign, some writers considering the prognosis hopeful as long as an inspiratory excursion of the diaphragm can be felt, this being taken as a sign that the peritonitis is not wholly diffuse.

The *subjective* symptoms are chiefly pain, uncontrollable thirst, shortness of breath, and anxiety.

Percussion gives a tympanitic tone over the distended intestine. Dulness over the dependent

portions is usually not made out until after considerable exudate has collected. When the tympanites is very marked a large amount of effusion may be present without its being detected on percussion. A change of level of the dulness with change of position does not always take place; the adhesions between the coils preventing the movement of the exudate. Moreover, there is usually too much pain to permit of a careful examination. The liver dulness is diminished, the upper border being pushed upward to the fifth or fourth rib. The splenic dulness cannot usually be made out. The heart is pushed upward, the apex beat dislocated upward and to the left. The movements of the heart in the intercostal spaces are more prominent than normal.

Auscultation of the abdomen does not throw much light upon the condition. Gurgling and splashing sounds may be heard in the intestines. Occasionally friction sounds may be heard, but these are not so common as in pleuritis or pericarditis. In pneumoperitonitis splashing sounds may be produced by shaking the patient. The heart sounds may have a metallic resonance in the case of extreme tympanites. The pulmonary second sound is usually accentuated.

The *urine* is usually diminished in amount, dark, strongly acid, of high specific gravity, and sometimes contains a small amount of albumin. The amount of indican present may be much greater than usual and this is regarded as an important point by some writers.

There is usually anemia, but the concentration of the blood keeps the red cell count from being much lowered. In the most severe cases there may be leucopenia, in the less severe a well-marked leucocytosis. The glycogen reaction of the polymorphnuclears is marked. Blood cultures are usually sterile.

Certain writers claim that there is a *local increase of temperature* in the abdominal wall, and that this fact constitutes an important diagnostic factor. The normal temperature of the surface of the abdomen is about 35.5° C.

In the case of *pneumoperitoneum* due to perforation or to formation of gas within the cavity the hepatic dulness is obliterated. The liver dulness may, however, disappear when there is no gas in the cavity; but if the patient is placed upon his left side a clear percussion tone will be heard at the seventh or eighth rib in the right axillary line in the case of pneumoperitoneum. In other cases dulness will be found at this region. The disappearance of the liver dulness anteriorly when pneumoperitoneum does not exist is due to the tilting backward of the organ and the presence between it and the abdominal wall of a loop of distended intestine.

The *course* of an acute general peritonitis is usually very rapid. The most severe cases may terminate fatally within thirty-six to forty-eight hours, while the average case usually lasts five or six days. Since the etiological factors vary so greatly no absolute statements can be made regarding the clinical course. The peritonitis occurring as the result of gastric or intestinal perforation is usually quickly fatal, but much is to be hoped from the surgical treatment of these cases. Puerperal septic peritonitis is likewise usually fatal. Pneumococcic peritonitis is also likely to terminate more or less quickly in the death of the patient. The peritonitis which occurs in connection with arthritis, as well as in all other cases in which the exudate is serous or serofibrinous, is much more likely to end in recovery.

In the fatal cases *death* may occur suddenly as if from shock or from cardiac failure due to the action of toxins upon the heart muscle, or in the case of extreme tympanites the high position of the diaphragm may cause death from suffocation. In some cases the final picture is that of a general sepsis or pyemia. In the great majority of cases the pulse becomes more rapid, the vomiting persists, the bodily powers are quickly exhausted, and the patient dies with symptoms of collapse. In such cases the temperature usually becomes subnormal as the end approaches.

In other cases of less frequent occurrence the disease may drag itself out over weeks and months, assuming the characteristics of a subacute or chronic process. Various complications may occur during such a prolonged course. Rupture of the exudate into the gastrointestinal tract or through the abdominal wall, etc., is most likely to occur in such cases. In the event of such perforation into the stomach, pus will be found in the vomitus; when into the intestine the pus will appear in the stools; when into the urinary tract the urine will show a sediment of pus; when into the respiratory tract the sputum will be abundant and purulent. In the event of a rupture through the abdominal wall redness, swelling, and edema will first appear at the affected spot, the skin becomes thinned, fluctuation occurs, and pus finally seeps through small fissures, or an opening of large size may be formed, through which the pus may be forced in streams during coughing, etc. The navel is the most common seat of perforation. In some cases the pus burrows beneath the skin for some distance before it finally breaks through. In other cases some of the exudate may be absorbed or encapsulation may take place. Exacerbations are frequent and death may take place finally from general marasmus. General dropsy, bedsores, albuminuria, etc., characterize the course of such cases.

In the mild cases of general peritonitis following labor, abortion, or menstruation recovery may occur. Even in those cases in which the disease runs a rapid and favorable course disturbances of the digestive tract usually develop, and the patient may die later from intestinal obstruction caused by the contraction of adhesions. A favorable prognosis should not be too hastily given in such cases. Nevertheless, complete recovery may result after a year or longer, even in very severe cases.

Acute Circumscribed Peritonitis.—The local symptoms of this form are similar to those of the general process, but are more limited. The vomiting is not so severe or so persistent as in the general inflammation. Though the general weakness is marked the symptoms of collapse do not occur to the same extent as in general peritonitis. An irregular fever is usually present, running a course suggesting that of a pyemic affection. The condition is usually very chronic. Many patients die from general debility. Spontaneous evacuation of the encapsulated exudate may take place through perforation into the gastrointestinal tract, pleura and lungs, abdominal wall, etc. Should the perforation take place into the remaining portion of the peritoneal cavity the peritonitis may become diffuse. According to the location of the inflammation (perisplenitis, perihepatitis, perityphilitis, perimetritis, peripancreatitis, perigastritis, epiploitis, mesenteritis, etc.), various symptoms may arise through the disturbance of function of the affected organ. Pain is usually felt in the affected region. The physical signs are local tumor, dulness, fluctuation, peritoneal friction, etc.

Subphrenic Abscess.—Of the various forms of acute circumscribed peritonitis the condition known as subphrenic abscess deserves especial attention. It is due to an encapsulated collection of purulent exudate between the upper surface of the liver, stomach, or spleen, and the diaphragm. Owing to the paralysis of the diaphragm the tumor may rise high into the thorax and may be mistaken for a pleural effusion, especially since a secondary pleuritis is usually present. Hepatic abscess, splenic infarction, splenic abscess, rupture of echinococcus cysts, and gallstones are the more common causes of the condition, but it is not a rare complication of perforating appendicitis. Sub-

phrenic abscess may contain no air or gas (simple subphrenic abscess) or it may show the presence of air or gas (subphrenic pyopneumothorax). Simple subphrenic abscesses are usually due to appendicitis, abscess of liver or spleen, but may be caused by the perforation of a gastric or duodenal ulcer, pericolic abscess, pancreatic abscess, retroperitoneal abscess, psoas abscess, etc. They are more often found on the right than on the left side. Six forms occur as to the anatomical boundaries of the abscess, two extraperitoneal and four intraperitoneal (right anterior, right posterior, left anterior, and left posterior), the diaphragmatic areas corresponding to the last four being defined by the hepatic ligaments. The physical signs vary with the location of the abscess. The symptoms are obscure; continued fever, rigors, diarrhea, pleuritic pain, and a palpable tumor may attract attention. Gaseous subphrenic abscess usually results from the perforation of a gastric ulcer, less commonly from a perforating duodenal ulcer, suppurating hydatid cyst of the liver or appendicular abscess. Gas-containing abscesses are more common on the left side. The diaphragm is pushed up, pleurisy with effusion follows and perforation of the diaphragm leading to pyopneumothorax, pulmonary gangrene, etc. The onset is usually sudden with severe pain, collapse, and vomiting; physical signs resemble those of pyopneumothorax.

Acute Pericolitis.—An inflammation of the serous covering of the colon is more common in the sigmoid and descending colon. It arises usually from stercoral ulceration, particularly of acquired diverticula of the colon. An acute abscess may be formed or the process may become chronic. The symptoms are pain, loss of appetite, slight fever, vomiting, constipation, hyperesthesia, elongated swelling, indicanuria, and leucocytosis. On the right side the symptoms are like those of appendicitis, and the conditions can hardly be differentiated clinically.

Perforation Peritonitis.—The peritonitis due to perforation may be local or general. It may run a very acute course, but when circumscribed is more likely to be chronic. In the case of the sudden perforation, as, for example, of the stomach, intestine, cystic tumor, etc., the patient may feel a sharp tearing sensation, as if something has given way within the body. The severest symptoms of collapse may immediately result. The abdomen may be contracted, hard as a board, and even scaphoid. The slightest touch causes extreme pain. Death may take place within a few hours. In other cases the entrance into the peritoneal cavity of stomach contents, feces, bile, etc., excites a general peritonitis with symptoms as described above. In the case of perforation of the gastrointestinal tract gas may also enter the cavity, and the picture of a pneumoperitonitis be presented. The liver and splenic areas of dulness are obliterated unless these organs have become attached to the anterior abdominal wall by means of adhesions. Succussion sounds may be produced, and the respiratory sounds may acquire an amphoric quality.

Puerperal Peritonitis.—This dreaded complication usually appears at from the third to the fifth day after labor. Safety from the condition is usually assumed if the woman reaches the end of the second week without its occurrence. The pain is usually much less intense than in the other forms of general peritonitis, and the tympanites more marked. Chills occur more frequently than in other forms and diarrhea is almost always present, the discharges often becoming bloody and of the character of a dysentery. The vomiting is especially obstinate. The lochial discharges often become offensive. The peritoneal exudate is usually more abundant and more purulent in character than in other forms, and not infrequently becomes putrid. The mortality is great, death taking place with symptoms of general sepsis usually between the fifth and twelfth days.

Infantile Peritonitis.—*Fetal* peritonitis occurs between the seventh and ninth months of intrauterine life. Syphilis is the chief etiological factor. Infection of the umbilicus may lead to a *peritonitis neonatorum.* The children of mothers suffering from puerperal sepsis are especially likely to become infected. In addition to the local symptoms of distention, pain, etc., there is usually a picture of general sepsis or pyemia. The condition is almost always fatal. A peritonitis may also develop in infants and young children (*peritonitis infantum*) as the result of syphilis, or of infection with pyogenic organisms, the pneumococcus, gonococcus, etc. In the great majority of cases peritonitis in young children is the result of appendicitis. In peritonitis which occurs in young girls the possibility of a gonococcic infection should always be borne in mind and the genital passages examined for the existence of such disease. Non-gonococcal vulvovaginitis rarely spreads to the peritoneum.

Gonococcic Peritonitis.—This is rare in men, but probably very frequent in women. It develops particularly in association with menstruation and delivery. The exudate is usually slight, consisting of a thin layer of fibrin. It may set in with great severity, but the symptoms quickly improve. There is but little distention, and muscular rigidity is absent. It is more fatal in children than in adults; in the latter its chief importance is probably the production of pelvic adhesions.

Pneumococcic peritonitis is more common in children than in adults and in girl than in boy infants. The infection is probably through the genital tract in the majority of cases, but may be hematogenous, or may reach the peritoneum from the pleura through the diaphragm, or from pneumococcic processes in contiguous organs. It is often associated with pneumonia, pleurisy, pericarditis or arthritis as a part of a general pneumococcus septicemia. In about fifty per cent. of cases it is localized. The exudate is greenish yellow, odorless and serofibrinous or fibrinous. The onset is usually very sudden, with abdominal pain, fever, and vomiting. The course of the affection is very similar to that of pneumonia, the active symptoms subsiding in from seven to ten days, but the abdomen remains distended, and later the presence of an exudate becomes manifest. The prognosis in the cases of general infection is not good, but when the inflammation is localized in the pelvis it is more favorable.

Chronic Peritonitis.—In the majority of cases chronic diffuse peritonitis is the sequela of an acute inflammation, although such an occurrence is relatively rare. Usually no sharp line can be drawn between the two; the symptoms of an intense acute process gradually abate and are replaced by those of a chronic type. In some cases the chronic inflammation develops as the sequela of a number of acute attacks; in others the onset is slow and insidious. The pain, abdominal tenderness, and distention are never so marked, as in the acute cases. The distention is usually moderate and often asymmetrical, certain coils of intestine being especially prominent. Sometimes the abdomen is flat or even scaphoid, the walls are hard and board-like. On palpation the thickening of the omentum and mesentery, as well as the fibrous adhesions between the coils, may be made out as tumor-like masses or as uneven prominences. When an effusion is present palpation may be negative. A friction rub may occasionally be felt. In some cases the abdomen may be so tense that nothing can be felt through it. Cases of chronic peritonitis, not due to tuberculosis or complicated with other conditions, do not usually show much exudation. In the great majority of cases, however, chronic peritonitis is associated with chronic ascites. The onset is usually vague; a gradual enlargement of the abdomen with slight or no pain, disturbance of

respiration, constipation and loss of strength. The course is very protracted. Recovery may follow the absorption and organization of the exudate, or its escape by perforation from the cavity. Death usually results from general marasmus. The healing of the inflammation may be followed later by stenosis and intestinal obstruction, which may result fatally. Occlusions of the common duct by the contraction of adhesions may cause a chronic obstructive jaundice.

A peculiar form of chronic serous peritonitis occurs in children, appearing under the form of a chronic ascites. It occurs most frequently between the ages of two and ten, and in girls at the age of puberty. The abdomen is distended by the exudate, which is usually quite abundant, serous in character, and freely movable. The affected children are anemic, more or less weak, but do not lose much in weight and do not suffer pain. The lower extremities may become edematous. The exudate may apparently entirely disappear and then return. The course may last many months and may terminate in complete recovery. The exact nature of the affection is unknown. Trauma, inflammation of the gastro-intestinal tract, lymph glands, and genital tract, etc., have been adduced as etiological factors. It is possible that the condition represents an infection of the peritoneum with tubercle bacilli of low virulence. In the fatal cases death results from an increasing marasmus.

Tuberculous Peritonitis.—The symptoms of tuberculous peritonitis vary greatly. The condition may be entirely latent, and discovered only by accident. In other cases the symptoms may be so severe as to suggest intestinal obstruction. In many instances the onset is like that of an acute general peritonitis. Other cases still resemble typhoid fever and may be mistaken for this disease. The clinical picture varies to such an extent that no very general description can be given. Ascites is usually present, though the amount of exudate may be small. In the acute cases the abdomen may be distended by tympanites, and meteorism is also of frequent occurrence in the late stages of the adhesive form. Fever is always present, though sometimes light. It may be remittent, intermittent, or continuous, and may reach 103°–104° F. A subnormal temperature is not uncommon in the chronic cases, the temperature for days in some cases running 95°–97° F. The patient may appear well nourished or may be emaciated and cachectic. Gastrointestinal disturbances are the rule, and the bowels are either constipated or loose. The skin sometimes shows pigmentation, and the condition may be mistaken for Addison's disease. The two conditions may, however, exist together. In those cases in which the tuberculous peritonitis is secondary to chronic tuberculosis elsewhere the symptoms of the former may be overshadowed by those of the primary affection. An important local sign in tuberculous peritonitis is the presence of tumor-like masses in the abdomen. These may be due to omental thickening, encapsulated exudation, thickening of the intestinal coils, enlargement of the mesenteric glands, caseating masses, nodules of tuberculous granulation tissue, etc. A friction rub may often be felt over the tumors. The omentum is frequently rolled up and thickened, forming a rope-like tumor lying transversely across the abdomen above the level of the umbilicus. In connection with the symptoms this local sign is of great importance in the diagnosis of tuberculous peritonitis.

The disease pursues a varied course. Spontaneous healing may occur. In the severe acute cases death may take place suddenly as in acute general peritonitis not due to tuberculosis. In the chronic cases the patient may gradually become marasmic and die from general weakness. The course of the affection if subject to various complications which may bring about a fatal termination. Obstruction of the intestine from the contraction of adhesions, perforation of the exudate into neighboring organs, fatal hemorrhage, etc., are the most common of these. Death may take place from the primary tuberculosis, or a general miliary tuberculosis may terminate the case. The prognosis in tuberculous peritonitis has, however, been greatly modified by the results of laparotomy.

Diagnosis.—The diagnosis of acute general peritonitis is usually very easy in those cases in which there is a characteristic picture of abdominal tenderness and distention, vomiting, and collapse. The starting-point of the inflammation is often very evident in cases in which a primary condition, such as typhoid fever, gastric ulcer, puerperal infection, etc., has already been recognized. Careful inquiry and search for such a cause should always be made. A history of previous attacks suggesting appendicitis, of pelvic disease, gastric ulcer, etc., aids greatly in establishing the starting-point. Such a cause cannot always be easily determined. Since many cases are first seen only after the tenderness and distention are marked, the physical examination cannot always be as thoroughly carried out as is desirable. In such cases the pelvic organs should be examined thoroughly. In some cases the diagnosis becomes very difficult, since similar symptoms may be produced by other conditions. Acute enterocolitis, lead colic, biliary or renal colic, enteralgia, acute intestinal obstruction, intestinal ulcers, acute hemorrhagic pancreatitis, ruptured tubal gestation, embolism of the superior mesenteric artery, rupture of an abdominal aneurism, etc., may present the picture of peritonitis so that it may be impossible to say whether the latter condition has been set up or not. A diagnosis of peritonitis may be given under these conditions when no evidences of it can be found at autopsy. The mistake may be easily made in those cases of typhoid fever in which the tympanites, abdominal pain, and constitutional symptoms are very marked. The presence of parasites in the intestinal tract may also give rise to symptoms suggesting peritonitis. In those cases in which the local symptoms are not marked, while the general collapse is severe, the diagnosis may be entirely missed.

The diagnosis of circumscribed peritonitis is almost wholly dependent upon the recognition of the condition from which the inflammation proceeds. This cannot always be accomplished, and it is often necessary to study the case for some time before a diagnosis can be made. The condition is most often mistaken for a tumor. On the other hand, the distended bladder and pregnant uterus have been mistaken for peritoneal thickenings. In doubtful cases aspiration of local tumors should always be carried out. The diagnosis of subphrenic abscess may be very difficult unless there is a palpable swelling. If after an operation for appendicitis or cholelithiasis the patient still gives evidence of the persistence of a suppurative process the bases of the lungs should be carefully examined by means of percussion, auscultation and the *x*-ray. If positive signs of abscess are found the exploring syringe should be used in the scapular or midaxillary lines in the sixth, seventh, eighth and ninth interspaces.

The diagnosis of chronic peritonitis is sometimes very difficult in so far as a differentiation between simple chronic peritonitis and tuberculous peritonitis is concerned. It may be borne in mind, however, that the former condition is very rare. In those cases in which it is a sequela of an acute process the previous history of the case usually clears up the matter, but in those cases in which the disease develops gradually and insidiously the determination of the nature of the process may be very difficult. The patient's family and individual history must be considered, a careful examination of the thorax and genitals must be made, the abdomen aspirated, and the exudate examined.

A hemorrhagic exudate favors tuberculosis. Carcinoma may be diagnosed by the finding in the exudate of small bits of tumor tissue or cells containing atypical division figures. The exudate should also be stained for tubercle bacilli, and animal inoculations may be made. The tuberculin test may also be given. The occurrence of pulmonary, pleuritic, or genito-urinary tuberculosis makes it almost certain that the peritoneal condition is likewise tuberculous. In children the symptoms of the condition known as *tabes mesenterica* are chiefly due to the tuberculous peritonitis present. Tuberculous peritonitis is often a terminal event in hepatic cirrhosis.

Blood Examination.—The red cells are usually diminished in all forms of peritonitis, to a slight or moderate degree in acute forms, but in the chronic cases the anemia may be marked. During the acute febrile stage the leucocytes are usually slightly increased. In purulent peritonitis the leucocytosis may be more marked, but sometimes is not present or the leucocytes may even be diminished. In perforative peritonitis the beginning of the inflammation may be marked by a leucocytosis. In typhoid fever perforation may be marked by an increase of the polymorphonuclear leucocytes, or the percentage of these may rise without an increase in the total number, or the leucocytes may not be affected. Likewise in appendicitis a very high leucocytosis is suggestive of a beginning peritonitis. In tuberculous peritonitis without obstruction and secondary infection with pyogenic organisms, the leucocyte count is usually low. As a rule leucocytosis in this disease is a sign of a complication.

Hysterical Peritonitis.—Cases have been reported of hysterical conditions in which all the symptoms of peritonitis were simulated: sudden onset, abdominal distention, pain and tenderness, vomiting, symptoms of collapse, etc. Fever may also be present. The cases usually give a history of recurrent attacks without apparent cause. Other hysterical symptoms may be wanting so that a mistaken diagnosis may easily be made.

Prognosis.—This is very grave. Abdominal distention, rapid pulse, low temperature and absence of leucocytosis constitute a bad prognosis. The streptococcus form is the most fatal, next in severity are the *B. pyocyaneus* and *B. coli* infections, while the forms of peritonitis due to the white staphylococcus, pneumococcus, and gonococcus are less serious. In perforative peritonitis the prognosis is fatal without operation; and better in the case of perforation of the upper portion of the gastrointestinal tract than of the lower.

Treatment.—The treatment of acute peritonitis has been much discussed in recent years, particularly from the operative side, and as a result of improved surgical methods the prognosis in this so frequently fatal condition has been greatly improved. There is much conflicting opinion as to the exact details of the treatment, and various writers even disagree as to more essential points. A survey of the literature, however, seems to indicate that the principle of early surgical interference is gaining ground. As a prophylactic measure in the case of an impending perforation operation has in some quarters met with notable success. In the case of all laparotomies various prophylactic measures are now employed against probable infection of the peritoneum, such as the injection into the peritoneal cavity of hot horse serum or saline solutions. With improvement of the surgical technique much may be hoped from the early surgical treatment of cases of acute general peritonitis, and it is not improbable that this disease, at present so dreaded, may be divested of much of its importance.

The older treatment may be summed up as follows: rest, opium or morphine, local applications, hot or cold, local application of leeches, milk diet, ice, small quantities of soda water, etc. In cases of distention the intestines were sometimes tapped with a fine trocar. The intestinal tube was also used to remove gas from the large bowel. Much discussion has also been waged over the use of salines in this condition, some authorities advocating them as an aid to the removal of the exudate, others condemning such use on the ground of danger in the case of intestinal lesions.

While in general the above outline of treatment is still carried out in many cases, important modifications have been made, and the surgical treatment is coming more and more to the foreground. Mikulicz, Krönlein, Oberst, Wagner, Trever, Péan, and Körte were among the first to advise laparotomy for general peritonitis. Many other writers have recently followed in their lead. The objects of the laparotomy are the removal of the infected focus, the prevention of new infection and the removal of exudates, by proper drainage when necessary. The patient is put in Fowler's position at an angle of thirty-five to forty degrees, both before the operation and afterward. In paralysis of the intestines they should be emptied by incision, or the insertion of a Paul tube. Injections of purgatives of magnesium sulphate by a syringe into the intestine during operation, hypodermic injections of physostigmine or extracts of the posterior lobe of the pituitary, enemas, saline purgatives, administration of calomel in repeated doses, etc., have been advocated but are not recommended by the majority of writers. Enemas and subcutaneous injections of physiologic salt solutions should be given to prevent collapse and toxemia, and to relieve thirst. No food or drink should be given by the mouth. Stomach lavage may stop the vomiting; the rectal tube should be used for the tympanites. Local applications to the abdomen are of no value. Morphine should not be used except in inoperable cases. Serum treatment (horse or human immune serum) may be employed intravenously. The operative treatment in general consists of opening the abdomen, removing the exudate as completely as possible, the so-called "toilet of the peritoneum," and after-drainage. The earlier in the disease, especially in the case of perforative peritonitis, the more likely is the operation to be successful. Authorities differ in their views as to the value of washing out the peritoneal cavity. Some recommend very highly the use of large quantities of sterile physiological salt solution, all parts of the abdomen being thoroughly flushed. This seems a rational proceeding, and from the published reports a number of cases have undoubtedly been saved by it. Appropriate general treatment is of course given, intravenous saline injections being freely used during the after-treatment. In those cases in which adhesions have already formed the washing out of the exudate is more difficult and less perfect. This fact is therefore the chief reason for operating as early in the disease as possible. Mikulicz advises several incisions for the purpose of draining and flushing localized collections of exudate.

On the other hand, Krogius does not advise the flushing out of the cavity, apparently for the reason that he does not think it accomplishes the desired purpose. He recommends the dry absorption of the exudate, all parts of the peritoneal surface being thoroughly mopped with sterile gauze compresses and particular attention being paid to the pelvis and the subphrenic space. In order to render all parts of the peritoneum accessible he makes two incisions through the abdominal wall, one along the lateral border of the right rectus, the other along the lateral border of the left. If the exudate in the pelvis cannot be removed through these openings, he advises a counteropening in the posterior wall of the fornix vaginæ in women, and a parasacral opening in males. After cleansing the peritoneum as perfectly as possible,

large Mikulicz iodoform tampons are placed in the pelvis and in the upper and lower portions of the abdominal cavity. These become offensive in a few days and are renewed, the outer dressings being frequently changed. In addition he uses intravenous saline injections, intestinal irrigation, and morphine when necessary. The occurrence of secondary collections of exudate, particularly subphrenic abscess, should be watched for and when found they should be opened and cleansed. Although these principles are applied chiefly to perforative peritonitis occurring in appendicitis they may be utilized in the treatment of all forms of acute general peritonitis.

The surgical treatment is particularly applicable to local circumscribed peritonitis. The encapsulated exudate should be evacuated by incision or puncture, and the cavity washed and treated as a chronic abscess cavity. The details concerning drainage, packing, after-treatment, etc., must be left to the judgment of the operator.

In the case of subphrenic abscess an incision may be made at the edge of the ribs, or the transpleural route may be followed by resecting several ribs. In the chronic forms with multiple adhesions relatively little can be expected from operative procedures. The treatment is symptomatic and palliative. Paracentesis should be performed when necessary.

In the case of tuberculous peritonitis laparotomy is at present the only method of treatment offering hope of improvement or cure, and is universally advised for this condition. The fact that a tuberculous peritonitis may spontaneously heal after laparotomy was accidentally discovered by Spencer Wells in 1862. So much has been written upon this subject that the reader is referred to some one of the recent monographs relating to it. The relation between the laparotomy and the cure of the tuberculosis is wholly unknown, although numerous theories—effects of daylight, evaporation, irritation of the peritoneal surface, promotion of healthy granulation-tissue formation, increase of the peritoneal resistance, hyperleucocytosis, increased bactericidal action of the exudate, etc.—have been advanced in explanation. Surgeons differ very much in the details of technique in their operations upon such cases. Some open the abdomen and remove the exudate with dry sponges; others flush with warm physiological salt solution; others still wash out the cavity with solutions of salicylic acid, etc. There is also a difference of method in regard to the removal of the organs (tubes, lymph glands, etc.) primarily affected. In general it may be stated that laparotomy is indicated in all cases of tuberculous peritonitis in which the general condition of the patient permits, or in which there is no evidence of cerebral, pulmonary, or extensive glandular or bone tuberculosis. Schömann has advised the use of injections of an emulsion of iodoform into the cavity. Schulze has recommended the intraperitoneal injection of oxygen. The medicinal treatment of tuberculous peritonitis is advised in some cases, the administration of iodoform as well as its use by inunction having been reported as resulting in cures. Cases of cure have also been reported as following the use of tuberculin.

Very recently a number of writers have been advising conservatism in the treatment of acute general peritonitis by operation. Those who advocate a medicinal method modify the older methods by giving no food by the mouth, employing rectal feeding, allowing no ice, checking thirst by wet gauze to lips and by rectal injections, giving no cathartics, administering small doses of morphine, and applying continued cold to the abdomen. This treatment is based upon the theory that the peritoneal exudate itself may weaken the virulence of or destroy the germs gaining entrance to the cavity. Alcohol has been strongly advised in the treatment of puerperal peritonitis, large and frequent doses being given.

The injection of purgatives directly into the intestinal canal has been advised and as strongly condemned.

Some surgeons advise against operation in sthenic cases of perforative peritonitis without symptoms of sepsis, on the ground that spontaneous resolution may occur. There is, however, a great danger that such cases may under the influence of morphine be allowed to drift along until too late.

Hot vaginal douches have been strongly recommended in cases of pelvic peritonitis. If the external genitals are protected injections of water at 40° C. may be given without discomfort. The pelvis should be elevated, and about four to five liters of water used for the irrigation daily. Tampons of glycerin or potassium iodide with glycerin are applied after the irrigation. Stratz in particular claims good results from the application of this method in pelvic peritonitis associated with pyosalpinx.

The statistics of the results of the treatment of acute general peritonitis by operation are very encouraging. Krogius in his monograph published in 1901 has made an elaborate study of the results of operation in general peritonitis following appendicitis. The percentage of cures ranged from 28.5 to 46.

Surgical interference in the case of impending perforation of gastric or intestinal ulcers, appendicitis, rupture of sac in ectopic gestation, salpingitis, necrotic ovarian cystomata or subserous uterine fibromata, hemorrhagic pancreatitis, etc., has proved of the very greatest value as a prophylactic measure. With improved methods of diagnosis much may be hoped for by the further development of such prophylactic operations.

The literature of peritonitis is enormous. Collections of bibliography will be found in the article by Döderlein in Veit's "Handbuch der Gynäkologie," and in the one by Eichhorst in Eulenburg's "Real-Encyclopädie." An exhaustive review of the literature of peritonitis from the year 1885 to 1900 is given by von Bruns (*Cent. f. allg. path. Anat.*, 1901.)

ALDRED SCOTT WARTHIN.

Perlèche (French *lécher*, to lick) is a superficial ulcerative involvement of the angles of the mouth, contagious in character, and is mainly noted in school children who have acquired it from a drinking utensil used in common with other children. The condition usually starts as a rough brownish patch at the angle of the mouth which later becomes grooved and then fissured. Itching and burning cause the child to lick the part which in turn frequently causes the infection to spread over the mucous surface of the lips. The lips may become considerably swollen and painful. The infection often runs its course in from ten to twenty days and is followed by desquamation. No definite organism has as yet been discovered as the cause of this infection though Le Maistre reports the presence of an aerobic streptococcus and Raymond a variety of staphylococcus. Treatment directed toward the early disinfection of the parts involved, by the application of the tincture of iodine or a mild nitrate of silver solution may abort the attack. Wet boric acid compresses during the day and oxide of zinc ointment at night or dusting powders such as bismuth subnitrate or aristol will be found to be beneficial.

MORRIS I. SCHAMBERG.

Peronine—benzyl-morphine hydrochloride, C_6H_5-CH_2.O.OH.$C_{17}H_{17}NO$.HCl—is an odorless, bitter white powder, composed of prismatic crystals and having the nature of an alkaloid. It is soluble in the proportion of less than one per cent. in cold water and in ten parts of boiling water, and is nearly insoluble in alcohol and chloroform. It is closely related to codeine, dionine, heroin, and morphine. It

is used as a substitute for morphine and codeine in various respiratory affections; it is also slightly analgesic and hypnotic. It is employed in tuberculosis, whooping-cough, emphysema, bronchitis, and similar affections in doses of gr. $\frac{1}{3}$–$\frac{5}{6}$ (0.02–0.05).

W. A. Bastedo.
R. J. E. Scott.

Peroxidase.—Peroxidase is the name applied to an enzyme supposed to effect oxidation in the presence of a peroxide, thus differing from an oxidase assumed to need the presence of oxygen only. The peroxidases act upon peroxides causing them to give off their oxygen in a form capable of producing oxidation. Peroxidases have been described in the blood, in pus cells, lymphoid tissue generally, and in sperm cells. See also *Enzymes*. F. P. U.

Persimmon.—*Diospyros.* Under the name persimmon, both the bark and the unripe fruit (chiefly the latter) of *Diospyros virginiana* L. (fam. *Ebenaceæ*) are considerably employed as astringents, particularly in the southern United States. The bark looks not unlike oak bark with the corky layer still upon it. The fruit in the unripe condition is green, drying dark brown, of globose form, and nearly an inch in diameter. It contains several flattened oval or ovoid seeds. Before maturity the persimmon is one of the most astringent of substances, but after thoroughly maturing, and especially after being attacked by frost, this astringency is mostly lost and it becomes sweet and edible. The only important constituent of both drugs is the tannin, and their uses are purely astringent, similar to those of geranium, sumac, etc. The common method of employment in the household is in the form of an infusion or decoction; only the fluid extract is employed by the medical profession. The dose of either the bark or the fruit should amount to ʒ ss. to ʒi. or ij. (2.0 to 4.0 or 8.0). Henry H. Rusby.

Persio.—Cudbear, *Red Indigo.* The coloring matter prepared from species of *Lecanora, Roccella,* and other lichens. It occurs as a purplish-brown powder and is used in the form of a tincture as a coloring agent in pharmaceutical preparation. The National Formulary contains a simple tincture (*Tinctura Persionis*), of a bright red color, prepared by percolating cudbear with a menstruum of alcohol, one part, and water, two parts; and a brownish-red compound tincture (*Tinctura Persionis Composita*), prepared by maceration of cudbear and caramel with alcohol of the same strength as that used in the simple tincture. Henry H. Rusby.

Peruscabin, benzoic acid benzyl ester, is an artificial product representing the active constituents of balsam of Peru. It is odorless, non-staining, and non-irritating, and is highly recommended by R. Sachs for the treatment of scabies. Diluted with three parts of castor oil, it is applied over the whole surface every twelve hours. The cure is said to be absolute, and no irritation whatever is produced, even in an area affected with eczema or dermatitis.

W. A. Bastedo.
R. J. E. Scott.

Pes Gigas.—Pes gigas, or macropodia, is the name given to a condition of congenital hypertrophy affecting either the foot alone (whence the name) or the leg and the foot. It may be unilateral or bilateral, the former being the more common; the left side is more often affected than the right. Pes gigas is found in two forms: (1) a form in which the hypertrophy is *true* or *symmetrical;* here the whole foot, or leg and foot, suffer a general hypertrophy, the symmetry and contour of the part being observed, and the only abnormality being the enormous size. (2) The *false* or *asymmetrical form,* in which only certain parts are affected; this is the more common variety, and generally shows itself in the enormous development of one or two toes, or in large fatty excrescences, or in hypertrophy of some of the muscles of the calf of the leg. The cause of pes gigas is unknown.

The skin is always involved, and, in addition to the hypertrophic condition, the cutaneous sensibility may be absent or diminished; it is never increased. In hypertrophy of the toes the nails generally enlarge *pari passu* with the other parts. The subcutaneous fat is increased in amount and is apt to be irregularly disposed in lumps. When the toes are affected the metatarsal and phalangeal bones are always enlarged; but this enlargement is general, and the only deformity noted is an outgrowth at the extremity of the bone, at the junction with the articular cartilage. The condition of the joints involved is variable; sometimes the motion is normal, sometimes it is limited, and sometimes there is complete ankylosis. Passive mobility may or may not be elicited; the ligaments are thickened.

The *treatment* is not satisfactory. (1) *Pressure* in various forms has been recommended; but, besides being tedious in its application, uncertain in its effects, and decidedly painful, it is not free from danger; and hemorrhage, ulceration, and erysipelas have ensued from this method of treatment. (2) *Ligature of the main artery* has also been suggested; but this method, too, has not been characterized by brilliant results. (3) *Amputation of colossal toes* and judicious trimming of superfluous tissue will give a presentable and serviceable extremity. This is probably the best procedure. R. J. E. Scott.

Petechiæ.—These are small, round, blue-red or purple spots or points in the skin, or in the serous or mucous membranes, that cannot be made to disappear by pressure. They are usually not elevated above the surface. They are caused by minute extravasations of blood into the subepithelial or subserous tissue. They arise for the greater part through diapedesis, and occur chiefly, though not exclusively, on the dependent portions of the body, particularly over the legs. They are often localized in the hair follicles. In the serous membranes they are found most often in the posterior wall of the pleural cavity, and on the posterior portion of the epicardium and pericardium. In the mucous membranes they occur most frequently in the conjunctivæ and mouth, but may be found in any part of the body. According to their etiology petechiæ may be classed as *traumatic, infectious, toxic,* and *neuropathic.*

Petechiæ may be produced by the bites of fleas (*purpura pulicosa*). These may be mistaken for purpura or other hemorrhagic diseases. They may be distinguished from the latter by the fact that the puncture caused by the flea shows as a darker point in the center of the spot, and by their greater abundance over the trunk. Localized petechiæ may occur also as the direct result of certain forms of trauma, and may be of medicolegal importance in the establishment of the occurrence of trauma.

Petechiæ occur also in the course of many of the acute infections: *scarlet fever, variola, diphtheria, endocarditis, plague, yellow fever, cholera, anthrax, septicemia, measles, typhus fever, rheumatism, typhoid, acute yellow atrophy, etc.* The cases in which such hemorrhages occur are usually more severe than the non-hemorrhagic ones. The different forms of the primary purpuras are also characterized by the occurrence of petechiæ in the skin and mucous membranes:

purpura simplex, purpura rheumatica, morbus maculosus Werlhofii, and *Barlow's disease.* In the last-named, innumerable minute hemorrhages may occur throughout all of the internal organs. In *scurvy* petechiæ occur in the skin, in the mucous membranes, and in the pleura, pericardium, endocardium, and peritoneum. It is very probable that the purpuras are infectious diseases, in part caused by the streptococcus, in part by bacteria not yet recognized. Hemorrhagic septicemias with cutaneous or subserous petechiæ, are most frequently due to streptococcus infections, but may also be caused by staphylococci, gonococci, *B. aërogenes capsulatus,* etc.

Petechiæ may result also from a lowered nutrition of the vessel walls, as in *starvation, pernicious anemia, leucemia, cachexia of malignancy,* etc. It is very probable that in these conditions there is an intoxication which is the chief factor in causing the changes in the capillary walls. Petechiæ occur also in *icterus, nephritis,* poisoning with *bromine, iodine, phosphorus, arsenic, snake-venom,* etc. Petechiæ have also been observed to follow the use of *quinine.*

In chronic passive congestion of marked degree petechiæ may be formed in the body surfaces and also in the internal organs. Petechial hemorrhages in the skin are also seen in fat embolism after fractures of the long bones, as the result of embolism of small cutaneous arterioles.

Petechiæ may arise as the result of excessive emotion, or during the hysterical or hypnotic state (stigmatization).

As diagnostic and prognostic aids petechiæ are of great significance. The size, location, conditions of occurrence, etc., are all very important factors.

ALDRED SCOTT WARTHIN.

Petit, Jean Louis.—Born at Paris, France, March 13, 1674. Even as a mere lad he showed a decided taste for the study of anatomy. On several occasions Mareschal, the surgeon-in-chief of La Charité, happening to visit the hospital at an unusually early hour of the morning, found Petit asleep at the door of entrance; his object being to secure the very best place from which he might witness Mareschal's operations. From 1692 to 1697 he followed the army in its movements through the region about Lille, Mons, Cambrai, and Tournai, and managed to pick up a good deal of surgical experience. In 1698 he returned to Paris and resumed the regular study of medicine. On March 27, 1700, he received the degree of Master of Surgery. Afterward, he gave for some time public courses of instruction in anatomy and operative surgery in the medical schools. Then he established, at his residence, a private school of anatomy and surgery; and many of those who were his pupils during this period of his career, became later, toward the middle of the eighteenth century, the most distinguished physicians and surgeons in Europe. He kept up these private courses for a long time, abandoning them at last only when he was forced to do so through the demands of his private practice. As was to be expected, Petit's remarkable success excited the jealousy of his rivals, who did their best to belittle his merits. Notwithstanding this, his reputation steadily increased, and he eventually acquired an immense practice. His death occurred April 20, 1750.

At the time of his death he had already been working for twelve years on his "Traité des maladies chirurgicales et des opérations qui leur conviennent" (published by de Lesne, Paris, 1774, in 3 volumes, with 90 illustrations), but he had not been able to complete the book. Of his other published writings the following deserve to be mentioned: "Traité des maladies des os, dans lequel on a représenté les appreils et les machines qui conviennent à leur guérison," Paris, 1705. (An edition in 2 volumes, published at Paris in 1759, contains an historical and critical discourse by Louis on the subject matter of the book.) The following articles are a few of those which Petit published in the Mémoires de l'Académie des Sciences: "Propriété et description d'une machine de nouvelle invention, servant à réduire les os cassés et démis; ensemble la manière de s'en servir," 1716; "Observation sur un ulcère carcinomateux qui perce le fond de l'estomac en dedans, et les tégumens," 1716; "Description d'une nouvelle boite pour les fractures compliquées de la jambe," 1718; "Sur la rupture des tendons qui s'insèrent aux talons, que l'on nomme tendons d'Achille," 1722; "Sur les chutes qui causent une luxation de la cuisse, dont les auteurs n'ont point écrit," 1722; and "Sur la tumeur qu'on appelle anévrysme," 1734.

A. H. B.

Petrifaction.—The deposition, in the tissues, of solid, crystalline, amorphous, or granular salts of lime, magnesium, or uric acid is known as *petrifaction* or *petrifying infiltration.* When the deposit consists of lime salts or of a combination of salts of lime and magnesium, the process is usually spoken of as *calcification* or *calcareous infiltration.* A physiological calcification takes place during the process of ossification of the skeleton; in this case the deposit of lime in osteoid tissue is an essential step in the development of a new tissue. All other deposits of lime salts within the body tissues must be regarded as being of a pathological nature.

With the exception of the new formation of bone in the repair of fractures and in tumors, calcification is essentially a retrograde change, the precipitation of the phosphates and carbonates of lime and magnesium occurring only in degenerating, dying, or dead tissues. In old age a deposit of lime salts occurs in the walls of the arteries, in the costal and laryngeal cartilages, in the walls of the capillaries of the lungs, stomach wall, and kidneys. This phenomenon is explained as due to an excess of lime salts in the blood, resulting from an excessive absorption of lime salts from the bones. Preceding the deposit of lime salts there occur certain retrograde changes characteristic of old age—hyaline change of the blood-vessel walls, etc. This calcification of old age is of such common occurrence as to warrant its being regarded as physiological. The resorption of lime salts from one tissue and their deposit in another is known as *metastatic calcification.* Such a metastasis of lime salts from the bones occurs in osteomalacia, syphilitic osteoporosis, and as the result of malignant tumors growing in the bones. It is worthy of note that in such cases the organs most frequently showing these metastatic deposits of lime are the lungs, stomach, and kidneys, all three of these organs being concerned in the secretion of an acid, carbonic, hydrochloric, and uric acids respectively. The nature of the chemical affinity existing between these tissues and lime salts is not yet understood. Tissues having an affinity for calcium salts also possess an increased affinity for iron. Calcification of the mature placenta is also of such frequent occurrence as to be regarded as physiological. The presence of brain sand in the choroid plexus and pineal gland is so universal that this may also be included under the head of physiological.

Calcification occurs most frequently as a sequel to fatty degeneration, hyaline change, cloudy swelling, simple or caseous necrosis. It is found in sclerotic vessels, endocardial thickenings, hyaline thickenings of dura, peritoneum, pleura, and pericardium, in the interstitial tissue of hyaline goiter, in corpora fibrosa of the ovary, old tubercles, gummata, old abscess cavities, inflammatory exudates, and in thrombi (arterioliths or phleboliths). A deposit of lime salts may occur in anemic or hemorrhagic infarcts, focal necroses, in dead ganglion cells, in encysted trichina, and in the necrotic areas of tumors. It occurs also in

osteoid and hyaline connective tissue of tumors, and in psammomata. The connective-tissue stroma of both carcinomata and sarcomata not infrequently shows calcification (*sarcoma* and *carcinoma petrificans*). Myofibromata of the uterus very frequently show a greater or less degree of calcification. Lime salts are also deposited in the dead fat cells in cases of fat necrosis; the free fatty acids resulting from the action of the fat-splitting ferment combine with calcium salts to form a calcium soap. Calcification of the renal epithelium follows the cloudy swelling produced by such poisons as mercuric chloride, carbolic acid, bismuth, aloin, etc. Retained decidua or chorion, or portions of the dead fetus and its membranes, may become calcified (lithocelyphopedion), or the sac may rupture and the fetus escape into the peritoneal cavity, later becoming calcified (lithopedion).

Calcified tissues are hard and white and sharply outlined; the area affected may be large or small. The lime salts may be dissolved out by the action of acids, in the case of carbonates with the formation of carbonic acid. Microscopically, deposits of carbonates or phosphates stain deep blue or violet with hematoxylin. Silver nitrate solution produces in calcium phosphate deposits a yellow silver phosphate which under the action of light is reduced to black (von Kossa's method).

A deposit of uric-acid salts occurs particularly in gout. The gouty deposits consist chiefly of sodium urate with small amounts of carbonate and phosphate of lime. The tendon sheaths, synovial membranes, ligaments, articular cartilages, kidneys, skin, and subcutaneous tissues are chiefly affected, but the deposits may ultimately be found in nearly every organ of the body. The larger deposits, called *tophi*, form large rounded masses, of a white, plaster-like substance, which are found particularly in the joints and tendons.

The individuals exhibited in museums as "petrifying" or "ossifying," are either cases of myositis ossificans or of scleroderma.

Petrifaction of the tissues of the body after death may occur under certain conditions, but is probably very rare. The majority of cases reported as such are in reality examples of adipocere formation. Very little is known with certainty regarding the petrifaction of the cadaver. Petrified or fossilized bones of the human race are very rare. Such have been reported to have been found in caves and in bog deposits whose waters were impregnated with iron and lime. In old bones there may sometimes occur a crystalline arrangement of phosphate of lime, or the bony structures may become so impregnated with mineral elements that its color and consistency become greatly changed. It is very probable, however, that a complete replacement of the elements of the bone or of the body tissues with mineral constituents is of very rare occurrence. (See also *Calcification*.)

ALDRED SCOTT WARTHIN.

Petrolatum.—PARAFFIN.—The word *petrolatum* stands, both in Latin and in English, as the official title in the United States Pharmacopœia for an unctuous derivate of petroleum, obtained by distilling off the lighter and more volatile constituents of the oil and purifying the residue. Three grades of petrolatum are official, the difference being in consistence only. They are entitled, severally, *Petrolatum*, *Petrolatum Album*, White Petrolatum, and *Petrolatum Liquidum*, Liquid Petrolatum. The first (which was formerly known as *Petrolatum Molle* and *Petrolatum Spissum*) is an unctuous mass of about the consistence of an ointment. *Petrolatum Album* is also of the consistence of an ointment; while *Petrolatum Liquidum* is an oily transparent liquid. *Albolene* and *Vaseline* are forms of Petrolatum. Petrolatum consists principally of a mixture of paraffins (hydrocarbons of the formula C_nH_{2n+2}), but probably also contains some olefins (hydrocarbons of the formula C_nH_{2n}), which, by their softer consistence, tend to increase the unctuousness of petrolatum. Petrolatum is a whitish or yellowish material, more or less fluorescent, tasteless, and with no odor, except when heated when a faint odor of petroleum is perceptible. It is entirely amorphous, and, in fluid condition, makes a transparent liquid. It is neutral in reaction. It is insoluble in water; scarcely soluble in alcohol, or in cold absolute alcohol; but soluble in boiling absolute alcohol, and readily soluble in ether, chloroform, disulphide of carbon, oil of turpentine, benzine, benzol, and in fixed or volatile oils. When heated on platinum foil, it is completely volatilized without emitting the acrid vapors of burning fat or resin.

Petrolatum owes its medicinal value to its combining with the physical attributes of the semi-solid fats the chemical peculiarity of the paraffins of being practically unalterable and indifferent to chemical agents. Petrolatum neither hardens nor turns rancid by exposure, and can be treated with any chemical likely to be prescribed medicinally in an ointment without being itself attacked thereby. The substance is, therefore, available, either by itself as a simple unguent, perfectly bland and changeless, or as the fatty basis for medicated ointments.

Recently, *liquid petrolatum* has been employed in the treatment of intestinal stasis and chronic constipation. Lane recommends that the petrolatum used in these conditions should be of a specific gravity of 0.885 to 0.890 at 15°C. The action of the petrolatum is only mechanical, since it is neither absorbed nor dissolved in the intestine. It is given in doses of one or two tablespoonfuls (for children as many teaspoonfuls) morning and evening half an hour before meals, this amount being gradually reduced as the desired effect is obtained.

EDWARD CURTIS.
R. J. E. SCOTT.

Petrosulfol is ammonium ichthosulphonate, a sulphur-containing bituminous product closely resembling ichthyol, but with a less disagreeable odor. It is miscible with water or oil, and is used as a general succedaneum for ichthyol.

W. A. BASTEDO.
R. J. E. SCOTT.

von Pettenkofer, Max.—Born at Lichtersheim, Bavaria, near Neuburg, on the Danube, Dec. 3, 1818. He studied medicine and, more particularly, chemistry, at the universities of Munich, Würzburg, and Giessen, and received his doctor's degree in 1843 from the first of these institutions. At about this period of his career he published a series of valuable memoirs on topics belonging to the domain of physiological chemistry—as, for example, "Ueber eine neue Reaction auf Galle und Zucker," in Liebig's Annalen, 1844; "Ueber den Schwefel-Cyangehalt des menschlichen Speichels;" "Ueber Hippursäure in Harn," etc. In 1847 he was chosen Professor Extraordinary of Dietetic Chemistry in the University of Munich, and from this time forward he turned his attention almost exclusively to the consideration of hygienic problems. The articles which he published during these early days of his professorship marked an epoch in the history of sanitary science. The subjects discussed were the following: "Bestimmung der Kohlensäure in der Luft und im Wasser;" "Ueber die Ventilationsverhältnisse in den Wohnungen;" "Ueber die physikalischen Verhältnisse der Kleidung, etc.;" "Ueber den Unterschied zwischen Ofen- und Luftheizung;" "Ueber den Luftwechsel durch das Mauerwerk;" "Ueber die Bodenluftverhältnisse;" etc. It is therefore proper to speak of von Pettenkofer as having laid the foundations of experimental hygiene. In 1853 he was made a full professor. In 1855 he began a series of investigations into the relations between

Asiatic cholera and the ground water. He urged upon the Government the wisdom of establishing in Bavaria three separate hygienic institutes, each under the directorship of a Professor of Hygiene; and the plan which he proposed was soon adopted. The first of these institutes was built in Munich in 1875, and placed under von Pettenkofer's charge; and, before long, similar ones were established in other European cities. Besides aiding very materially in bettering the sanitary conditions of the cities and countries in which they were located these institutes served as training schools for a class of expert sanitarians. In 1873 von Pettenkofer was made President of the Cholera Commission summoned by the German Government; in 1883 he was made a noble (hereditary); and in 1889 he was chosen President of the Bavarian Academy of Sciences. He shot himself, on Feb. 10, 1901, in a fit of depression, at his home on the Starnberger See, near Munich.

In addition to the memoirs already mentioned, the following published writings from von Pettenkofer's pen deserve to receive special mention: "Zur Aetiologie des Typhus," Munich, 1872; "Ueber den Werth der Gesundheit für eine Stadt," Braunschweig; "Vorträge ueber Kanalisation und Abfuhr," 1880; and "Der Boden und sein Zusammenhang mit der Gesundheit des Menschen," 1882. A. H. B.

Peyer, Johann Conrad.—Born at Schaffhausen, Switzerland, Dec. 26, 1653. He received the degree of Doctor of Medicine, in 1687, from the University of Basel, and then settled in his native city. He died Feb. 29, 1712.

Peyer's name has become permanently attached to certain intestinal glands ("Peyer's patches") which he was the first to describe in a somewhat careful manner. He also reported a fairly large number of observations that were interesting chiefly from the pathologico-anatomical viewpoint.

Of his published writings the following deserve to receive special mention: "Exercitatio anatomico-medica de glandulis intestinorum, earumque usu et effectibus; etc." Schaffhausen, 1677; "Schediasma de pancreate et ejus usu," in Brunner's *Experimenta nova circa pancreas*, Amsterdam, 1683; and "Parerga anatomica et medica septem, ratione ac experientia concepta et edita," Amsterdam, 1682. A. H. B.

Phænocystes.—A suborder of Myxosporidia, protozoan parasites usually found in fish. See *Protozoa*. A. S. P.

Phagedena Tropica.—This and the synonyms *ulcus tropicum* and *tropical gangrene* are terms loosely applied to many ulcerative and gangrenous processes observed in the tropics, especially to those that show no tendency to heal spontaneously or under simple treatment. The term *tropical gangrene*, and, more recently, the term *ulcus tropicum* have thus been applied at different times and by different writers to a great variety of lesions encountered in the tropics —among them, tuberculous and leprous lesions with or without streptococcic or other complicating infection, syphilitic ulcers, noma pudendi, blastomycetic dermatitis, leishmaniasis (Delhi boil or Oriental sore), the "blue button" of the West Indies, the "espundia" of Peru, the rapid or fulminating type of rhinopharyngitis mutilans, the "epidemic gangrenous rectitis" of Guiana and Venezuela, and the condition called sloughing phagedena or hospital gangrene which is rarely seen now in the temperate zone but which is still encountered occasionally in the tropics.

Neither *tropical gangrene* nor *tropical ulcer* is now used to designate any single definite disease due to a known cause, and both terms would be better dropped. J. F. Leys.

Pharmacopœia.*—(Greek φαρμακοποιΐα, from φάρμακον, medicine, remedy, and ποιεῖν, to make, to prepare; Latin, *pharmacopœa* or *pharmacopœia;* German, *Pharmakopöe;* French, *pharmacopée;* Spanish, *farmacopea*, etc.). A *pharmacopœia*, in the modern sense, may be defined as a book of standards for drugs, medicines and related substances, published by some recognized authority, for the purpose of securing uniformity in kind, purity, quality, strength, and composition. Although it gives instructions for the preparation of many articles, this is done merely to insure their proper character, and other methods may be employed, provided that they produce the required product. It may either be of a local character, or it may apply to a whole country. During the early history of pharmacopœias, the term was also often applied to works written or published by individuals, without the official sanction of governmental or professional authority.

Ancient and Medieval Precursors of Pharmacopœias.—While the ancient nations did not possess any works which could be fully set side by side with our modern pharmacopœias, yet the gradually accumulating mass of facts relating to the preparation and practical use of medicines resulted in the composition of numerous works which treated at least incidentally of this subject. In giving an account of the literature relating to the latter, we shall confine ourselves to those works the influence of which has, in one way or another, extended to our times.

Egypt.—Papyrus Ebers, 1552 B.C.; *Medical Papyrus of Berlin*, about 1350 B.C.; various formularies sculptured in stone.

India.—An examination of the oldest Indian literature, that of the Vedas, Brahmins, and Sutras, reveals little but superstition as to both diseases and remedies. The principal medical works of the Hindoos, viz., those of Charaka and Sucruta, cannot be traced back beyond the eighth century A.D., the foundations evidently having been derived from the Greeks. Most of these medical works are characterized, and their meaning is obscured, by the poetic or metrical style employed in them. Among the later medical treatises the most important are "Ashtângahridaya," by Vâgbhata, and the "Bhâvaprakâca," by Bhâva, both of them only a few centuries old. Regular treatises on pharmacy, or formularies, are not numerous (to the former belongs the "Prayogâmrita" of Vaidyachintâmani, and others); but treatises on materia medica or glossaries of simples are much more common. The most extensive of these is the "Nighanturâja," by Narahari, of Cashmere, being a dictionary of products of nature, etc., with synonyms. Another smaller but useful work is the "Madanavinoda" of Madanapâla.

Greece.—The writings of Hippocrates (about 460–377 B.C.) were the first, as well as the most important, in the early history of Greek medical literature. Although none of his genuine writings is devoted exclusively to the preparation of specific medicines, numerous such directions are contained in them, and the pharmaceutical art became developed during the succeeding centuries in proportion as the rational treatment of disease, upon the foundation laid by Hippocrates, spread through the cultivated nations of Europe and Western Asia.

Of those works which are known to have exerted a permanent influence upon the formularies of later times, that of Andromachus of Creta, Nero's court physician, next requires mention, being a sort of poetic formulary. He also wrote a poem on Theriac and its preparations, which for centuries was highly influential in medical practice. About 65 A.D.,

* This article is based upon the one contributed by Dr. Charles Rice to a former edition of this work. The records, I might add, have been brought up to date, and a few changes have been made in the interest of economy of space.—H. H. R.

Servilius Damocrates composed similar pharmacological poems, his compound of theriac, thus treated, being subsequently known as "Confectio Damocratis." In about 78 A.D., Dioscorides wrote his famous ὑλικά ("Materialia"), a most valuable cyclopedia of simples, which became one of the chief sources of pharmacological writers down to the Middle Ages.

The next important Grecian medical writer was Claudius Gallinus (131 to about 210 A.D.). His numerous writings exerted an influence equal to that exerted by the works of Dioscorides. His numerous complex mixtures gave origin to the term "Galenical."

Of later writers, the more important are: Aëtius, of Amida, in Mesopotamia (sixth century A.D.), Alexander, of Tralles, in Lydia (525–605 A.D.), Paulus, of Ægina (seventh century A.D.) and Nicolaus Myrepsus, of Alexandria (second half of thirteenth century A.D.). This work was written in Greek, but only the Latin translation has been published (first edition, Basle, 1549). In spite of its encyclopedic character, this formulary did not acquire as much reputation as the less extensive works of Mesue or of Nicolaus Præpositus.

Rome.—Previous to C. Plinius Secundus (23–79 A.D.) only the writings of M. Porcius Cato (234–149 B.C.) interwoven in agricultural treatises, need be mentioned. In the great work on "Natural History" by the former, many subjects relating to materia medica are treated. The "Compositiones Medicæ of Scribonius Largus" (first century A.D.) is the first literary production, having the nature of a formulary, of Roman origin. It contains the first correct description of the method of obtaining opium. A treatise by Rufus of Ephesus on cathartics was for a long time influential. Many other more or less important works by Romans were written in Greek.

Arabic Countries.—The Arabs were the first to develop the art of the apothecary and to establish regulations regarding the quality and price of his medicines, and specifying which of them were to be kept in stock for instant use. Their advent infused new life into the torpid condition of the medical and other sciences.

At the end of the ninth century, Shâbûr ben Sahl wrote a sort of dispensatory under the title of "Ibdâl" (Haji Khalfa, ed. Flügel, i., 142), and about the middle of the twelfth century Abû'l Hassan Hibetallah ibn Talmîd composed a similar work, entitled "Krabadin" or "Grabaddin" (Arabic, *quarâbâdîn*, or *qrâbâdîn*), which was commonly followed by Arabic apothecaries. The most important of these works was that composed by the younger Mesue (Mâswîyah el-Mârdinî, died 1015 A.D.), of Maridin, on the Euphrates, and of which only the Latin translation is extant, under the title "Antidotarium, seu Grabaddin Medicaminum compositorum." This remained for a long time the chief canon of pharmacy. It contains a large number of formulas arranged in twelve chapters, each treating of a different form (for instance, Pilulæ, Cerata, etc.) under which medicines are applied or administered. Not less than four Italian translations of this work appeared previously to the year 1500, and the Latin text was often reprinted.

The writings of the most celebrated of all Arabic physicians, viz., Avicenna (Abû 'Ali Hussain ben Abdallah, Ibn Sinâ, 978–1036 A.D.,) also contain many formulas which were incorporated in subsequent collections.

Other writers, whose works contributed in this direction, were Ibn Wâfid el-Lachmî (about 1050 A.D.), called Albenguefit in medieval literature, whose work on simples has been published only in Latin translation. Serapion the younger (Ibn Seràbî, about 1070 A.D.) was the author of a similar work, but this was much more esteemed and made use of than the former.

The most important Arabic writer on materia medica is Ibn Baitâr (about 1197–1248 A.D.). His work on simples and foods, based on his own observations and on the works of Greek, Arabian, Persian, and Syrian writers, is a perfect storehouse of information, and has exerted considerable influence upon the development of therapeutics and pharmacy among his countrymen.

Persia has little of interest to present in this direction. If we except a treatise on materia medica, based upon Greek, Arabian, and Indian sources, written by Alherwî (ninth century A.D.), we meet nothing of interest until the close of the seventeenth century, when Father Angel de la Brosse, de St. Joseph, published at Paris (in 1681) the "Pharmacopœa Persica, ex idiomate Persico in Latinum conversa." In 1771 Mîr Mohammad Hussian, of Khorasan, wrote a Persian pharmacopœia, and subsequently an encyclopedia of materia medica ("Makhzan el-adwiya," "Treasury of Medicines") of considerable merit.

Medieval Europe.—Among the works written during the Middle Ages, which either served themselves as pharmacopœias or formularies or at least contributed to their compilation, may be mentioned the following: The "Antidotarium" (also called "Antidotarium parvum," to distinguish it from the "Antidotarium" of Nicolaus Myrepsus) of Nicolaus Præpositus, of Salerno (first half of the twelfth century), This compilation, together with Mesue's "Grabaddin" (see under Arabic countries), constituted the most celebrated formulary of the Middle Ages (first edition, Venice, 1471). The "Compendium Aromatariorum" (first edition, Bologna, 1488), by Saladinus Asculanus, was a useful and much used work, as was "Luminare Majus," by Manlius de Boscho (first edition, Venice, 1496), a highly esteemed dispensatory. A counterpart of this is the "Luminare Minus" (Venice, 1517), of Quiricus de Augustis de Torthona. The "Antidotarium Florentinum" (first edition, Florence, 1489; often reprinted) is the first pharmacopœia or formulary published in Europe under governmental authority.

History of Pharmacopœias.—The literature of pharmacopœias is very extensive, and an exhaustive account is beyond the limits of this work. Yet, since a reliable list or sketch of at least the more important pharmacopœias is often of great use to those who have to consult medical works published in previous years, a condensed account of them is here given, arranged by countries; among the latter being included, for the sake of completeness, most of those which possess no regular pharmacopœia of their own, but use some other work either from choice or by command.

Note.—In quoting editions of the less important pharmacopœias, only the date of the first one is usually given. A plus sign (+) behind the date indicates that several editions followed. In some cases the date of several or of all editions is given. The word "pharmacopœia" is usually abbreviated to save space.

Austria-Hungary.—Dispensatorium Pharmaceuticum Austriaco-Viennense, 1729, repeatedly revised and reprinted; *Dispensatorium Medico-Pharmaceuticum Pragense*, 1739, which also saw several editions; *Pharmacopœia Austriaco-Provincialis*, 1774, several times revised and translated into German and Dutch; *Pharmacopœia Austriaca*, 1812, and six times reprinted previous to 1879, when a supplement appeared and then a new edition in 1890; a special military pharmacopœia, 1795, and many times reprinted; a separate work for Hungary in 1871, reprinted in 1888 as "*Magyar Gyogyszerkonvy; Masodik Kiadas.*" The latest edition to this appeared in 1909. A practical reprint of the edition of 1888, appeared as the Croatian Pharmacopœia.

Belgium.—Pharmacopœia Belgica, 1659; various works representing individual cities; *Pharmacopœia*

Batava, 1805; *Pharmacopœia Belgica Nova*, 1854, reprinted in 1885, and the last edition appearing in 1906.

Bolivia and *Brazil* are without Pharmacopœias. The Spanish, Portuguese, and French works are largely used, and the work of Cernowicz is highly influential.

British Empire.—Up to the year 1864, England, Scotland, and Ireland possessed each its own pharmacopœia. That for England was first published in 1618, under the title "Ph. Londinensis," by the London College of Physicians. It was several times reprinted with slight alterations, until 1650, when its second revision was published. Its tenth revised edition appeared in 1851. It was translated into various other languages, even into Hindustani (Calcutta, 1824).

The first pharmacopœia for Scotland was published by the Edinburgh College of Physicians in 1699, under the title "Pharmacopœia Collegii Regii Medicorum Edinburgensis." The subsequent editions or re-issues were very numerous.

The first pharmacopœia for Ireland appeared at Dublin in 1807, under the title "Pharmacopœia Collegii Medicorum Regis et Reginæ in Hibernia." Previously, however, a specimen pharmacopœia had been prepared and circulated already in 1794, and again in 1805. The Dublin Pharmacopœia was revised in 1826 and 1850.

In 1864 appeared the first "British Pharmacopœia" under the medical act of 1858. In 1867 a new edition was produced by the general medical council, and to this a supplement was published in 1874. In 1885 a new edition was produced by Professors Attfield, Redwood, and Bentley, under the direction of the Medical Council. In 1886 Attfield was appointed "reporter on the British Pharmacopœia to the Medical Council," his duty being to submit to the Medical Council annually a synopsis of current publications bearing upon the contents of the British Pharmacopœia, and making suggestions for its future improvement. The third reprint of the British Pharmacopœia appeared in 1888, and a supplement thereto in 1890. The fourth edition of this work was published in 1898, and the latest in 1914. The tendency in this, as in other modern pharmacopœias, is toward the elimination of antiquated and worthless articles, as well as those of complex composition.

The usefulness of the British Pharmacopœia is restricted by a wholly selfish, unscientific, and unprofessional refusal to permit the quotation of any portion of its text, even for purposes of comment or criticism.

One of the dependencies of Great Britain, viz., *India*, has a pharmacopœia of its own. In 1842, Dr. W. B. O'Shaughnessy issued, by order of Government (under the authority of the East India Company), "The Bengal Dispensatory" (Calcutta), as a precursor to "The Bengal Pharmacopœia and General Conspectus of Medicinal Plants" which he published at Calcutta in 1844. In 1868 a "Pharmacopœia of India" was published at the same place by Dr. Ed. J. Waring, under authority of the Secretary of State for India. This is now in force, alongside of the new British Pharmacopœia. The main object of issuing a separate pharmacopœia for India was officially to encourage and authorize the employment of East Indian drugs, among which are many possessing very valuable properties. A most useful companion to this work is the "Supplement to the Pharmacopœia of India," by Moodeen Sheriff, published by order of the Government of Madras, in 1869. This work contains synonyms of the pharmacopœial articles in fourteen languages. A revision of the pharmacopœia of India is in contemplation.

In 1887 the British Pharmaceutical conference produced the "Unofficial Formulary," containing thirty-seven articles, to which nine were added by a supplement published in 1889. The abbreviation of the title of this work is "U. F. B. P. C."

Chile.—In 1886 appeared the "Farmacopea Chilena," prepared by Dr. Adolfo Murillo, and published in Leipsic. Its text is Spanish, and it bears much resemblance to the French Pharmacopœia, though containing far fewer errors.

China.—This country has no official pharmacopœia, though there are numerous works of an unofficial character treating of such subjects, the best known and most extensive being "Pen tsao kung mu," of Lis-hi-chin, published about 1560 A.D. While containing much of value, its basis is largely superstitious.

Denmark.—In 1658 the "Dispensatorium Hafniense" was published at Copenhagen, and this was several times reprinted. The first official pharmacopœia appeared in 1772, the second in 1805, and the third in 1830. The last mentioned was, however, counted as the first work, the others not being regarded subsequently as deserving of the name. Hence the next edition, published in 1868, was designated as "Editio Secunda." Supplements to it appeared in 1874, 1876, and 1886. On August 1, 1893, a new edition went into effect. The latest revision is that of 1907. The text of the work is in Danish, the titles are in Latin. Much similarity exists between the Danish, Norwegian, and Swedish pharmacopœias, which is the result of deliberate design, as these countries are closely allied in customs, traditions, and language. A separate military pharmacopœia is in existence.

Ecuador.—The statements made concerning Bolivia apply also to Ecuador.

France.—In 1353 King John, "the good," commanded the apothecaries to follow the "Antidotarium" of Nicolaus Præpositus. Strict regulations regarding the practice of pharmacy were made in 1536, and frequently afterward. As early as 1546, a "Ph. Lugdunensis" was published at Lyons, which was several times reprinted. A French "Paraphrase sur la Pharmacopée" was issued by Briçon Bauderon, of Mascon, in 1588+. In 1590 the Paris Faculty of Medicine was directed to prepare a dispensatory; but, as nothing was done, Parliament, in 1597, ordered twelve members of the faculty, designated by name, to prepare the work. The order was, however, not obeyed. Several French cities early possessed pharmacopœias of their own, thus: Burdigal ("Ph. Burdigalensis," 1643); Strasburg (Ph. Argentoratensis," 1725+); Toulouse ("Codex Medicamentarius, seu Ph. Tolosana," 1648, 1695); Valenciennes ("Ph. Valentianensis," 1651). A new "Pharmacopée de Lyon" was also published by Vitet in 1788. The last-named work, to a slight extent, answered the purpose of a revised edition of the last Paris Pharmacopœia in some localities. In 1637 the "Ph. Parisina" appeared as a precursor to the first official Paris Pharmacopœia, which was issued in 1639 under the title "Codex Medicamentarius, seu Ph. Parisiensis, in lucem edita a Ph. Harduino." Revisions of this appeared in 1645, 1732, 1748, 1758. No further revision appeared then until, after an interval of sixty years, a national pharmacopœia was issued in 1818, under the title: "Codex Medicamentarius, seu Ph. Gallica," the text being in Latin. In the second and following editions the French language was chosen for the text, only the synonyms of the titles being given in Latin. These editions appeared in 1827 (ii.), 1839 (iii.), 1866 (iv.), and 1884 (v.). Immediately after the last revision had been issued very numerous errors were discovered in it, so that the Government was compelled to make a fresh issue, in which 132 alterations were incorporated; and a special pamphlet entitled "Erratum," was shortly afterward sent out, in which eighty-three additional changes were directed to be made. But this list of errata is not only itself not free from errors, but is far from being complete. In connection with the French Pharmacopœia should be mentioned the well-known work of Dervault, "L'Officine," constituting an exhaustive commentary

and supplement to the pharmacopœia. In some foreign countries, which do not possess a pharmacopœia of their own, this work is frequently followed as the principal authority, being used either in the original French or in Spanish translation.

Germany.—The first official formulary published in Germany was that of Valerius Cordus, published after his death by the city of Nuremberg in 1546, under the title "Pharmacorum omnium quæ quidem in usa sunt conficiendorum ratio; vulgo vocant Dispensatorium pharmacopolarun" (see *Am. Drug.*, 1887, 21). The work was often reprinted at home and abroad. There is a Paris edition of 1548, three of Lyon (1552, 1559, 1599), two of Venice (1556. 1563), etc. In the Nuremberg edition of 1592, great advances were made, chemicals first appearing as well as some artificial salts from ashes of plants and other substances. Extracts and distilled waters were also added. Other editions appeared in 1598, 1612, and 1666. This last edition contained nearly all classes of preparations of which we still make use, organic proximate principles being of course unknown. It certainly formed the basis upon which subsequent European pharmacopœias were constructed.

In 1538 the physicians of Augsburg prepared a sort of pharmacopœia and in 1564 the first edition of the "Ph. Augustana" was published, which was often revised. Cologne followed the example in 1565, by the publication of a "Dispensatorium," which was replaced by a "Ph. Coloniensis" in 1627.

The disunited condition of the countries inhabited by the German nation up to within recent times has been the means of bringing into the world a large number of independent pharmacopœias, for separate cities or principalities, of which a list follows here: Stralsund ("Actuarium Ph. Stralsundensis," 1645); Quedlinburg ("Quedlinburgensis Officina Pharmaceutica," 1665); Brandenburg ("Dispensatorium Brandenburgicum," 1698, forming the starting-point of the later Prussian pharmacopœias); Hanover ("Ph. Hanoverana," 1706; last edition, 1861); Hamburg ("Dispensatorium Hamburgense," 1716; "Codex Hamburgensis," 1835, 1845); Ratisbon ("Disp. Pharm. Ratisbonense," 1727); Munster ("Disp. Monasteriense," 1739); Würtemberg, ("Ph. Wirtembergica," 1741; last edition, 1847); the Palatinate ("Disp. Med.-Pharm.," 1764); Brunswick (Disp. Pharm. Brunsvicense," 1777); Würzburg ("Pharm. Herbipolitana," 1778; last edition, 1796); Westphalia ("Disp. Westphalicum," being identical with Piderit's "Pharmacia Rationalis" [see under Saxony], 1779); Fulda ("Disp. Fuldense," 1787); Bremen ("Pharm. in usum . . . Bremensis," 1792); Schaumburg-Lippe ("Disp. Lippiacum," 1792); Oldenburg ("Ph. Oldenburgensis," 1801); Hessen ("Disp. Electorale Hassiacum," 1806; "Pharm. Hassiæ," 1827, 1860); Erfurt ("Neue Pharmakopoë" . . . von Trommsdorff, 1808, was introduced by order of the French in place of the "Prussian Ph."); Saxony (in 1806, Piderit's "Pharmacia Racionalis," Cassel, 1779–81 was prescribed as Ph. In 1820 appeared "Ph. Saxonica," the last edition in 1837); Bavaria ("Ph. Bavarica," 1822, last edition in 1859); Schleswig-Holstein ("Ph. Slesvico-Holsatica," 1831); Baden ("Ph. Badensis," 1841).

Many of these were revised and republished a number of times.

The most important of all former German pharmacopœias has undoubtedly been the Prussian. This had its beginning in the "Brandenburg Dispensatory" of 1698, the last revision of which, or the sixth edition, appeared in 1781. In 1799, the first "Ph. Borussica," was published. The next editions came out in 1801 (ii.), 1813 (iii.), 1827 (iv.), 1829 (v.), 1846 (vi.; this is considered to have been the best pharmacopœia of its time); 1862 (vii.). Four editions of a separate Military Pharmacopœia were also published, the last one in 1868.

The problem of a united pharmacopœia for all German States had often been agitated, but in vain. In 1861 Dr. Walz proposed the publication of a German Pharmacopœia by private enterprise, which was to be recommended for adoption, or at least as a pattern, to the different German States. The work appeared in 1865, under the title "Pharmacopœia Germaniæ." A second edition was published in 1867, which, like the former, failed of recognition. It was only after the establishment of the German empire that the desired object was attained. In 1872 was issued the first "Ph. Germanica," superseding all the separate pharmacopœias at that time in force in German countries. Some amendments to this were published in 1873. The second edition, published in 1883, was prepared by a committee of thirty-three. It was published in both Latin and German and an English translation was published in New York in 1884.

A standing committee, appointed by the German Pharmaceutical Association, almost immediately undertook a critical revision of this work, and in 1887 a permanent pharmacopœia commission was created by the Government. In 1896 the third edition appeared under the title, "Arzneibuch für das Deutsche Reich. Dritte Ausgabe. Pharmacopœia Germanica. Editio III." The Latin language was abandoned and the text made wholly German, with the exception of the titles of the articles. In the work of its revision the pharmacopœia committee of the German Pharmaceutical Association was of the greatest value.

The example set by the United States (1886 to 1888) and Great Britain (1887), in preparing national formularies of unofficial preparations was followed by the pharmacists of Germany in 1891, when the German Pharmaceutical Association published a similar work under the rather awkward title: "Arzneimittel welche in dem Arzneibuch für das Deutsche Reich (Dritte Ausgabe; Pharmacopœia Germanica, Editio III.), nicht enthalten sind" ("Remedies which are not contained in the Arzneibuch," etc.). This contains 807 articles.

The fourth edition of the German Pharmacopœia was published in 1900. It exhibits the degree of progress which might reasonably be expected at the close of a decade so noted for research and criticism as that between 1890 and 1900. An unfortunate departure, however, is that of the uniform omission of the authorities of botanical names. In those cases in which there is but one such authorship, hence but one interpretation of the name, the omission is not serious; but there are some instances in which actual doubt as to what plant is intended may exist. Another unfortunate custom is that of placing the class name of a drug in advance of its individual name, in the title, as "Flores Malvæ" instead of "Malvæ Flores."

The influence of the German Pharmacopœia extends far beyond the geographical limits of the German empire. Outside of the United States Pharmacopœia there is probably no other, even not excepting the British, which is so frequently drawn upon by prescribers in this country.

Greece.—The first Greek Pharmacopœia was published in Athens under King Otto I., in 1837, and was based on the French, Bavarian, and various other German pharmacopœias existing at that time. It was reprinted, with a supplement, in 1868.

Italy.—Italy was the first country in Europe in which an official pharmacopœia was published. This was the "Antidotarium Florentinum," first published at Florence in 1498. Other similar works appeared at Mantua ("Antidotarium Mantuanum," Venice, 1559); Bergamo ("Ph. Bergomensis," 1580); Venice ("Ph. Veneta," 1617; "Codice pharmaceutico," 1790); Messina ("Ph. Messanensisis," 1629); Naples ("Antidotarium Neapolitanum," 1649); Turin ("Ph.

Turinensis," 1736); Sardinia ("Ph. Sardoa," 1773; the last edition, "Farmacopea per gli Stati Sardi," of 1853 is still in force); Bologna ("Antidotarium Coll. Med. Boloniensis," 1783); Genoa (Formulario farm.," 1791); Ferrara "Farm. Ferrarese," by Campana, 1799, etc.); Parma ("Ph. Parmensis," 1823; another edition of this appeared in 1839 for Piacenza, Parma, and Modena together). The Church States, Tuscany, Lucca, and many other Italian provinces follow a dispensatory published by Orosi, under the title "Farmacologia teorica e practica ovvero Farmacopea Italiana." Lombardy and Venice use the Austrian Pharmacopœia; Naples uses, besides other works, the "Ricettario farm. Napolitano," 1859. Throughout Italy a new work by Ruata, entitled "Farmacopea Nazionale e Generale, Materia Medica e Terapia" (Verona and Padova, 1883) is now frequently employed.

In 1892, a national work, the "*Farmacopeia ufficiale del regno d'Italia*, was published. Although one of the first to introduce requirements as to active constituents of drugs, it gave no methods of essay for them.

Japan.—In 1880 a commission of twenty-one members, several of them Europeans in the service of the Japanese Government, under the presidency of Mr. Hosoakwa, undertook the work of preparing a pharmacopœia, which was published in August, 1886, as an octavo volume of nearly 400 pages, the text in Japanese, under the title, "On yaku zuki Nippon yaku kiyoku ho." It consisted of an introduction, preface, and body, the latter comprising 475 titles, followed by general directions for keeping certain drugs and preparations, lists of reagents and volumetric solutions, lists of articles always to be kept on hand, list of separanda, maximum doses, tables of specific gravity and of elements, a Japanese and Latin index, list of errata, table of doses for adults and children, then another list of errata. The official text was in Japanese, the scientific chemical, botanical, and zoological terms in Latin, in Roman characters, with Japanese transliteration. In the treatment of the subject, the United States, British, and German Pharmacopœias were mostly followed, but the text showed also independent and careful work on the part of the compilers. The sign ⊳, placed under an unusual quantity of a powerful remedy, is to be used by prescribers for the same purpose as the exclamation point in European practice, viz., as an evidence that the prescriber intentionally ordered a large dose. The second edition of this work appeared in 1891, under the title "Pharmacopœia Japonica. Editio Altera. Tokyo, Anno xxiv. Meiji (1891)." It was wholly in Latin. It resembled its predecessor in general appearance and construction, but in the nomenclature of chemical substances, the last German and Austrian pharmacopœias were followed as guides. A revised edition of this appeared in 1907, and of this there was an English translation.

Liberia.—The United States and British pharmacopœias are usually followed.

Mexico.—The Pharmaceutical Society of Mexico, in 1874, published a pharmacopœia which was officially recognized by Government. It was one of the best pharmacopœias of its time. In 1884 a second edition was issued by the same society, the text of which was already completed at the close of 1881. Its title is "Nueva Farmacopea Mexicana de la Sociedad Farmacéutica de Mexico." It presents among other special features a very copious materia medica, paying particular attention to native products. The text is in Spanish in two columns. In general the work rather corresponds to what we would call a dispensatory, as it treats also of the medical properties and uses of the several drugs and preparations, and covers a good deal more ground than is usual for a pharmacopœia. It is a very carefully prepared and meritorious work.

Netherlands.—The frequent political changes in the Low Countries were not without influence upon the existence or validity of its pharmacopœias. Among the earlier works of this kind which may be mentioned here are the following, in cities now belonging to the Netherlands: Amsterdam ("Ph. Amstelodamensis," 1636; last edition, 1792, see below); The Hague ("Ph. Hagana," 1652; last edition, 1758); Utrecht ("Ph. Ultrajectana," 1656; last edition, 1749); Louvain ("Ph. Lovardensis," 1687; last, 1745); Harrlem ("Ph. Harlemensis," 1693; last, 1741); Dort "(Ph. Dordracena," 1708; last, 1766); Rotterdam ("Ph. Roterodamensis," 1709; last, 1835); Alcmar ("Ph. Alcmariensis," 1723); Groningen ("Ph. Groningana,'. 1724, '30). At one time the Netherlands belonged to Austria, hence the "Ph. Austriaco-Provincialis" was made official and a Dutch translation of this was published in 1781. After the establishment of the Batavian republic (1795–1806) a commission was appointed to draft a pharmacopœia. This was completed and published in 1805 under the title "Ph. Batava," and was a work of great merit, being by far the best of its time. This work has been extended and commented upon by Niemann (1811, second edition, 1824) in an excellent manner. In 1851 appeared the first "Ph. Neerlandica," the text being both in Latin and in Dutch. It had much resemblance to the French Codex. A revised edition, both in Latin and in Dutch, appeared in 1871, the Latin version being, as in the first edition, the official text. It contained 655 titles. In 1884 a Government commission was appointed for revising this work, and a new edition appeared in 1889 under the title, "Nederlandsche Pharmacopee. Derde Utgave (= third edition), 's Gravenhage, 1889." Excepting the titles of the articles, the text is entirely in Dutch. The fourth and last edition appeared in 1905. A Latin edition soon appeared under the title "Pharmacopœia Neerlandica. Editio tertia. Hagæ Comitis, 1889." It was specially decreed, however, that the Dutch edition was to be considered the official one.

In 1891 the Rotterdam branch of the Netherlands Pharmaceutical Society (Nederlandsche Maatschappij ter Bevordering der Pharmacie) followed the lead of other countries, by issuing an unofficial formulary under the title: "Supplementum op de derde Utgave der Nederlandsche Pharmacopee . . .'s Gravenhage, 1891." It contains 573 articles.

Norway did not possess a pharmacopœia of its own until 1854, the Swedish Pharmacopœia being used in the country up to that time. The "Ph. Norwegica" was revised in 1870, and this second edition was reprinted with additions in 1879. It contains some 510 titles. The text is in Latin. It much resembles the Swedish and Danish pharmacopœias, but the influence of the German Pharmacopœia is clearly perceptible.

Paraguay.—The French, Spanish, and occasionally other pharmacopœias are usually consulted.

Peru.—The French, Spanish, United States, and British pharmacopœias are usually drawn upon.

Poland.—See *Russia.*

Portugal.—In 1704, Cætano de Santo Antonio published a "Pharmacopea Lusitana Galénica" at Coimbra. This was republished at Lisbon (as "Ph. Lusitana," or, "Ph. Ulissiponense") in 1716, and twice reprinted. In 1785 appeared de Poiva's "Farmacopea Lisbonense." The first official pharmacopœia was published by Dr. Tavares in 1794, under the title "Farmacopeia Geral para o Reino e Dominios de Portugal." In 1825 this was supplanted by the "Ph. Lusitana," and this was followed in 1838 by the "Codigo Pharmaceutico Lusitano" (revised 1858). Finally a new "Pharmacopêa Portugueza" was issued in 1876. This is a very good work, prepared with care and judgment. The text is in Portuguese, except the synonyms of titles, which are

in Latin. It has been shorn of the obsolete rubbish of the therapeutics of former times.

Roumania issued a pharmacopœia in 1861, under the title "Pharmacopœa Romana." A second edition, revised, appeared in 1874. The text throughout is in Roumanian, without Latin synonyms. It bears some resemblance to the Austrian Pharmacopœia, but has some distinctive features of its own.

Russia.—Up to the year 1866 Russia had no official national pharmacopœia, except one for the army which was first issued in 1765. In 1779 a revised and much improved edition of the latter appeared, under the title "Ph. Castrensis Rossica." This was followed in 1789 by a special pharmacopœia for the navy ("Ph. Navalis," last revised in 1869). Both of these were superseded in 1808 by the "Ph. Castrensis Ruthenica," edited by Wylie, of Moscow. This was several times revised, last in 1866. A civil pharmacopœia appeared as early as 1778 at St. Petersburg (reprinted in 1782), under the title of "Ph. Rossica," and a second edition in 1798 (reprinted 1803); but these were not officially recognized, the pharmacists being compelled to consult almost every prominent European pharmacopœia when putting up prescriptions. That which was most followed, generally, was the "Ph. Borussica." In 1866 the first official civil pharmacopœia was issued. This was followed by new editions in 1871, 1880, and 1891. The title is "Rossiiskaya Pharmakopeya," edited by the Medical Council in the Department of the Interior, by order of his Imperial Majesty, etc. A special pharmacopœia for the use of the imperial court was published in 1874. Hence there are four Russian pharmacopœias in existence—the military, the naval, the civil, and the court pharmacopœia.

A separate pharmacopœia was published for Poland, in Warsaw, in 1817, under the title, "Ph. Regni Poloniæ," but this does not seem to have long remained in force. On the other hand, Finland published a pharmacopœia of its own ("Ph. Fennica") in 1819 (at Abo). Later editions of this appeared at Helsingfors in 1850 (ii.), 1863 (iii.), and 1885 (iv.).

Spain.—Previous to the appearance of a national work, local pharmacopœias had been in existence in the following cities: Salamanca ("Ph. Salamanca," by J. Bravo, 1588); Barcelona ("Ph. Catalana," 1686); Almeria ("Ph. Almeriana," 1724); Saragossa and Valencia ("Officina Medicamentorum," 1601, 1698, 1739); Madrid ("Ph. Matritensis," 1729+). In 1521 was published at Madrid the "Examen Apothecariorum," composed in 1497 by Pedro Benedicto Mateo, which has been found by Mallaina to be a veritable pharmacopœia. The first national pharmacopœia ("Ph. Hispana") appeared in 1794. This and the next three editions, viz., of 1798, 1803, and 1817, were written in Latin. Later editions are in Spanish with Latin synonyms of the titles, the latest appearing in 1905.

Sweden.—A. "Ph. Holmiensis" was published at Stockholm in 1686. The first work, bearing the title "Ph. Suecica," appeared in 1705, but without special authority. The first official pharmacopœia appeared in 1775, and the succeeding editions in 1779 (ii.); 1784 (iii.); 1790 (iv.); 1817 (v.; in this edition the chemical portion was edited by Berzelius, and the botanical and zoological by Swartz; it was the most advanced and perfect pharmacopœia of its time); 1845 (vi.), and 1869 (vii., with supplement of 1879). A revised edition was published in 1908.

Switzerland.—A. "Ph. Helveticorum" was published at Geneva in 1677. In 1684 there appeared in the same city an edition of Charas "Pharmacopœa Regia Galenica et Chymica," which was followed as authority for a long time. The Basle Medical Society, in 1771, published a "Ph. Helvetica" (containing an introduction by A. de Haller). A "Ph. Genevensis" appeared in 1780, and was reprinted several times afterward. In 1852 an elaborate draft of a pharmacopœia for the Canton of Berne was published at Berne under the title "Pharmacopœæ Bernensis Tentamen." This may be regarded as the precursor of the "Ph. Helvetica," published in 1865 at Schaffhausen, by the Swiss Pharmaceutical Society. The latter work has been recognized by law in most of the cantons, but not in all. Several editions have made their appearance, the latest and best in 1907.

The Canton of Tessin has a pharmacopœia of its own, published in 1848. Geneva uses the French Codex.

Turkey.—The Imperial Medical School at Constantinople has directed the use of the French Codex. Other foreign pharmacopœias, however, are also in use.

Uruguay.—The French and Spanish pharmacopœias are chiefly in use.

Venezuela.—The French and Spanish pharmacopœias are mostly in use. Long since, the medical faculty at Caracas took initiatory steps to prepare a national pharmacopœia, without result so far.

United States Pharmacopœia.—The first pharmacopœia in the United States was published at Philadelphia, for the use of the Military Hospital of the United States army, located at Lititz, Lancaster County, Pa., in 1778, under the title, "Pharmacopœia simpliciorum et efficaciorum in usum nosocomii militaris ad exercitum fœderatarum Americæ civitatum pertinentis; hodiernæ nostræ inopiæ rerumque angustiis, feroci hostium sævitiæ, belloque crudeli ex inopinato patriæ nostræ illato debitis, maxime accommodata" (Pharmacopœia of the more simple and efficacious [preparations] for the use of the Military Hospital of the Army of the United States of America; specially adapted to our present poverty and distress, due to the ferocious cruelty of the enemy and to the bloody war unexpectedly brought upon our fatherland"). Only one copy of this edition is known to exist, which is in the surgeon-general's office at Washington. Of a second edition, there appears to be likewise only one copy known (see *Am. Jour. Pharm.*, 1884, 483). This was issued in 1781. Upon the title page appears the name of Dr. William Brown, as author. It is entirely in Latin, in thirty-two pages. It contains eighty-four internal and sixteen external remedies. Previous to the year 1820, various European pharmacopœias, chiefly those of London, Edinburgh, and Dublin, were used in the United States, though the want of a national pharmacopœia was, to some extent, filled by Coxe's "American Dispensatory" (first edition, Philadelphia, 1806+), and Thacher's "American New Dispensatory" (first edition, Boston, 1810+). In 1808 the "Pharmacopœia of the Massachusetts Medical Society" was published at Boston, and in 1816 the "Pharmacopœia of the New York Hospital" at New York. The first impetus to a national pharmacopœia was given in 1817, by Dr. Lyman Spaulding, in a plan laid before the Medical Society of the County of New York. The first convention for the formation of a national pharmacopœia assembled at Washington on January 1, 1820, at which time the several drafts previously prepared by the several district conventions were consolidated and revised. The finished work was published at Boston, on December 15, 1820, both in Latin and in English. A second edition appeared in 1828. Before adjourning, the convention provided for a future revision of the work, by arranging for the call of a convention in 1830. Owing to a misunderstanding, however, two separate conventions were held in this year, one meeting at New York, and the other at Washington, and two separate pharmacopœias resulted from this, one being published at New York in 1830, the other at Philadelphia in 1831. Fortunately, the bodies who had met at New York subsequently abandoned

the plan of continuing a separate revision in the future, and in 1840 the third general convention assembled again at Washington. The Committee of Revision appointed at this convention was authorized to request the cooperation of the colleges of pharmacy, and this resulted in the contribution of much valuable material. The new revision was published in 1842, the text being for the first time only in English, the Latin being restricted to the titles and synonyms. Subsequent revisions have been made decennially, and the complete history of the work will be found in the introduction to the several editions.

In these revisions there has been a progressive movement toward the deletion of little used drugs and preparations, as well as of mixtures.

To take care of such articles, the American Pharmaceutical Association undertook the compilation of a "National Formulary of Unofficial Preparations," primarily designed to establish uniform formulas for any compound used in legitimate pharmacy or prescribed by physicians, and for which there is no recognized official standard. This work was published in 1888 and has proven very useful. It was believed that this formulary might eventually be made the repository of all such pharmacopœial articles as are no longer deemed of sufficient importance to be included in the official list which hope is in some measure realized in the new edition, published in 1916.

The tenth edition of the Pharmacopœia also appeared in 1916.

Authority of the Pharmacopœia.—The authority of a pharmacopœia may be legal or professional, and may be established either before the existence of the work, by the legal or professional appointment of its compilers, or thereafter, through its adoption by a government or by a representative professional body. In either case it occupies a special office, and all matters pertaining to it are therefore denominated *official*, or, according to older usage "officinal." Thus we have official and unofficial drugs, medicines, reagents, and other substances, as well as official titles, synonyms, definitions, descriptions, tests, formulas, processes, doses, etc. The professional authority of the Pharmacopœia is not compulsory, except as a violation of such of its provisions as have professional sanction involves professional disrepute. Its legal authority, established by statutes, with penalty attached, is of course so. In this way the United States Pharmacopœia has been made the legal authority in many States, as well as wherever the jurisdiction of the national Government extends. In this way, its standards for drugs and medicines have been made to control the character of imports and exports, as well as of interstate commerce in these articles, since the year 1907, when the Division of Food and Drug Inspection was organized for the purpose by the U. S. Department of Agriculture, Bureau of Chemistry. The effect of this administration has been, not only to work a complete reformation in the character of our materia medica supplies, but to expose grave omissions and defects in the official standards, and especially in the language in which they were stated. Emendation of the pharmacopœia in these respects has constituted the most important part of the work of the latest revision.

Objects and Scope of the Pharmacopœia.—In the definition given under *Pharmacopœia*, it is stated that the standards named apply to the "medicines used in the practice of medicine;" not merely to those whose merits justly entitle them to such use. The object of the book is to provide a means of assuring the user of a drug or medicine that he shall receive that for which he calls. The right of each individual to such assurance, regardless of whether his selection of the article is well advised, is obvious, and constitutes the chief basis of procedure in the preparation of the book. The selection of the articles to be made official is thus based upon the fact of their common use. Since very many worthless or very inferior articles are in common use by physicians as well as among the laity, the recognition of such in the Pharmacopœia is thus called for. On the other hand, many valuable drugs are brought forward without ever attracting much attention or coming into general use, so that the mere fact that the compilers of a pharmacopœia believe a new drug to possess merit does not justify them in recognizing it. Such a drug must first establish at least a probability of coming into general use before it shall receive recognition. From the above, it follows that "the recognition of a drug by the Pharmacopœia is not evidence, *prima facie*, that it possesses merit, nor the absence of such recognition that it does not." It also follows that the Pharmacopœia is not to be regarded as a guide to the practitioner in the selection of his remedies, but rather as an index to the general conditions of practice in such respect and as an authority for testing the genuineness of the articles treated by it. A knowledge of the merits of the articles, and an ability to make a judicious selection, are supposed to be gained from a study of text-books and other literature relating to therapeutics. It may be added that experience in the United States has repeatedly demonstrated the fact that the introduction of an article to the Pharmacopœia has very little weight by itself in extending it use.

In spite of these general facts, however, the compilers of our Pharmacopœia do recognize a certain responsibility for favoring the worthier articles; so that at their periodical revisions they are disposed to employ a liberal construction of the above guiding principles and to lean toward the expurgation of the more worthless articles and the introduction of meritorious ones whenever the conditions will possibly justify them.

There is another class of important articles which many physicians, even among the more intelligent, see with surprise to be denied a recognition in the Pharmacopœia, notwithstanding that such denial is a natural necessity; such articles, namely, as are, for one reason or another, not subject to any official definition, description, or standardization. Of this class the most conspicuous examples are found among copyrighted articles. In these cases it is the names alone which are copyrighted and which have a fixed identity. Absolute ownership of these names is conferred by the copyright, and there is no stipulation as to the use which is to be made of them. Furthermore, the substance to which the name is applied may be changed or substituted at the will of the owner of the name and as often as he desires. Manifestly, control and standardization by a pharmacopœia of an article so named is an impossibility. The case is quite different with those articles which are protected by patents of limited duration, either upon the product itself or upon the process by which it is prepared. Such protection provides for publicity and freedom at the end of the patent period. Ethical views regarding such protection have undergone a very great change. Here, as in many other parts of the medical field, rationalism has replaced blind and arbitrary ruling, and the *cui bono* standard has come to be applied, with the result, as stated below, that certain important, not to say absolutely necessary drugs which enjoy limited protection are now recognized in our Pharmacopœia.

Official Names and Definitions.—The official Latin and English titles call for little discussion. They constitute, like other names, a basis for specifying the respective articles, and their use in preference to that of any other names by which the articles may be known, enables the prescriber to secure the support of official, and in many cases of legal authority, which he might find it difficult to obtain if he used an unofficial title, subject to different applications in

different localities, and perhaps even in professional literature. In special cases, when the latter condition exists so as to involve special danger of misunderstanding, the Pharmacopœia may also recognize one or more synonyms. In the tenth edition, official abbreviations of the titles are given.

The official definition is intended to be a full statement of what constitutes the article named by the title, and at the same time limits it by the exclusion of all else. In the case of pure chemicals or pure substances of natural origin, as alkaloids and glucosides, the chemical formula usually constitutes a complete definition. If the article is not required or expected to be absolutely pure, a statement of the allowable amount, and perhaps of the nature, of the impurity frequently forms a part of the definition. In the case of animals or plants or their parts, the definition states clearly what part or parts shall be employed. The terms used in naming such plants and parts are those authoritatively employed in zoology and botany. In cases in which zoological or botanical authority is divided, as in the rules of botanical nomenclature, the compilers decide which method and rules shall be employed, and a statement to that effect is incorporated into the introduction of the book. The family or natural group to which the animal or plant pertains is also named in the definition. This is, strictly speaking, superfluous to a definition, but proves convenient and instructive.

When the living part is to be taken or collected in some particular stage or condition, as "in full bloom," "in the second year of its growth," "when full grown," "fully ripe," etc., this fact also is stated in the definition, as is any change which is to be made in it in preservation or preparation, as "the dried root" "a prepared exudation," "an inspissated juice," a bark "kept one year before being used," or "not kept longer than one year," etc. In special cases, a note may be appended to a definition specifying some danger to which the article is peculiarly liable, and stating how the same may be avoided. In a few cases, when the facts regarding the origin of an article are unknown, as in the case of the root of an unknown species of Smilax, or when the number of species yielding the article is indefinite or inconveniently large for specification, the definition cannot be made fully to accomplish its purposes. The best possible must then be done with it and the description must be relied upon, to accomplish the remainder.

Official Standards.—The standards of the Pharmacopœia are physical chemical, and physiological, and are incorporated into the descriptions.

The description, in other cases than those referred to above, is not to be regarded as partaking of the same nature as the definition, but as a statement of the tests which are to be applied by one having the article in hand, for the purpose of employing the specified standard. These standards and tests may be qualitative or quantitative. The ordinary physical test is included in the description of the drug as regards color, surface, and other external appearances, hardness, weight, fracture, structure, odor, and taste. Chemical standards, qualitative or quantitative, do not differ from those ordinarily employed in chemistry. Physiological tests were by many long regarded as excluded by the general nature and uses of a pharmacopœia, but have been definitely provided for, under the title "Biological Tests," in the tenth edition.

Preparations.—Among the several preparations to which drugs are subject the Pharmacopœia makes a selection, in each individual case, based upon the nature of the article, on both pharmaceutical and therapeutical grounds, and these preparations are enumerated just after the description. In those cases in which a small amount of the drug enters into some other article or preparation merely as an adjuvant, and not especially for its own medicinal effect, such article or preparation is not regarded as a preparation of that drug and is not thus named. Proximate principles, such as alkaloids, glucosides, fixed and volatile oils, also, are not treated as preparations. There are a number of instances in which neither pharmaceutical nor therapeutical considerations can determine a selection, and here no preparation is specified, though opinions are not wanting to the effect that at least one official preparation ought to be supplied for every official drug. The preparations thus named are then treated, in the regular alphabetical order of their titles, as official articles, their formulas and methods of preparation being given in full detail and in some cases definite standards being supplied, similar to those above described for the drugs themselves. The question has been much mooted as to whether a preparation can be considered to be official if, made strictly in accordance with the formula and of a quality fully equal to that resulting from the official process of manufacture, it differs merely in some variation from the latter. The question is a delicate and not unimportant one. It is urged upon the one hand that the principal object of prescribing an official process is to insure the quality of the preparation, and that if departures from it be permitted, a tendency to laxity may be encouraged. Upon the other hand, it is clear that in large manufacturing operations the methods of the retail pharmacist are impracticable, and even that a better result may be otherwise attained. The view of this subject, which has always been taken, at least in modern times by the revisers themselves, is that a deviation from the process is permissible, provided that a satisfactory preparation is insured.

Doses.—The United States Pharmacopœia has never been willing to assume the responsibility involved, or which might be involved in particular cases, by the adoption of maximum doses. It has, however, introduced *average* doses, to serve merely as an indication to the practitioner, without relieving him of his proper professional responsibility.

The Appendix.—The Appendix of the Pharmacopœia, containing lists, definitions, descriptions of reagents, tables of atomic weight, thermometric equivalents, alcohols, acids, and other important chemicals, of saturation, equivalents of the English and metric systems of weights and measures, is of great importance, possessing an authoritative value for accuracy and a facility for reference which, without any regard to the subject matter found in the body of the work, entitles the latter to a convenient position upon the shelf or table, not only of every physician and pharmacist, but of every person whose work brings him into contact in any way with physical or chemical science.

Use of the Pharmacopœia.—The use of the Pharmacopœia by pharmacists is incomparably greater than that by physicians, and to this fact is in great part due the higher degree of accuracy and care and the more definite knowledge of the former profession regarding the materia medica. Not only is this true, but it is undeniable that the most serious shortcomings of the medical profession in matters therapeutical might be largely eliminated were they to rely more fully upon reference to this work. While it is true that the Pharmacopœia provides no information directly concerning therapeutics, yet it contains very full information, and of the most reliable character, concerning materia medica, fundamental to therapeutics and, in turn, the highest teachings of therapeutics constitute its basis as to preparations and dosage, and as to a majority of the drugs treated. HENRY H. RUSBY.

Pharyngitis, Acute.—While in nearly all acute inflammations of the pharynx the contiguous structures are so much involved that it is quite impossible to separate the symptoms of the first from those of the others, yet as diseases of these other structures are

considered elsewhere in detail in this work, the endeavor in this article will be to describe the pharyngeal conditions as separate entities, the line of demarcation being of necessity sometimes as arbitrarily drawn as would be any attempt to say where on the posterior pharyngeal wall the nasopharynx ends and the pharynx begins.

Simple Acute Pharyngitis.—Acute inflammation, not septic or traumatic, strictly limited to the pharynx is very rare.

Etiology.—As a rule acute disease is either the lighting up of a subacute inflammation or an extension of an acute nasopharyngitis. As etiologic factors may be mentioned ordinary colds, bad air, poor food, sedentary habits, excessive use of tobacco or alcohol, or both, and in general anything that tends to lower the vitality. Digestive disorders, nasal disease, mouth breathing, sudden atmospheric changes, influenza and tonsillitis are frequent causes. Rheumatism, so-called gout, and other like constitutional diseases are sometimes factors. As traumatic causes may be noted irritant poisons, flame, hot water, steam, foreign bodies.

Pathology.—The pathology is that of acute inflammation of any mucous membrane. This particular membrane, it must be borne in mind, has everywhere in its submucosa a well marked lymphoid layer which is always thicker around the outlets of the groups of racemous mucus glands amounting often when hypertrophied to the well developed follicles so frequently seen on the posterior pharyngeal surface. In the region known as the lateral column just behind the posterior pillars of the palate this tendency to a development of lymphoid tissue is much more pronounced, so much so that it often becomes exaggerated into large masses, until to all intents and purposes we have another pair of tonsils, one on each side, and we may have the acute processes here exactly similar to those that occur in a tonsil. We may, therefore, have follicular inflammation, membranous, diphtheritic, and to complete the resemblance we may also have here abscess formation, a veritable quinsy. It is, therefore, wise to consider any single follicle or any group of them on the posterior pharyngeal wall as well as the lateral column as though they were miniature tonsils when we attempt to sum up the pathologic conditions which may transpire. From the acute always follows the subacute, and repeated subacute attacks later develop hypertrophies, and such hypertrophied masses, whether isolated or as they exist in their more complete form in the lateral columns of the pharynx, possess in this hypertrophied condition crypts like the tonsils. Absorption can take place from any or all of them and systemic disturbance, not merely the febrile manifestations but the other infections known as rheumatic fever, gout, endocarditis, as well as streptococcic, tubercular, and glandular manifestations. Many a tonsil is extirpated as the source of such general pathologic conditions when the real culprit is acute, subacute, or chronic disease of the lateral columns and pharynx or as recently shown by Sohier Bryant by processes higher up in the nasopharynx, thus supporting by fresh evidence a life-long conviction of the authors of this article.

Some acute inflammations of the pharynx may present simple congestive surfaces, may show follicular exudates with simple plugs of mucus in the crypts as in the crypts of the tonsils, may be membranous as when affected by Friedlander's bacillus, may be diphtheritic, may be septic, a so-called streptococcus throat, may be mycotic as in Vincent's angina, may be due to influenza, erysipelas; and to rheumatic or gouty systemic conditions as well as sometimes to produce them. The inflammations may be due to typhoid, may appear in the form of herpes, pemphigus, canker, or urticaria, or may be due to measles, scarlet fever, varicella and smallpox. Any or all of these latter influence the inflammation in ways which are more or less evident and characteristic and which will be brought out more in detail in discussing the conditions under their separate headings.

Symptoms.—When occurring by itself the attack is usually sudden and may be ushered in by a sense of malaise and chilliness or even a distinct chill. The temperature rarely goes beyond 100° or 102°. The digestive system to which tract the pharynx surely belongs is usually deranged; the appetite is lost; the bowels are constipated; the tongue is furred; and the breath is foul. Pain in the muscles of the neck and back is common when there is any fever or general headache, and often there is aching of the joints. At first there is dryness of the throat and the surface of the mucous membrane is shiny and smooth. Later the secretion becomes abundant and the membrane seems thickened and sometimes roughened by the prominence of the follicles when present. The voice is thickened and husky even when there is no apparent involvement of the larynx, and there is fatigue on talking. In the attempt to get rid of the mucus the patient hawks and hems rather than coughs, and the dryness and later thickening cause frequent efforts at swallowing. The feeling is often as though there were something foreign adherent to or stuck in the region of the pharynx. Pain is often a symptom, being increased by the efforts at swallowing, and especially is this true on awaking in the morning when there has been much breathing through the mouth during the night.

Inspection of the pharynx under these conditions shows the mucous membrane to vary from simple pink to dark red with the mucus adhering in different regions according to the period of the attack, and generally the whole posterior surface of the pharynx from side to side involved in the process. Almost always the inflamed area extends up back of the palate, and what we see as pharyngitis is really the lower portion of a trouble extending upward to the region of the pharyngeal tonsil and may be to the very roof of the pharynx.

When simple and uncomplicated by inflammation of other parts, the disease lasts for from one to five days, and with proper treatment usually tends to subside readily, unless it is the acute involvement upon a subacute or chronic condition which has existed through weeks or years. Even when quite uncomplicated in its origin, in the later stages where recovery is not immediately evident, much trouble is experienced by the caking on of the mucus and the dry sensation which is produced by such well-nigh scabbing surfaces.

Lateral Pharyngitis.—When the lateral columns of the pharynx are involved and when, owing to previous disease, there has been a marked hypertrophy of these parts, the inflammation, no matter how simple in its character, may locate itself entirely in these lateral columns, or the symptoms produced by the inflammation of the lateral columns entirely dwarfs anything referable to the other portions of the pharyngeal surface. Frequently one sees in looking into the throat, in these conditions, large red masses of thickened, hypertrophied tissue running up and down back of the posterior pillars of the palate like hugh red cords. As has already been mentioned, the inflammation in these areas may assume proportions quite beyond that which the posterior pharyngeal wall itself ever presents. Frequently one sees the outlets of the glands like crypts plugged with white masses, and under these conditions the patient to all intents and purposes has to do with an acute follicular tonsillitis, *i.e.*, there is just as much fever, constitutional symptoms, pain and distress as ever occurs with any attack of simple follicular tonsillitis. Every once in a while a patient so inclined will develop in the region of the lateral column which is just out of sight above and behind the palate, actual abscess formation. The infiltration which accompanies the pus formation causes edema and swelling of the palate and a pushing

downward and forward of the tonsil, so that as one looks into the throat he seems to be dealing with peritonsillar abscess, the usual form of quinsy. A careful survey of the situation usually develops the fact that instead of the tonsil being pushed forward away from the posterior pillar of the palate as occurs in the ordinary form, this particular type of quinsy drives the posterior pillar together with the tonsil away from the posterior pharyngeal wall and by holding forward the palate the pocket of pus may be diagnosed and later opened and cared for. This form of inflammation is quite as liable to lead to edema glottidis as is the ordinary form of quinsy, and one must be very particular to examine and discover if that is the case.

The first manifestations of a diphtheria may occur in this lateral region, and may be in the part just behind the palate which was referred to a moment ago.

The so-called gouty forms of inflammation which sometimes occur are supposed to have marked differences from the ordinary type and may be briefly described as occurring in subjects who present the other symptoms of this diathesis. The type of the inflammation is usually acute, the membranes are darker red, more frequently edematous, and there is not the tendency toward involvement of the glands in the neck or the presence of exudate. The pain of such an attack is usually much greater than that of the simple inflammation, and the whole thing tends to run a chronic and more obstinate course.

Membranous Pharyngitis.—The inflammation of the pharynx in non-diphtheritic cases sometimes possesses a membranous type. A very thin adherent, pellucid exudate takes place over the whole posterior pharyngeal wall forward on to the palate and uvula. This sometimes occurs also in the type of inflammation which we have in measles. It also occurs in epidemic form, and at least in two instances these localized epidemics have been due, in addition to those mentioned by Emil Mayer in 1900, to the Friedlander bacillus. This form of inflammation when it occurs is quite different from that which may happen upon the lateral columns of the pharynx from the fusing of the follicular exudate into a more or less definite membranous condition. In this latter instance the explanation is the same as when it occurs in the follicular inflammation of the faucial tonsils. The acute pseudo-membranous type is, however, in general to be considered as one of the rare forms of manifestation.

Ulcerative Septic Pharyngitis.—This form of infective pharyngitis occurs usually in persons reduced in health by hard work in unsanitary employments. It is frequently institutional in origin, as from hospitalism. In recent years attention has been called to it as it occurs in epidemic form, and is known to medical literature as the streptococcus throat. Numerous epidemics have been reported due to infection from milk. In these severe types which occur particularly in those very much run down, or in connection with the just referred to epidemics, the pharyngitis is usually but a part of a general sore throat, and yet when it is the part principally attacked it seems to have a power for evil such as is with great difficulty explicable. The patients are from the start severely sick; they have a sepsis, as is indicated by the name, and the disease often terminates fatally. Whether or not, as in other forms of streptococcic invasion, there is a streptococcemia the writer at the present time is not definitely informed, but that would explain the fatality and the course taken by the sepsis better than any other suggestion. In such cases abscess formation and ulceration frequently occur anywhere on the pharyngeal surface, particularly of course in the lateral columns, and such ulcerations have to be distinguished from that form of ulceration known as Vincent's angina. The microscope sufficiently characterizes the form of germ which is infecting to make the diagnosis by this means simple and easy. The sufferings of the patient and the intensity of his illness are greatly accentuated oftentimes by a lymphadenitis of the glands in the neck. A number of cases have been reported where this throat condition led to pneumonia, giving strength to the suggestion that pneumonia may frequently be caused by absorption from the pharynx and nasopharynx. As said before, such cases run a very rapid course, and death will occur in various ways, endocardial inflammation, general acute septicemia, and sometimes with no definite symptoms, other than that the vitality of the patient is so swiftly sapped that he succumbs to the overwhelming force of the inflammation almost like a hydremia. Fortunately the cases occurring outside of these particular epidemics as the result of the causes mentioned, hospitalism and unsanitary employment, run a milder course, and the chief suffering comes from the swelling and the dysphagia and from the liability to involvement of the ears as well as of the other contiguous parts.

Vincent's Angina.—This is a form of ulcerative disease which is usually of a less sthenic type than those considered under the immediately preceding heading. However, it may come on in acute form and the areas involved, as low down in the lateral columns of the pharynx or in the single follicles of the posterior wall, may be covered before ulceration takes place with a pellucid membrane, later becoming perhaps dirty gray in color so that it very much resembles a beginning diphtheria. There is not so much fever or constitutional involvement as one would expect from the other forms of membranous sore throat, but the glands in the neck sometimes are very early involved and are quite painful and sore, leading to all the greater probability of the diagnosis being that of diphtheria. Whereas Vincent's angina is usually particularly mild in its course, and whereas the diagnosis is readily made by the discovery in the discharges of the fusiform bacillus in conjunction with a spirillum, yet once in a great while it takes an acute course and quickly causes large sloughing of broad areas, and in two cases seen by the writer and notably in cases seen by Dr. Arrowsmith, of Brooklyn, no other cause was found than the fusiform bacillus of Vincent and its ravages for the fatal termination. Evidently, then, this particular form of germ has its very virulent type as well as its more usual, simple, amenable form.

Herpes, Pemphigus, and Urticaria of the Pharynx.—Mention is generally made in such treatises of the herpetic form of inflammation and that due to pemphigus. The former might be called a type of aphthous sore throat. The small spots which form with a good deal of burning and stinging in the throat pass quickly from the vesicular stage to the very superficial ulcerative stage, and is so frequently accompanied by the labial herpes that one generally readily makes the distinction as to their character. These are also very liable to occur in conjunction with the urticarias which of course are usually a disturbance due to the ingestion into the stomach of things that are not borne well by the particular patient. There is a form of herpes which comes in elderly people, apparently as one of the manifestations of influenza, where the tongue is more often involved than the pharynx, and here the areas involved, even when apparently healed over, frequently give rise to stinging and local distress over a long period during the convalescence from the general grippe depression.

In pemphigus the spots are usually larger, and there one sees at times distinct bullæ even where the skin is not at all involved. There is always a tendency to recur, especially in the aged, and the ulcerations which follow these bullæ are much deeper than those which follow the simple herpes.

Urticarias make their appearance in the pharynx sometimes before, sometimes after the occurrence on

the skin but always in conjunction with them. The causes of pharyngeal urticaria are the same as those of the general urticaria, *i.e.* the ingestion of shell fish, small fruits, from the stings of insects, drugs, and other neurotic and digestive disturbances which are ordinarily causative. The manifestations in the throat are seldom serious only as they produce the forms of edema which sometimes occur, and here they may be positively dangerous, as the edema may settle in the larynx and produce dangerous dyspnea. The swelling is at times located entirely on the palate and tongue, and here makes disturbance entirely in proportion to the amount of said swelling. Aside from the pain and disagreeable conditions produced, the only symptom which requires special treatment is the dyspnea, and cases have been known where quick intubation or tracheotomy must be done to save the life of the patient, in this respect being similar to the effect which follows traumatic injury as from burns or steam.

Traumatic Pharyngitis.—This is an acute inflammation of the pharynx due to wounds, foreign bodies, caustics, and the inhalation of dust or vapors. Children are especially liable to it owing to their frequent mistakes in swallowing hot or caustic fluids. Persons working in dust or in the presence of caustic vapors are liable to pharyngitis of this type. Any foreign body which has become lodged in the throat may so lacerate the mucous membranes of the throat as to give rise to inflammation. In traumatic pharyngitis there is the same danger that the inflammation will lead to edema of the glottis as occurs in some other forms of throat trouble. In the aged and enfeebled a wounding of the surface no greater than by the swallowing of a bit of crust or a piece of egg shell may be sufficient to lead to an inflammation which is fatal. So-called inhalation of flame, or exposure to very hot steam may cause the same sort of disturbances of the mucous membrane as would a burn of similar degree on the skin or other surfaces. Contractions and adhesions always follow such deep injuries to the pharynx, palate, and esophagus.

Pharyngitis in the Exanthemata.—Any or all of the exanthemata, including under this heading typhoid, smallpox, and chickenpox, are liable to have pharyngeal manifestations. Erysipelas, either as a progression from the cutaneous disturbance or as a separate manifestation, may attack a pharynx, where it produces a brawny, smooth, red, glistening surface on the membrane, with mucus and mucopus present in large masses. Certain areas vesiculate and numerous small blisters occur which readily break down and form gangrenous areas. The glands in the neck swell up, and the whole picture may be, in the early stages, very confusing where there is no skin eruption to help in the diagnosis. Such cases are always grave, and the danger of extension to the larynx is extremely probable, where it often is attended with fatal result.

Intermittent fever has been known to produce a pharyngitis apparently as a part of the manifestation of the disease. The influenza bacillus and the pneumococcus frequently find their first entrance from the pharyngeal surface, producing as their first symptoms an acute pharyngitis which soon is lost from sight amid the graver issues which the constitutional disease presents. The influenza bacillus has been known to occur in pure culture in a membranous exudate on a pharyngeal or tonsillar surface, but this is a rare form of its manifestation. The pneumococcus throat may occur without any progression of the disease toward the lungs. It produces a form of membranous or semi-membranous inflammation where it is exceedingly difficult to get a line of demarcation between where the false membrane ends and the swollen tissues begin. Such pneumococcic exudate may be very persistent, recurring readily after removal though persisting in attacking a given area without further spreading, a form of inflammation which is not only interesting but difficult to diagnose without a very careful microscopical study.

Scarlet fever and measles appear on the pharynx and may form in their later stages manifestations which are of serious import. Scarlet fever will make a bright rash which occurs upon the soft palate and over the pharyngeal surface, on the tonsils, and even on the buccal surfaces before the skin rash is at all manifest. In measles one may see small areas affected, the so-called Koplik spots. In general the eruption is more likely to be in blotches with very slight elevation than in scarlet fever. In both of them the lymph glands at the angle of the jaw may enlarge and the fever and constitutional symptoms quickly follow or accompany the throat manifestations. Later in both, more likely in scarlet fever, but sometimes in the severer types of measles, deep inflammation and sloughing occur, apparently the result of streptococcic invasion, and one frequently sees, especially in poorly nourished children, large areas involving one-third or one-half of the pharynx which slough and heal very slowly producing a large amount of constitutional disturbance. In the final cicatrization they produce adhesions and distortions of the palate and pharynx as great as occurs in syphilis or in lupus, or as that which follows the more dreaded diphtheria. In typhoid we have the pharynx involved in a general way if for no other reason than the drying of prolonged mouth breathing, but the trouble is not of serious moment and quite unlike the unusual and very critical laryngeal crises.

Smallpox and the milder chickenpox have manifestations on the pharynx. In the severer types of smallpox, hemorrhagic forms occur with much sloughing as in scarlet fever.

Treatment.—In the simpler forms all that is required in the way of general treatment will be a simple saline cathartic generally preceded by some calomel and soda in triturate form. If the pain is considerable and if there is any high degree of fever, it is perfectly proper to give antipyretics, and in the simpler cases, as with children, very mild doses of Dover's powder seem to be helpful. When marked rheumatic or gouty manifestations are in evidence the constitutional remedies should be given accordingly. One may give the salicylates in the various forms in appropriate dosage and be very much pleased with the relief which follows such administration. Quinine is frequently recommended in the simpler types and undoubtedly is helpful as with other forms or manifestations of the common cold. Colchicum has always had a considerable vogue when there is a suspicion that gouty manifestations are present, but more frequently in acute inflammation it is the salicylates and alkalies that receive the greater commendation.

Locally nothing gives so much relief as one form or other of gargle, and yet in no condition is the right method of gargling more necessary. The gargle should be used as warm as is possible, and may be, according to the nature of the disease, simple saline, astringent, antiseptic, or may have some demulcent or mucilaginous additions as the practice of the medical attendant seems to have warranted. Ordinary gargling simply washes off the front part of the tonsils, palate and tongue, but seldom will hit the posterior pharyngeal wall. If, however, the patient will, after taking some of the fluid into his mouth, bend the head back and swallow with widely open mouth, the fluid will drop back on to the pharyngeal surface, and then while being gurgled around the fluid can be made to reach any portion of the pharyngeal cavity, even up behind the palate. If the mouth is wide open when the process of swallowing takes place, the fluid will not descend into the esophagus and stomach. If the tongue rides up toward the roof of the mouth sufficiently far wholly or partially to occlude a half-open mouth the fluid of course will descend into the stomach. For general cleansing nothing quite equals physio-

logical saline solution, *i.e.* a solution of salt as is usually prescribed of the strength of half a teaspoonful of salt to the ordinary glassful of water. Such a solution used hot and by the swallowing with the mouth-open method will always relieve to a certain extent any pharyngeal inflammation and may be followed by such other solutions as the taste or practice of the medical attendant may indicate. When there is anything in the way of spots or false membrane present an exceedingly good practice is to follow the salt solution so gargled with peroxide of hydrogen reduced either one part to two or one part to three of warm water. As many preparations of hydrogen peroxide are acid in their reaction, and as the products of decomposition of hydrogen peroxide due to the pus and inflammatory exudates may also be more or less acid and irritating, it is an exceedingly good practice, after having gargled with peroxide, to follow such a gargle with some alkaline preparation, as a solution of potassium chlorate and borax, or any of the forms of alkaline detergent solutions with which the market is flooded. It has been proved by the gargling of colored fluids that by this method of swallowing with the mouth open, in the hands of those who become adept, gargles may reach all portions of the nasopharynx to the pharyngeal tonsil itself, and when the patient nods his head forward at the latter end of the gargling the fluid may be made to come out the nose. Therefore it is no exaggeration to say that a properly executed gargle can reach every portion of the mucous membrane of the pharyngeal cavity and also a large proportion of the nasal cavity. Such gargles so used are of the greatest possible relief to patients suffering from manifestations of pharyngitis. In very acutely sore throats and in the dry conditions of the nasopharynx which sometimes follow the acute type nothing is more soothing than a gargle of milk and water mixed together half and half and used as warm as is comfortable.

Topical applications are, of course, of great aid in relieving congested areas. When the lateral columns of the pharynx are involved and follicular exudate is present, it is very simple and easy to make applications to these surfaces of peroxide of hydrogen, undiluted, and then follow with some alkali, ending with solutions of argyrol. Years ago the practice was to use weak solutions of nitrate of silver, especially in the subacute and chronic stages, but in argyrol one finds, especially in the 20 per cent. or stronger solutions, an astringent, germ inhibiting, soothing, comforting and effective application, quite equalling the more irritating solutions of nitrate of silver. In general the rule should obtain that all solutions which go above the palate must be much milder in strength than those which one can apply to the posterior pharyngeal wall itself. In subacute and chronic conditions 10 per cent. nitrate of silver is an exceeedingly stimulating and helpful solution to apply to the pharyngeal membrane, especially in conditions which are liable to become chronic in the lateral columns of the pharynx but in the nasopharynx nitrate of silver should never be used stronger than two and one-half to five per cent., except on very limited areas accurately and definitely applied.

When dealing with very adherent bits of false membrane such as occur in the form due to Friedlander's bacillus, or in the pneumococcic or streptococcic exudates, great care should be exercised in trying to wipe off the membrane not to cause bleeding of the surface beneath. Here peroxide is very helpful, and one will also receive a great deal of aid, especially in the region of the nasopharynx, from the blowing up of the powdered boric acid. This latter seems to cause exudation to occur from within the crevices of the mucous membrane and cause a separation of the membrane from the pharyngeal wall from within out rather than the reverse as is the case with most applications.

Limited areas of ulceration that occur in the herpetic, rheumatic, or scarlet fever types may need the stimulating action of strong solutions of nitrate of silver to cause healing. In the deeper ulcerations which occur sometimes very quickly in the process due to the Vincent's bacillus it is a very good plan to clean out the ulcer with the peroxide solutions and then apply zinc chloride. In the hands of the author a ten per cent. solution of zinc chloride has been extremely helpful in causing a stoppage of the progress of the ulcer and a quick healing. Iodine has been equally successful with others, as have solutions of nitrate of silver; in fact the fusiform bacillus of Vincent yields readily to the action of germicidal solutions, the only thing being that it be intelligently and thoroughly applied.

In addition to all forms of local application to a pharyngeal inflammation it is, of course, necessary that the patient's gargling and care should be frequently repeated, the gargles being used once in two or three hours during the active stage. The same is true of the applications that are used on the surface; they must be used once or twice every day until the inflammation is brought under control and cured.

Certain forms of gouty manifestations have been credited to yield very readily to such specific local applications as guaiacol. Personally, the writer has not had sufficient experience to speak with any degree of authority.

In all forms of ulcerative disease, especially those of the severer type which follow the streptococcic throat, or measles, or scarlet fever, where large areas have become denuded of epithelium or active ulceration of a deeper type occurs, something has to be done to ease the pain of swallowing. For immediate relief to lessen the pain of caustic applications, of course, nothing is as good as cocaine, but this will not bear repeating indefinitely and is altogether objectionable because of the liability of habit formation. As substitutes various things have been suggested, such as powder of orthoform or anesthesin. These may be given to the patient to use, and after the cleansing gargles he may blow the powder upon the ulcerated areas and receive considerable relief, not only for the time being, but the effect lasting over a considerable period of time, especially if he follows such application with a spray of some oily solution of menthol, five to ten grains to the ounce. Such anesthesia will sometimes be sufficient to make a possibility of swallowing which otherwise would not exist.

Sprays are always helpful. It should not be forgotten that a spray of some saline solution like Seiler's tablets when put through the nose and allowed in this way to reach certain areas of the nasopharynx will give a comfort that will never be obtained by spraying straight into the open mouth against the pharynx. Here the sensitiveness of the throat when the spray hits it causes gagging and certain surfaces are covered which sometimes are the very ones most desired to reach. In the office of the physician is frequently found the spray apparatus with condensed air and with this the medicaments can be so applied as to be extremely helpful and give a great deal of relief. Certain alkaline solutions are perfectly compatible with solutions of adrenalin, and where there exists no idiosyncrasy against the latter, the comfort received from using a spray is greatly enhanced when it is used. All edematous and swollen areas are contracted by the use of adrenalin, and such action should be called into use whenever it seems wise. Edematous areas after having been anesthetized and sprayed clean can be frequently relieved by multipuncture, and this is true in any part of the pharyngeal cavity. Abscess formation must, of course, be reached and the abscesses opened and drained.

Where there are ulcerations or areas have been denuded of the epithelium by burns or caustics, mucilaginous preparations and oily solutions seem to give much satisfaction and comfort, and in such solutions it is perfectly proper to incorporate ortho-

form and adrenalin to assist and abet the work of the solution.

In edematous conditions and in certain of the severe inflammations as in cases of streptococcic throat and scarlet fever where the swelling and the painful condition of the parts is such that no gargling is possible or can be comfortably executed, it should not be forgotten that a steam atomizer may be most grateful. In just such conditions solutions sprayed down through the nose sometimes reach and help when all else fails, but an effective steam atomizer which may spray into the throat only a simple alkaline solution like that of Seiler's tablets will give a great deal of comfort, especially if it also contains a very small amount of harmless anesthetic like alypin, and always will be more effective when it contains a proper amount of adrenalin. Such an atomizer may be directed to any given part of the throat with so little inconvenience to and effort on the part of the patient that it may be used no matter how sick and weak the patient is.

When the acute stages of all these various pharyngitides have passed, the patients often receive much benefit if they gargle some astringent solution after the cleansing salines are used, or these may be perhaps even more effectively applied by the attending physician. Such astringents aid in the resolution of the parts, and in the restoration ad integrum.

In the healing which follows deep ulceration, especially when such is due to burns from chemicals and scalds, too much care cannot be taken to avoid adhesions and contractions of the scars.

HENRY L. SWAIN.

Pharyngitis, Chronic.—SIMPLE CHRONIC PHARYNGITIS.—In this form of inflammation the morbid process usually localizes itself on the pharyngeal mucosa proper, the surrounding structures escaping. Occasionally it localizes itself in the faucial pillars and may then be properly called chronic faucitis.

A frequent cause is the continuous action of irritants such as excess in alcohol, tobacco, dusty occupations, etc. Many cases are associated with chronic nasopharyngitis. In many cases also the malady is but one feature in a general catarrh affecting the entire food tract, for to the latter and not to the respiratory tract does the pharynx functionally belong. Acid fumes, overuse of the voice, abnormal humidity of the air, high temperatures, are all to be reckoned as possible causes. It may be difficult to isolate the exciting factor, for many of the cases come on so gradually that it is difficult to determine any special reason for their occurrence. Undoubtedly the modern method of living in overheated houses is a powerful predisposing agent.

The changes set up in the mucosa are those of a proliferative inflammation. The vessels may show an initial hyperemia, but the essential change is the formation of new connective tissue in the deeper layers of the membrane. Mucous glands are here scanty, but secretion from the membrane as a whole is increased, and in view of the abnormal surroundings it soon becomes viscid. Occasionally nodular veins may be seen coursing over the posterior wall of the pharynx.

The most prominent symptom is local irritation, but actual pain in swallowing is rare. Owing to the co-involvement of the stomach, there are more or less morning retching, nausea, and even vomiting. These conditions may make examination of the throat extremely difficult. The breath may be sour and offensive. Constipation and flatulency are frequent. Cough and huskiness of the voice are not uncommon. Hemorrhage occasionally takes place from a ruptured capillary. The mucosa is dark and beefy in appearance, but this feature does not extend farther forward than the posterior pillars. The pharyngeal wall may be covered with tenacious secretion. The grade of severity of the symptoms is generally conditioned on the amount of accompanying nasopharyngitis.

Treatment should be first directed toward the correction of any vicious habits in eating or drinking. Excesses in tobacco and all alcohol must be cut off short. The former are indicated by a dry glazed look, and the latter by a red, angry appearance of the mucosa. To facilitate a thorough examination of the throat, we may use ice-water gargles, bromide sprays, bromides internally, and even weak cocaine sprays. It is frequently found necessary to interdict, during treatment, tea, coffee, and all very hot or highly seasoned fatty and greasy foods. All food must be thoroughly masticated, and but little fluid should be taken at meals. Attention is now to be given to the gastroenteric tract. Cholagogues, salines, alkalies with bitters, etc., here find a proper application. Attention in detail to the foregoing matters will often obviate the necessity for local treatment. For topical use we may employ solutions (twenty grains to the ounce) of silver nitrate, the zinc salts (the chloride excepted), alumnol, or protargol. For such remedies as are applied by cotton carriers, the oleostearate of zinc, made of zinc stearate in mentholated albolene, forms an agreeable viscid menstruum. Before any of these are applied, the mucosa should be thoroughly cleansed with a warm, alkaline spray. For daily treatment at home nothing is as universally useful as a cleansing with properly gargled saline solution. As described under acute pharyngitis, astringent gargles should be always preceded by this cleansing saline solution and much comfort will be afforded when such a removal of all mucus is followed by one of the oleaginous sprays. The nose and nasopharynx should be thoroughly treated.

CHRONIC FOLLICULAR PHARYNGITIS.—This variety practically limits itself to the pharyngeal wall proper, the faucial structures not being involved. It is of clinical importance because the symptoms are out of all proportion to the mild appearance of the lesion.

The brunt of the process falls on the lymphoid follicles and is one expression of "lymphatism" or the tendency of all lymphatic structures to take on overgrowth during the earlier periods of life. While during the very early years this tendency is more noticeable in the nasopharynx, it may become localized, as time goes on, in the pharynx proper. Bad hygiene is an important causative factor. The subvariety of the disease called "granular," because the smallness of the follicular enlargements gives the mucosa a granular appearance, has been referred to a systemic hyperacidity; but this view is objectionable, in that it invokes the relation of the mucous glands to the condition, they becoming stopped up by the action of the acidity which precipitates their mucin. Improper vocal effort, both overuse of the voice and use under improper conditions, may lead to follicular enlargement; hence the familiar name of "clergyman's sore throat."

As noted above, the follicular enlargement may be granular or may occur in the form of large masses like red beads on the pharyngeal wall. At times it may be localized behind the posterior pillars, the appearance presented being not unlike that of columns or bead-chains. This is the "pharyngitis lateralis" of some writers. These longitudinal deposits may fuse with the pillars, but are generally of a darker hue. In all cases the process is essentially a hyperplasia, an actual increase in the number of lymphoid elements, especially about the efferent channels of the nodes themselves. This hyperplasia may involve the entire thickness of the mucosa or it may confine itself to projections from the surface. At first the enlargements are soft, but they harden and become smaller with time. Such hypertrophies of the lateral columns become to possess all the possibilities for pathology that occur in the faucial tonsil. They are a constant

source of trouble in themselves and are a menace because of the frequent acute seizures, which involve them. As stated under acute pharyngitis, all forms of inflammation may attack them, even abscess formation, and very frequently cryptic absorption takes place just as with the faucial and lingual tonsils. Hence these strips of hypertrophy should never be forgotten when casting about for the cause of the so-called rheumatic pains as well as joint inflammations. The process seems to involve the tendrils of the sensory nerve fibers, though whether merely by compression or in some other way not understood is uncertain. This nerve involvement accounts for the relative severity of symptoms.

The most prominent symptom is pharyngeal dysesthesia increased by swallowing or vocal effort. Secretion is not as a rule increased. It may be blood-streaked by the rupture of a superficial vessel. The tonsils often become adherent to the faucial pillars, and from the frequent efforts at hawking the uvula becomes irritated. The voice is husky and a nervous irritable cough is present. The patients become very neurotic, and this fact in turn aggravates pre-existing symptoms. Such a result often occurs when the patient becomes obsessed with the idea that baneful systemic disturbances come from the swallowing of the secretions. If the individual becomes "germphobic" then he or she, more frequently she, will seek to remove all mucus from the throat and by the very frequency of the hawking and gagging provoke a tremendous flux of secretion until they are fairly weak from the efforts of clearing the throat. No progress can be made to cure such a case while this is going on. The disease continues indefinitely unless treated, though it does not seem to predispose to lesions of the air tract below.

Treatment calls for the same general measures as for simple chronic pharyngitis, and in addition for the destruction of the enlarged follicles. This should be most thorough in the regions of the lateral columns until the hypertrophies are entirely reduced. Any of the caustic acids or the electrocautery may be used for this purpose. A small iron wire, heated in the flame of a spirit lamp, will answer. A drop of a two per cent. solution of cocaine injected into the area of puncture makes the latter practically painless. Six or eight punctures may be made at each sitting, an antiseptic spray being used on the intervening days. The minute sloughs should be allowed to come away before treatment is resumed. Curetting of the entire area has been advised. Internally we may give the iodides in small doses and the various alkaline mineral waters freely. It is unlikely that the latter are of real service unless they correct some underlying diathesis. Tobacco should be cut off. Alcohol may be used sparingly. Nervous patients need arsenic, strychnine, and phosphorus.

Chronic Atrophic Pharyngitis.—In this variety there is an acutal atrophy of glandular tissue and of the other elements of the mucosa. Some authorities look on the process as merely the terminal stage of the ordinary catarrh; others as a separate affection. It may occur alone, but is more often associated with similar lesions in the nose and nasopharynx. It may be a sequel of severe local acute conditions such as occur in the exanthemata and diphtheria, and is not infrequently a feature of diabetes and chronic Bright's disease.

There may be a proliferation of new connective tissue, so that in the earlier stages, before the follicles have atrophied extensively, they appear to lie on a whitish bed and the whole membrane is very dry. This is the so-called "pharyngitis sicca."

The main symptoms are an uncomfortable feeling of dryness with more or less pharyngeal dysesthesia. The mucosa may be covered with thick, dry, tenacious secretion. Removal of this, which strings down from the nasopharynx, may uncover a rather red subacutely inflamed area.

Treatment calls for restoration of the nose and nasopharynx to the normal and for the correction of any vicious habits. Persistent dryness should always lead to an examination of the urine, for the underlying cause may thereby come to light. The dried mucus should be removed by warm, alkaline sprays, and for home treatment the patient may inhale mentholated steam or the vapor of menthol in association with eucalyptol and compound tincture of benzoin. For topical application we may use ichthyol in glycerin (ten to thirty per cent.) or the familiar Mandl's solution—iodine gr. v., potassium iodide gr. x., carbolic acid ♏ij., and glycerin ℥ss. The writer has had much satisfaction with solutions of mucin. This comes in the form of tablets containing gr. v. each of mucin and bicarbonate of soda, and gr. i. of menthol, the latter giving an agreeable odor and flavor, and serving to keep the solution in warm weather. For the latter purpose thymol may also be used. Mucin seems to restore moisture to the mucosa and maintain it simply in virtue of its hygroscopic properties. The above tablet, which has the appearance and odor of pepsin, may be added to half an ounce each of sterilized water and sterilized lime water, shaken well, and applied either on a cotton carrier or in spray. If the latter be used, the spray tube should be flushed out with clean water at intervals so as to prevent clogging. The tablets may also be given to the patient for use as troches.

It must be remembered that treatment is at best only palliative, for advanced stages of the affection present a condition practically irremediable.

Rheumatic Pharyngitis.—This occurs in two forms: (1) acute, and (2) chronic.

In the acute form we find the same list of predisposing and exciting causes as for rheumatism in general. The local changes follow the same sequence as in acute catarrhal inflammation, except that the grade of inflammation is less severe, is apt to be localized in patches, and causes an amount of pain out of all proportion to its apparent intensity. An inflammation of the fibrous fascia of the pharynx is possible.

The course of an attack is somewhat as follows: Local symptoms—burning, dysphagia, and dryness—first appear, and are followed by a mild attack of fever and constitutional depression. After two or three days these disappear, the pain suddenly shifting to the muscles of the neck, back, or extremities, possibly to some joint. The swallowing of the saliva continues to be annoying. Inspection may show livid patches or streaks in the throat. The pain is somewhat peculiar and stinging, so that those affected learn to recognize it. The sudden onset, the character of the pain, the history of rheumatism, and the sudden shifting of the local storm area form a fairly definite clinical picture which lasts for four or five days. In the writer's opinion, a diagnosis from mere inspection of the fauces cannot be made. Some writers have reported pharyngeal ulcerations which proved to be resistant to every other mode of treatment, but healed under antirheumatic measures.

Treatment calls for the exhibition of the usual remedies for rheumatism, together with local anodynes and sedatives.

In the chronic form we find the same list of causes as for chronic muscular and joint rheumatism. It is more common in men than in women, and the period from the twentieth to the sixtieth year marks its age limits. The onset may be sudden, but it is generally very gradual, and patients come under observation only after months or even years of indefinite pharyngeal pain. This is often referred to the region of the hyoid bone. Ingals finds the lesion more common on the right side. From this site the pain may radiate to or be felt on one side of the larynx, in the tonsils, trachea,

side of the base of the tongue, etc. The parts within reach are painful on pressure, and are generally so during swallowing or phonation. Continuous speech is especially tiresome. Curiously enough the pain may disappear during eating. It is very capricious as to character, localization, and intensity. All combinations in these respects are possible. The gastroenteric tract is generally sluggish. Inspection reveals nothing constant. An area of congestion may surround the painful spot. The affection may be confounded, as far as subjective symptoms go, with almost any common inflammation of the throat, and each must be ruled out by exclusion, special stress being laid, for rheumatic pain, on the shifting of the area of annoyance, a change of severity according to the weather, and a history of the rheumatic diathesis.

The treatment is identical with that of the chronic rheumatic state in general plus the use of local sedatives. To the areas of tenderness we may apply solutions of aconite, morphine, metallic astringents, etc. Ingals advised the use of applications of the following mixture: Morphine sulphate, gr. iv.; tannic acid, gr. xxx.; carbolic acid, ♏ xxx.; and glycerin and water, of each fl. ℥ ss. Internally, salol, the various preparations of aspirin and its substitutes, alkalies and various spring waters may be given. Frequently a careful regulation of the diet and particular attention to the condition of the intestinal tract will be rewarded by cessation of these more chronic conditions.

Gouty Pharyngitis.—As in rheumatism gouty manifestations in the pharynx may be either acute or chronic.

The acute form occurs in those of a lithemic diathesis, in heavy eaters who indulge in but little exercise, and in those who have lead poisoning or renal changes. The outbreaks are more common in cold weather and follow dietetic excesses, overindulgence in wine, heavy mental or emotional strain, etc. Most of the patients are between thirty and forty years of age.

So far as concerns pathology, nothing more than a catarrhal inflammation can be found. There is a patchy hyperemia with redness and edema of the pharyngeal wall, possibly with swelling of the soft palate and uvula. The tonsils may be moderately enlarged and the larynx congested.

The *symptoms* are pain, out of all proportion to the apparent severity of the inflammation, irritable pharynx, coated and flabby tongue, scanty and high-colored urine. After a series of such attacks the teeth may appear large from retraction of the gums and they have a yellowish appearance. Diagnosis must be made from rheumatism and from simple neuralgia. Assistance is derived from the presence of tophi or other gouty manifestations elsewhere. The pain may suddenly leave the throat and appear in the joints, usually bearing the brunt of gouty outbreaks.

Treatment calls for the exhibition of colchicum and the use of local sedative washes, as for rheumatism.

In the chronic form of gouty pharyngitis we find a dark-red discoloration of the uvula, soft palate, faucial pillars, and tonsil, the "angina uratica" of the older writers. Occasionally an acute edema of the parts is added. At times the process localizes itself in the corner between the posterior and lateral pharyngeal walls, which may be swollen and red. In young patients the mucosa may be covered with mucus or muco-pus; in older patients it is more apt to be dry and glazed, with a network of enlarged vessels or scattered livid spots. In one case there was a daily casting off of lime salts from the mucous follicles.

The *symptoms* consist of attacks of sharp pain radiating to the ears, irritable cough with the expectoration of pellets of viscid mucus, intense throat irritability, and disordered gastroenteric tract. Possible symptoms are spasmodic obstruction of the nose (alone or with coryza), dysphagia, laryngeal spasm, modification of voice, and rapid vocal fatigue. There is always a tendency to acute exacerbations. The urine shows an excess of oxalates, phosphates, and urates.

Treatment comprises an antigout regimen and local sedatives. The mineral waters are of especial service. One of the best local applications consists of menthol gr. x., and terebene ♏ xv. in liquid paraffin.

Syphilis of the Pharynx.—For information as to present-day views of the nature of the syphilitic virus, other articles in this Handbook must be consulted. It may be said in passing that acute and chronic inflammations of the pharyngeal mucosa distinctly predispose to specific infection.

The initial lesion may appear on either the soft palate or the tonsils. A chancre, more or less indurated, is present with later erosions from irritation or ulceration. There is invariably enlargement of the cervical glands, and in due time constitutional symptoms developed.

Erythema appears in from the sixth to the sixteenth week or later. The mucosa on the lips, cheeks, tonsils, uvula, soft palate, and posterior pharyngeal wall has the appearance of passive congestion. The areas involved vary in size from a pea to a penny. The erythema is symmetrical and shows a sharp demarcation from the surrounding tissue. This demarcation and symmetry are strongly suggestive, for otherwise the mucosa appears as if only ordinarily inflamed.

The mucous patch may occur at any time, though it is generally one of the "secondary" manifestations. It poisons the buccal secretions and is, therefore, especially dangerous. The patches are ovoid and shallow, possibly symmetrical, and represent areas with an exudate of serum and a free supply of imperfectly developed cells. Without treatment these areas and their surrounding zones of tissue ulcerate and cicatrize, the cicatrix being stellate.

The gumma appears in from five to fifteen years after infection. Its favorite site is on the posterior surface of the soft palate. This lesion rarely passes over anatomical boundaries, that is, it does not extend directly in front of the faucial pillars, above the pharyngeal tonsil, or to the larynx. It appears as a diffuse infiltration, may form rapidly, and may undergo rapid destruction. It may be nodular, in which case there is a bulging of the superjacent mucosa. There is an infiltration of the tissues and vessel walls with small round embryonic cells embedded in a gelatinous basement substance. The mutual crowding of these cells shuts off the blood supply, and the whole mass breaks down into a cheesy consistency surrounded by a zone of granulation tissue, which later becomes fibrous. Abscess formation is rare. Destruction does not pass beyond the confines of the original deposit. Large areas may give way while bands of fibrous tissue pass from one point to another, thus distorting the parts. Fluids may therefore regurgitate into the nose and the soft palate becomes adherent (rarely completely so) to the posterior pharyngeal wall. The hard palate may become involved and perforated and occasionally a large vessel is eroded. Gummata are more rarely absorbed in the pharynx than elsewhere. Occasionally the course is so acute that immense destruction occurs in a very few days.

The *symptoms* of the initial lesions are painful swallowing and enlarged glands, that is, nothing outside of what may accompany an ordinary sore throat. The diagnosis is often indecisive until cutaneous lesions appear. In erythema we find a peculiar stiffness of the throat muscles and painful swallowing. In the mucous patch there is extreme sensitiveness increased by all irritants and by overuse of the voice. Nutrition may be interfered with. Fresh patches appear in groups occupying, in order of relative frequency, the soft palate and uvula, anterior surface of anterior pillars, tonsillar convexities, and anterior surface of the posterior pillars. A patch on one side may by contact

symmetrically reproduce itself on the other side. A fresh patch is strongly suggestive of a recent application of silver nitrate. A few cases have been seen with a thick exudation suggestive of diphtheria and attended with marked constitutional symptoms.

The *symptoms* of the gumma are mainly mechanical. After ulceration has occurred pain may be severe. The typical tertiary ulcer is deeply excavated with sharply defined edges, surrounded by an angry red zone and covered with bright yellowish pus.

The *diagnosis* of the advanced lesions is not difficult; but the same is not true of the earlier ones. At first sight the patients may present nothing but the lesions of an ordinary sore throat. A most careful examination should be made, together with an investigation into the possibility of infection. All apparently simple catarrhal cases not yielding to treatment must be regarded as suspicious, and also those cases presenting a persistent dysphagia without apparent cause. Even when not in much doubt, certainly when a dianosis is not to be otherwise made, a Wassermann should be instituted. In view of the fact that a negative Wassermann proves nothing it will be frequently found wise to give a salvarsan injection. This may be done when the destruction of parts is thus about to be serious, without waiting for the Wassermann. This saves very valuable time and tissue by so doing, starts the patient on the way to recovery, while at the same time establishes the diagnosis beyond all peradventure.

Treatment must be prompt and energetic. Alcohol, tobacco, condiments, and all irritants must be given up. The toothbrush must be used regularly and followed by rinsing with some weak antiseptic. If deglutition be extremely painful a weak cocaine solution may be used before eating. The patient must be told that he is a potential source of danger to others, and strict hygiene in every sense must be enforced. Local lesions should be cleansed with an alkaline spray and dusted with orthoform, or argyrol (silver vitellin) may be applied in thirty per cent. watery solution. For home use as a cleansing agent we may order bichloride solution, 1 to 3,000, or black wash. Each mucous patch should be touched with silver-nitrate stick. Indurated areas may be painted with a solution of bichloride two grains, in sulphuric ether, five drams. Small palatal perforations may heal under the combined effect of constitutional treatment and the application to their edges, thrice weekly, of mono- or trichloracetic acid fused on a probe. Sometimes an obturator may be fitted, with advantage to the act of swallowing.

Constitutional treatment must be adapted to the existing stage of the disease (see article on *Syphilis*). Deformities and stenoses must be treated according to the requirements of each individual case.

Tuberculosis of the Pharynx.—In the vast majority of cases pharyngeal tuberculosis is secondary to deposits in other parts of the body. The primary form is, however, possible, and forms about one per cent. of all cases of acute tuberculous inflammations of the upper air passages. As opposed to this rarity is the virulence of the disease. Favorite seats of invasions are the uvula and soft palate, especially the anterior surfaces of these structures; then come the tonsils, posterior pharyngeal wall, and hard palate.

The general causes are those of tuberculosis in general. The exposed position of the parts would seem to predispose them to infection, but their constant movement in normal function tends to clear away morbid material before it has had time to penetrate the tissues. Some authorities believe that the saliva offers a distinct barrier to the acclimatization of the tubercle bacillus, while other forms of bacterial life, with which the oral cavity swarms, are also inimical to bacillary growth. Infection may come through the blood and lymph, through the inspired air, and through foodstuffs.

The disease may manifest itself in two forms: (1) the ordinary miliary tubercle; and (2) a papular lesion confined to small areas, and especially apt to settle on the anterior surface of the soft palate. In both the microscopical picture is the same, viz., a small round-celled infiltration of the connective tissue gradually extending into the vessels walls. Then follow endarteritis, obliteration, cheesy softening and ulceration. It is difficult to find either bacilli or giant cells in scrapings from the surface or in bits of tissue removed.

On inspection we may note either the miliary deposits studding the mucosa and apparently shining through it as white points, or there may be the larger papular masses extending in the primary cases as a fringe of small excrescences along the anterior pillars. After a while these deposits break down into characteristic ulcers. These may by their coalescence involve a large area. The uvula becomes swollen, edematous, and exquisitely painful. Cases of perforation of both the soft and the hard palate are on record. The general appearance of other pharyngeal surfaces is one of anemia due either to the endarteritis or possibly to a toxic vasoconstriction.

The most constant *symptom* is early and constant pain in the affected areas. The palatal muscles are swollen and stiff with resulting dysphagia. Food accumulates in the pharyngeal recesses and may get into the nasopharynx. Cough is present and the accumulation of saliva is excessive. Speech is hesitating, but the voice is not changed unless the larynx is involved. Later the cervical glands are enlarged. If the process is confined to the tonsils the difficulty in swallowing is much less. Owing to the latter symptom the patient is loath to take food, and the emaciation incident to the constitutional malady is hastened.

Diagnosis is based upon the characteristic appearance of the parts and the coexistence of tuberculous lesions in other parts of the body. Syphilis must be excluded in doubtful cases by the results of treatment. The two diseases may coexist. The typical tuberculous ulcer is shallow, with a surface flush with the surrounding mucosa, with the same color, covered with ropy mucus and possibly with a periedema; in cases complicated by syphilis the ulceration is extremely sluggish, has a dirty looking secretion, and is but little painful.

The *prognosis* is as a rule bad, though a few recoveries have been reported. The local condition is but one feature of a constitutional involvement. Healing of the ulcerations will greatly conduce to the tolerance of living, even though the constitutional deterioration goes steadily on.

Every hygienic and tonic measure possible should be instituted. Climate does not seem to be of much service in pharyngeal tuberculosis. All sources of buccal irritation should be removed, the teeth placed in order, and the food should be pultaceous. The patient will often find it easier to gulp food down than swallow it in the conventional way. The plan most in vogue at the present time for treating the ulcers is to curette them thoroughly under cocaine and then rub in solutions of lactic acid in water, beginning with say ten per cent. and gradually increasing up to eighty per cent., or even the pure acids. The ulcerated surfaces should be regularly cleansed with hydrogen peroxide, then with a weak alkaline solution, and finally dusted with some such powder as aristol. Enzymol, a proteid ferment, may be substituted for the peroxide. It is less irritating and just as efficient. Menthol in olive oil, twenty per cent., has its advocates. Morphine with cocaine or tannin may be cautiously applied, but the use of the first-named remedy should be avoided as long as possible. For the cough we may give heroin in one-twelfth grain doses every three hours, or dionin in proper dosage may be substituted. Orthoform is here used as a local anodyne with great advantage.

When it fails anesthesin used in the same way will be helpful. It may be dusted on with equal parts of stearate of zinc or subcarbonate of bismuth, or blown on clear with a powder blower. To insure its contact as long as possible with the affected parts we may use the excellent formula of Freudenthal, viz., Menthol ten grams, expressed oil of almonds thirty grams, yolks of two eggs, orthoform (twelve and one-half grams), and water to make 100 grams.

Actinomycosis of the Pharynx.—This is an infectious, parasitic, and inoculable disease primarily attacking domestic cattle, but communicable from them to man. The original source of infection is grain. Bollinger says that oats grown on newly ploughed land are the main carriers of contagion, but that rye and other grains are at times similarly affected. In man the infection may arise by inoculation from animals, possibily from infected cereal foodstuffs, and doubtless often from the frequent habit of field workers of chewing bits of hay, straw, etc. Flies may carry the contagion. In one instance kissing was the method of conveying the disease.

It is difficult to say just how often the pharynx is affected, as reliable statistics on this point are lacking. We may refer to the figures of J. Israel, who found that out of 500 cases the head and neck were involved in fifty-five per cent., and the throat and lungs in twenty per cent. Figures as to localization in the pharynx are not given. In the latter site the disease may be primary or secondary.

The infecting agent is an organism called the "ray fungus." Its exact place in classification is still a matter of dispute. By some it is called streptothrix actinomycotica; by others, actinocladothrix. It appears in the suppurative foci (hereinafter described) aggregated in small masses of a yellowish color. It can be cultivated in gelatin and more quickly in agar and beef serum. Its favorite temperature is about 95° F. For examination a bit of the suspected material should be smeared or teased on a slide, carefully dried in a flame and then stained a few minutes in a solution of picrocarmine, washed in water or alcohol, and mounted in glycerin. Sections of tissue are handled in the same way and mounted in glycerin or Canada balsam. The fungi appear yellow and the remainder of the field red. The actinomycotic tufts and single nodes may be recognized, scattered about in the field, and easily distinguishable from the surrounding red.

According to Leumann each of the yellowish masses may be subdivided into three zones; (1) An outer zone made up of club-shaped, wedge-like rays with rounded bases appearing when viewed in sections to be set on star fashion and surrounded by large cells or by cells seeming to contain fragments of the fungi in their substance; (2) a middle zone made up of branching mycelial threads (furcated) passing from the center to the periphery; and (3) an inner zone made up of cocci in chains. The threads are the active portion of the organism and the portion capable of artificial growth.

Certain observers have noted the presence of structures known as Rainey's or Mieschler's corpuscles. These are cylindrical tube-like bodies and are supposed to be due to the growth of the ray fungus inside muscular fibers. They are therefore rather a result than an essential element of the process.

When once infection has occurred extension is probably not through the lymphatics but by destruction of the vessel walls and the consequent easy access to the inner organs by the blood stream. The accompanying glandular enlargement is due to the admixture, with the ray fungi, of pus microorganisms, notably the *Streptococcus pyogenes aureus*.

Undoubtedly the mouth is the most frequent portal of infection especially the alveolar processes of the lower jaw. Israel has found the fungi in the lacunæ of healthy tonsils, but they are harmless in the absence of solution of tissue continuity.

The first manifestation of infection is generally a periosteal abscess running the usual course and leading in about six weeks to true periostitis. The surrounding tissues are invaded, and suppuration appears between the chin and the hyoid bone, produced, be it remembered, not by the fungi but by pus cocci. Other cases begin as a gingivitis with spongy gums and alveolar stomatitis. From the foregoing sites the lesion attacks localities farther back, notably the pharyngeal wall. The tonsils and palatal arches are but rarely involved. Not infrequently the cheeks suffer. When once the pharynx becomes invaded, either primarily or secondarily, we note small reddish elevations looking not unlike a subacute pharyngitis upon a mucosa previously the seat of chronic changes. The adjacent tissues swell and then seem to lose their appearance of acute inflammation, becoming more like a zone of chronic infiltration, irregular in surface and firm to the touch. Suppuration soon appears with the development of angry-looking sinuses with undermined edges.

Aside from general pharyngeal discomfort, there are no *local symptoms;* actual pain is not constant. Later, comes the general deterioration due to the suppuration, but it is not accompanied by any special features. The characteristics, therefore, of the disease are: (1) The remarkable extension and induration of the parts; (2) the slow dragging course of the inflammation; (3) the extension of the process to the surface, after the lapse of several months, by a softening and final spontaneous evacuation, the pus being sero-sanguinolent; and (4) the quick healing of the local focus with apparently a favorable outlook, but the appearance of the infection in the neighborhood, or at a distance, with fresh vigor. Fatal symptoms are always tardy in development.

Diagnosis is called for from syphilis and from malignant disease, especially sarcoma. Sections of the latter may present appearances which strongly suggest actinomycotic tissue, but in the latter the microscope will reveal the ray fungi.

Treatment calls for radical excision if this is possible. Internally, large doses of the iodide of potassium have been given, and have apparently cured some cases. The internal use of silver nitrate has also been advised. Nearly every antiseptic has been used locally, but there is no specific. Without doubt bichloride of mercury is as efficient as any.

Glanders.—Glanders is a disease primarily affecting horses, and may be communicated from them to man and from one man to another. The exciting agent is the *Bacillus mallei*, resembling morphologically the *B. tuberculosis*, though somewhat shorter and thicker (see vol. iv., p. 711). In man the nasal structures are generally the portals of infection, and the process extends to the pharynx.

Retropharyngeal Abscess.—These cases are often overlooked, because no digital examination is made of the pharynx, the observer contenting himself with mere inspection. The affection should always be suspected in a child with difficulty in breathing and swallowing without apparent cause.

The phlegmon forms in a flat shallow cavity behind the pharynx and esophagus, limited posteriorly by the spinal aponeurosis and anteriorly by a connective-tissue sheath. Its lateral boundaries are sheaths which stretch from the aponeurosis to the lamellar spinal sheaths. Above is the basis cranii, and below, the mediastinum. The contents are sympathetic ganglia and lymph nodes receiving drainage from the neck, nasopharynx, and pharynx. Externally are important vessels and nerves. The above is the most frequent site of the abscess, but lateral sites are possible; many of the latter are doubtless but "pointings" from a central focus.

The inflammation begins in the lymph nodes and extends to the cellular tissue. It may, however, begin in the latter from irritation, as from instruments or a foreign body. In children in whom the disease is far more common than in adults, infection may come from such conditions as otitis media, erysipelas, pharyngitis, etc. An antral empyema is recorded as the cause of one case. In children of the tuberculous, syphilitic, and lymphatic diatheses, there is always a lessened resistance to infection, and it is in just such children that the malady is most common.

In infants the first symptom may be refusal of the nipple; then follow a metallic cry, dysphagia, and dyspnea. In older children there is the usual sore-throat symptom-complex, and inspection may at once reveal the nature of the trouble, but *palpation should never be omitted.* This may reveal a soft, boggy tumor, which pushes forward the soft palate, and in which perhaps fluctuation may be felt. Lateral cervical swelling is also possible.

The main danger previous to rupture lies in possible laryngeal edema with bulging of the entire larynx forward, and consequent asphyxia. Burrowing may lead to infiltration of the cervical tissues and death from sepsis. The most common danger is rupture during sleep, escape of the pus into the lower air passages, and speedy asphyxia.

Pus accumulation may occur within twenty-four hours after initial symptoms; other cases may last several weeks, or even several months if they are tuberculous in origin. Diagnosis is called for from coryza, tonsillitis, croup, and even diphtheria.

Immediate evacuation of the pus is necessary. The child must be held in a good light with open mouth, a gag being used if necessary. With a protected blade a liberal incision should be made from the middle of the fluctuating area to its bottom. *Immediately after incision, the child which has been held with its head forward should be inverted so as to allow the pus to run out of the mouth.* Meanwhile the finger which was *in situ* directing the incision may be passed into the sac so as thoroughly to open it and thus prevent refilling. Lateral pressure of the pus will direct the large vessels outward so that there is little practical danger of injuring them. It can generally be arranged when one is operating with a head-mirror, good light, and some assistance as ought always be the case when at all possible, to make the incision with the head hanging downward as on the end of a table or over the shoulder or back of an assistant. This prevents the first rush of pus from running down into the larynx and the child can quickly be put on its side when the cutting is over. In one case sudden death occurred as the incision was made. Edema of the glottis was not present, but the pneumogastric nerves had been stretched by the pressure of the pus. Death was ascribed to reflex syncope. In cases with much cervical swelling lateral incision from the outside has been suggested. Some have even recommended this procedure for central fluctuation, the escape of pus into the lower air passages being thereby prevented.

Pharyngeal Mycosis.—Over 100 organisms are found in the healthy mouth. The most common are the *Oïdium albicans,* actinomyces, *Aspergillus fumigatus, Bacillus fasciculatus,* the fungus causing nigrities linguæ or "black tongue," and various species of leptothrix. By common usage the term pharyngeal mycosis, when used without modification, refers to the affection characterized by the growth of the leptothrix. It was first described by Fraenkel in 1873, receiving the name mycosis tonsillaris benigna. It occurs on the tonsil, tongue, pharyngeal wall, faucial pillars, epiglottis, and rarely in the nose, nasopharynx, and larynx.

The fungus clings to the epithelia and often prefers a healthy to a diseased surface, above which it appreciably projects. It is of horny consistency and is removed with difficulty. Threads may connect the isolated deposits so that the general appearance is that of roots with running tendrils. If a portion be teased out and examined in glycerin under the glass, we note a mass of epithelia surrounded by irregular granules in which are embedded the spores of various species of leptothrix. These spores are arranged in link-like processes, their ends being rounded or club-shaped. The processes vary in length, and may be curled up at the ends in hair-like filaments. Besides these bodies there are round or oval, highly refractive bodies arranged in colonies or scattered among the branching spores. The link-like processes are the mycelia of the fungus, and staining with methyl blue will show alternating colored and uncolored segments. The fungus has never been cultivated outside the human body.

As clinically seen the affection follows previous pharyngeal inflammation, deposits of tartar on the teeth, altered reaction of the buccal fluids, disordered digestive states, etc. There is no reason to believe that rheumatism or gout has any direct causative relation. Incidentally it may be said that the same fungi have been found in fetid bronchitis, tracheal ozena, pulmonary gangrene, rhinoliths, tonsilloliths, vesical calculi, the tongue coating of low febrile states, in the lachrymal duct, intestines, vagina, and feces. At any site they may precipitate lime salts from fluids holding the same in solution.

In 1895 Siebenmann advanced a different view as to the nature of the familiar pharyngeal mycosis, claiming that it was essentially a hyperkeratosis of the mucosa. All tonsils exhibit this in a varying degree, and this collection of hyperkeratosed epithelium is a constant menace to the integrity of surrounding structures.

The *symptoms* are pharyngeal dysesthesia, cough, difficulty in swallowing, sensation as of a foreign body, and occasionally reflex pain in the larynx. Possibilities are fever, enlarged submaxillary glands, and congestion of the palate and uvula. Periods of improvement and relapse succeed each other without any treatment whatever. The affection is in no wise dangerous, and it alarms patients out of all proportion to its gravity.

Treatment.—In treating a case the teeth must be placed in proper condition, the digestion regulated, and for a time at least all sweets must be cut off. Climatic changes may give surprisingly favorable results. Nearly every caustic has been suggested for the destruction of the roots of the fungi; mere superficial clipping off is useless. The only reliable measure is the use of the galvanocautery plunged into each crypt harboring a root of the fungus. If the cautery is unavailable, chromic acid fused on a probe will answer.

James E. Newcomb.
Revised by Henry L. Swain.

Pharynx, Malformations and Deformities of the.—There are two kinds of malformations which affect the pharynx—stenoses and dilatations. We will take up these subjects in the order named.

Stenoses may be congenital or postnatal, and they may be incomplete or complete. Complete stenosis or atresia is accompanied by pocket-like dilatations or pouches. These malformations are to be ascribed to prenatal anomalies of development. The constrictions are most often found in that part of the pharynx which lies adjacent to the cricoid cartilage of the larynx but they have been met with also in the upper part of the pharynx, at the junction of the oral and nasal portions of this cavity.

The lower constriction appears as a ring-like septum of mucous membrane, which may reduce the caliber of the tube by one-half or more of its diameter, and cases of complete atresia have been reported. Fortunately, these stenoses may exist without being pro-

ductive of suffering so long as they do not become the seat of an inflammatory process.

The palatal, or high, stenosis is formed by a membrane which stretches from the soft palate backward and outward to join the posterior and lateral walls of the pharynx. Cases of diaphragm of the pharynx resulting from scarlet fever, such as the writer has reported, and syphilitic adhesions, may be mistaken for congenital stenoses, but a close examination may reveal scar tissue, which is indicative of a previous inflammation.

Postnatal malformations are the result of two classes of causes: intrinsic and extrinsic. Intrinsic causes, or those which have their origin in the pharynx, are such as scarlet fever, lupus, syphilis, diphtheria, and traumatisms. Extrinsic causes, or those which operate from without the pharynx, are in the nature of deformities of the spine, tumors, and abscesses.

Intrinsic stenoses are most often due to syphilitic adhesions which spread out above the oral pharynx and connect the posterior pharyngeal wall and posterior columns of the fauces with the soft palate. The diaphragm thus formed may be partial or complete. The appearance of this adventitious tissue, and the presence of suggestive scar tissue, together with more or less inflammatory destruction of the adjacent soft parts, will simplify the diagnosis. The differentiation is still further facilitated when perforations of the hard palate are present, for these sequels are particularly characteristic of syphilis.

Syphilitic membranous adhesions are sometimes found connecting the posterior pharyngeal wall with the base of the tongue, or a syphilitic stenosis may be formed at a point opposite to the cricoid cartilage of the larynx, where the congenital stricture is most often located. These membranous diaphragms are perforated, and, like the prenatal stenoses, they may cause little or no inconvenience so long as they are not involved in any inflammatory action, and they are not prone to such attacks.

Scarlet fever is sometimes responsible for these membranous obstructions. Such a case was reported, with an accompanying photographic illustration (Fig. 4270), by the writer in "Diseases of the Ear, Nose, and Throat, and their Accessory Cavities," 4th edition, p. 230. The subject was a young lady who had had an attack of scarlet fever when she was a small child. The age at which she was sick could not be ascertained. The nasal pharynx was found to be separated from the oral portion by an adventitious membrane, which extended from the posterior columns of the fauces and the arch of the soft palate downward laterally and backward to the lateral and posterior walls of the pharynx opposite to the base of the tongue. Its general direction from the palatal attachment, instead of being nearly horizontal, closely approximated a vertical plane. In the center of this diaphragm was an oval opening, the long diameter of which was vertical. Through this perforation the posterior wall of the pharynx was visible, and nasal respiration took place. The patient complained of no serious inconvenience resulting from this anomaly, except that food would lodge behind the membrane and demand her attention to wash it out so as to prevent decomposition and its results.

Percy Fridenberg reported to the Section on Laryngology and Rhinology of the New York Academy of Medicine, April 29, 1908, a case of a man twenty-one years old, in whom there were symmetrical clefts in the pillars of the fauces. The author could find only three other cases like his on record, among a considerable number of defects of the faucial pillars, which had been reported. There was no disturbance of function due to these lateral supernumerary openings, but the voice had a nasal twang, and a metallic timbre characteristic of cleft palate.

Suppurative processes of the pharynx in the course of other diseases may produce anomalies similar to the one which I have just described. Such diseases are diphtheria, smallpox, lupus, and erysipelas. In such instances the pharyngeal symptoms become very prominent and distressing during the inflammatory stage. The constitutional disturbances are pronounced, the cervical glands may be involved, the difficulty of swallowing is marked and becomes evident to the patient's friends. Inspection of the throat reveals the characteristics of an intense degree of inflammation: redness and tumefaction of all the surfaces involved, edema of the soft palate and uvula, and, in the advanced stage, suppuration and ulceration. These characteristics of inflammatory affections which eventuate in pharyngeal stenoses should put the practitioner on his guard against such results.

Traumatic causes of pharyngeal stenoses are in the nature of scalds, such as the accidental drinking of hot liquids by children, and the chemical action of caustics, such as carbolic acid, potash, etc.

Fig. 4270.—Diaphragm of the Pharynx. (Case of Dr. S. S. Bishop.)

Treatment.—The treatment of stenoses of the pharynx may most conveniently be considered under two headings—general and local. In the case of syphilitic adhesions general treatment should first be instituted, and should consist of the exhibition of the iodides, mercury, etc., according to the principles laid down in the article on syphilis. The local treatment formerly consisted of systematic dilatations by means of graduated bougies, but the firm, fibrous character of the membrane does not lend itself encouragingly to this method of treatment, for the stenosis returns after the dilatations are discontinued. The knife also was much in vogue in early days for the eradication of these anomalies, but we now have, in the electric cautery, a much safer and more certain means of removing adventitious tissue.

A practically bloodless and painless operation is possible by means of the electric-cautery dissection after the application of suprarenal extract and cocaine to the field of operation, as follows: A fresh or preserved saturated solution of the suprarenal gland is applied to the periphery of the membrane which is to be removed. The writer reverses the method usually employed in the application of suprarenal solution and

cocaine, and applies the suprarenal preparation first for the following reasons: If the blood-vessels of the tissues to be operated upon are first contracted, the blood current is so far diminished in volume as to reduce to a minimum the amount of cocaine that is taken into the circulation. Hence there is less liability to the toxic manifestations of cocaine. Moreover, when it is possible to contract the tissues before applying cocaine to them the anesthetic penetrates relatively deeper and produces a more profound degree of anesthesia. By observing this rule of procedure it is possible to employ a stronger solution of cocaine than would be safe if the order of application of the remedies were reversed. I have demonstrated the importance of these facts in a long series of operations.

Cocaine should be applied to the surfaces to be severed, not by means of a spray, but by the cotton applicator, care being taken that the surplus of the cocaine solution is expressed from the cotton pledget on the carrier before the application is made. This is necessary in order to prevent any excess of cocaine from running down into the larynx or the esophagus. Strong solutions of this very toxic remedy must be either avoided, or employed in the pharynx with the greatest caution. For the sake of emphasizing this statement it is excusable to cite a case which was brought to the attention of the writer by a former clinical assistant. He was about to operate on a patient's throat after having applied cocaine, but before be began the operation alarming symptoms developed, and the patient suddenly expired in his chair. It must be kept in mind that in these throat operations an extensive surface must be cocainized, and that, therefore, a large amount of the drug may be absorbed. The writer has seen numerous cases of collapse and acute mania result from its employment in operations where the surfaces requiring anesthesia were of much smaller area, but these unfortunate manifestations were probably due to the use of sprays that medicated other parts, in addition to those which were operated upon. I believe that such accidents can be avoided by the use of weaker preparations than those commonly employed, since they are often of twenty or thirty-three per cent. strength, and by taking the precautions already advised. The writer attributes to these reasons the fact that he has never had any such distressing experiences as those mentioned above. It is better not to apply to the pharynx solutions of cocaine stronger than from four to eight per cent. I speak in detail of these matters here in order to avoid repetition in treating of pharyngeal procedures under local anesthesia later. The operation, after cocainization, consists of passing a bent electrode, at a white heat, through the periphery of the obstructing membrane, carrying the electrode, as it burns its way, throughout the whole circumference of the diaphragm. Care must be exercised not to encroach upon the surrounding tissues, which we do not wish to attack. After the membrane has been thus severed, if any hemorrhage occurs, the suprarenal extract must again be applied; but if the electrode is properly used and is not allowed to cool before being removed from the tissues, little or no hemorrhage follows.

It is advisable to keep the patient under observation for a few hours after the operation in order to anticipate any secondary bleeding that might occur. Should any tendency to the formation of exuberant granulations appear, they may be suppressed by the application of the silver-nitrate pencil. If a ten-per-cent. solution of this remedy be painted over freshly operated surfaces, there is far less danger of hemorrhages, and the desired effects of the operation are enhanced.

Little in addition need be said regarding stenosis due to lupus, but the present indications are that we are justified in expecting beneficial effects from the *x*-ray treatment.

Extrinsic causes of pharyngeal stenosis may consist of tumors, such as an aneurysm or a goiter, or the cervical portion of the vertebral column may be deformed or diseased, or a retropharyngeal abscess may encroach upon the lumen of the cavity; but the treatment of these conditions obviously does not lie within the limits of this article.

Dilatation of the pharynx may affect the whole, or only a part, of the cavity. It generally exists in the form of a pouch, which is comparable to the aneurysmal distention of an artery. The congenital variety is to be attributed to an intrauterine developmental anomaly.

The acquired, or postnatal, form probably occurs in consequence of an imperfectly developed, or weakened, area of the tunic of the pharynx, which yields to undue pressure. Contributory to these causes are the habits of improperly masticating food, and a hasty manner of forcing large and irregular boluses of food down the gullet. It is easy to conceive that these repeated distentions of the pharynx tend to carry the mucous membrane between the surrounding muscular fibers, especially where the latter may be weak or defective. A pouch so formed may continue developing until it becomes several inches long. It is most likely to be found extending downward and backward between the vertebræ and the esophagus. Generally this diverticulum consists of the mucous and submucous coats of the pharynx, but it has been found to be enclosed in the esophageal cellular membrane. Occasionally these pouches extend to one side, and are sufficiently prominent to appear as a tumor in the side of the neck.

The most prominent and constant symptom is a difficulty in swallowing. Food lodges in the pouch and forms a temporary tumor, which obstructs the act of deglutition, until the pouch is emptied automatically or by the patient. He generally learns, however, that by digital pressure and manipulation of the tumor he is able to express the contents and enjoy relief. Unless this is done the imprisoned food may decompose and set up an inflammatory condition. Indeed, such an inflammatory process has given rise to the formation of adhesions which have resulted in a closure of the sac and a consequent permanent cure. But a less fortunate termination of such an inflammation may be the occurrence of sloughing of the surrounding tissues.

Other distressing symptoms arising from the ejection of food retained in the pouch are in the nature of an irritation of the lower respiratory tract. For example, the emptying of food into the larynx occasions violent spasms of coughing, and some particles may even reach the bronchial tubes and cause attacks of bronchitis or pneumonia.

The *diagnosis* of this condition is made with comparative facility. The obstruction to swallowing, the tumor which disappears and recurs, or which can be dissipated by pressing out its contents, the ejection of undigested food in the absence of actual vomiting, the entrance of particles of food into the larynx subsequently to, instead of during, a meal, together with the results of an examination with the throat mirror and digital exploration, afford a mass of evidence that is of a pathognomonic character.

The *prognosis* is not a cheering one. Without operative interference the condition is rarely corrected. In an occasional instance an inflammatory process is instituted which eventuates in a spontaneous closure of the pocket and a resulting cure. But there is always the danger of retention and putrefaction of food. In some cases patients must needs subsist on a fluid diet in order to avert such results; but in conditions that lend themselves favorably to operative measures the anomalies may be corrected.

Treatment.—We may best consider this subject under two divisions—palliative and curative. Palliative treatment rests mainly with the patient. By avoiding hurried eating and imperfect mastication he removes the principal cause of acquired pharyngeal

pouches, for it is the forcing of boluses of food through the cavity that distends the mucous coat of the pharynx and pushes the membrane between the fibers of its muscular tunic. After a meal during which ingesta enter the pouch he should manipulate the distended sac with his fingers until it is emptied, and he may even be able to wash it out by means of a properly curved syringe. By this means the fermentation and decomposition of retained food may be prevented.

When the diverticulum is situated at the side of the neck the patient may be able to prevent it from filling if he will press upon it with his fingers, or if a compress be worn over it at meal time. If these means do not suffice, and if the symptoms become urgent, it may become necessary to resort to an operation.

Operative Treatment.—The simplest and most promising measure of this nature consists in the application of the electric cautery to the periphery of the pharyngeal mouth of the sac. Cocaine should first be applied to the field of operation, the surgeon being careful to observe the precautions already mentioned. After this preparation for the adhesion of the adjacent borders of the pouch rectal alimentation is resorted to for a few days. In certain cases it may be necessary to operate after the methods employed in pharyngotomy or esophagotomy, suturing the edges of the divided mucous membrane to hasten recovery and insure the subsequent integrity of the pharyngeal cavity.

Waggett and Davis have reported (*Progressive Medicine*, March, 1914) a successful operation for pharyngeal diverticulum by removing the pouch. "The stump was carefully stitched with a continuous silk stitch and then buried by a layer of Lembert sutures. The wound was closed and drained." The cure was complete. "Examination showed that the sac was composed of the mucous and submucous layers, which had apparently become gradually invaginated between two definite parts of the inferior constrictor muscle." SETH SCOTT BISHOP.

Pharynx, New Growths of the.—Neoplasms of the pharynx will be considered under the following classification:

1. *Epiblastic and Hypoblastic.*	2. *Mesoblastic.*
Papilloma	Fibroma
Adenoma	Lipoma
Cystoma	Angioma
Carcinoma	Sarcoma

Fortunately the pharynx is not so often the seat of neoplasms as are the nose and some other areas; but when growths do occur in the pharynx they give rise to warranted apprehension, even if they are of a benign nature, since, as Virchow has observed, they may take on a malignant character. More particularly is this true of tumors situated, as these are, in a passageway which renders them subject to frequently repeated disturbances and irritation. A still further important consideration is the hindrance which they may cause to the acts of swallowing and breathing, and the consequent impairment of nutrition and deficient oxygenation of the blood. To these genuine reasons of anxiety may be added the tendency to recurring attacks of inflammation to which these growths predispose the subject, and the proneness of the inflammatory process to invade the larynx and lungs.

PAPILLOMA.—This is an epithelial tumor of a benign character, which occurs less frequently in the pharynx than in the larynx and mouth. The structure consists of epithelial cells, with a framework of connective tissue beneath the epithelial proliferation. Within this tissue, and separated from it by the membrana propria, is the vascular area. What has been said relative to the transformation of innocent tumors into malignant ones applies with especial appropriateness to papillomata, since no other growths are so likely as these to undergo degeneration. Add to this fact the exposed situation in the pharynx and the frequently repeated irritation to which their location subjects them, and all of the conditions favor their malignant transformation. Aside from the pillars of the fauces and the tonsils, the most common location of papillomata in the pharynx is the posterior wall. They vary in size from a hempseed to a cherry.

The *diagnosis* of pharyngeal papilloma ordinarily presents little or no difficulty, particularly when no inflammatory process is present. But since they are often associated with an inflammatory condition, or follow it, in such cases there is room for doubt. Then a section should be taken from the base of the tumor, or tumors if they are multiple, for a microscopical examination. The growths have a warty or cauliflower shape, and are of a pale pink or gray color when not made red by irritation or inflammation. Their glistening appearance is due to the reflection of light from the secretions which moisten their surface.

Unless they attain to a considerable size they do not provoke any symptoms sufficiently marked to call attention to their presence, such as a sense of a foreign body in the throat, or impeded deglutition or respiration.

The *prognosis* of papillomata of the pharynx is favorable, provided that they do not undergo a transformation into carcinomata or sarcomata. They rarely become larger than a small-sized grape, and so long as they remain of an innocent nature no suffering is experienced.

Treatment.—Treatment consists in extirpation and cauterization of the seat of attachment. This is best effected by means of the electric cautery, which accomplishes both purposes at the same time. Or the tumor may be severed close to the surface from which it springs, by means of the scissors, knife, or the cold snare; but the base should be well cauterized afterward either with the electrode, or the silver nitrate, or one of the other chemical caustics, in order to lessen the likelihood of a regeneration or degeneration of any tumor tissue which may remain.

ADENOMA.—True adenoma does not occur in the pharynx proper. Adenoid vegetations in the nasopharynx are discussed under the heading of *Tonsils*.

CYSTOMA.—The true cystic tumor, or that in which the wall of the cyst is produced from a matrix of embryonic cells, and the products of tissue proliferation of the cells lining the cyst wall constitute the contents of the sac, is rarely, if ever, met with in the pharynx. Retention cysts, however, occur as the result of an inflammatory process, which causes a stenosis or closure of the duct leading from a gland, with the result of distending the duct, as the glandular secretions accumulate behind the stricture until the consequent tumefaction becomes apparent. The continued accumulation of the contents of the sac causes sufficient pressure on its walls to account for the degeneration of its epithelial lining and for the atrophy which is present in the attenuated membrane. These cysts are generally found in adult life, or in those who have passed the meridian of life.

Treatment.—A simple and effective method consists in opening the sac and destroying its walls. This may be accomplished by an electrode, which serves the double purpose of dividing the wall and destroying the cyst after the contents escape. Or the opening may be made with a knife, after which the walls of the sac are destroyed by a curette. Then the parts had best be treated with tincture of iodine or a ten-per-cent. solution of silver nitrate.

CARCINOMA.—When cancer exists in the pharynx proper it is generally either secondary to the same

affection of adjacent tissues, such as the tonsils, the soft palate, the esophagus, or the larynx, or it is associated with such an affection; and as diseases of these structures are considered in other sections, in order to avoid repetition the reader is referred to their proper headings.

Fibroma.—Fibromata are found in various parts of the pharynx, but they are more common to the nasal portion than to the oral division of the cavity; and they more frequently spring from the basilar process of the occipital bone. A fibroma is a representative tumor of the mesoblastic type. Like the submucous tissue from which it takes its origin it is a connective-tissue growth, and is the offspring of a highly vascular area. It is made up of mature fibrous tissue from a matrix of fibroblasts. The growth of this neoplasm is always slow, and frequently there is a tendency toward a myxomatous degeneration, or it may undergo transition into a sarcoma. As it is most often seen in the superior portion of the pharynx it is pear-shaped (Fig. 4271), but it may be sessile, and it is a product of youth rather than of old age, for it is rarely encountered above the age of thirty or forty years.

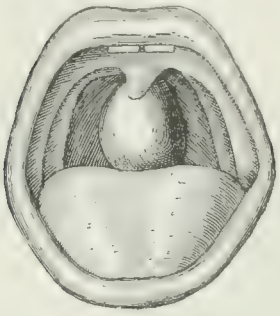

Fig. 4271.—Fibroma of the Pharynx.

The *symptoms* referable to pharyngeal fibromata are determined by the position and size of the tumors. Located in the upper or nasal portion of the pharynx they interfere with nasal respiration and impair the resonance of the voice. They sometimes attain to enormous proportions, extending forward into the nasal fossæ, crowding forward the nasal and orbital bones, protruding and separating widely the eyes so as to constitute the unsightly deformity known as "frog face," and giving rise to persistent headache. Extension of the growth upward causes encroachment on the cranial cavity, evoking cerebral symptoms. If the direction of the tumor is principally downward it causes frequent efforts to swallow, and it may produce sufficient pressure on the soft palate to impede its movements in speech and deglutition. When it reaches the aperture of the larynx it may even threaten suffocation. Mouth-breathing is a prominent symptom, and hemorrhages frequently occur as the tumors are exceedingly vascular. Impaired respiration, mental torpor, and "thick speech" characterize large growths; and when pressure is produced on the orifices of the Eustachian tubes, the proper ventilation of the middle ears is interfered with and the hearing becomes defective. A copious mucopurulent discharge is sometimes present.

Fig. 4272.—Frog Face in a Case of Fibroma of the Pharynx. (Author's case.)

The *diagnosis* of fibromata is not attended with serious difficulties. Their occurrence in young persons and their slow growth are characteristic. From mucous polypi they are recognized by their firm, dense substance. They are distinguished from adenoid growths in the vault of the pharynx by the soft, spongy lobulated appearance of the latter and their occurrence mostly in the very young. Fibromata are dense, smooth, and of a dark red color.

Prognosis.—It should not be forgotten that, as Virchow says, "fibroma only needs an increase in the size of its cells and a diminution of the cement substance to change it into a sarcoma." The location of a fibroma in the pharynx subjects it to a great amount of irritation; hence it is thereby predisposed to a degenerative transition into a sarcoma and to attain to large dimensions. Unless the growth can be removed, or unless its development can be repressed until the patient has passed his twenty-fifth year, the prognosis is grave.

Treatment.—Curative results have been claimed by numerous writers from injections of alcohol, caustic potash, chloride of zinc, dilute acetic or hydrochloric acid, etc., into new growths. It is asserted that if alcohol will produce contraction and atrophy of tissues, as occur in the cirrhotic liver of the inebriate, it will have a similar effect on a neoplasm, into the parenchyma of which it might be injected. While some observers believe that the curative effect is produced, when the alcohol is injected into the interior of the tumor, by causing the formation of new connective tissue, with the obliteration of blood-vessels, lymphatics, and the parenchyma, others inject it into the circumference, maintaining that the new connective-tissue formation, girdling the periphery of the growth, will choke the afferent and efferent blood-vessels, cut off nutrition, and thus cause atrophy.

Electrolysis is especially indicated for growths having a sessile formation, which precludes the use of torsion or the snare. For this purpose a strong current is employed under general anesthesia. Much has been claimed for the method of introducing medicaments with the electric current, or cataphoresis; but whenever it is practicable to remove the tumor in its entirety, this procedure should be preferred.

Operations.—There are several methods of operating from which to choose according to the size and situation of any given tumor. However, before detaching the growth it should be secured by passing a strong thread through it, in order to prevent it from falling into the laryngeal region of the throat and producing suffocation when the attachment is severed. The old method of removal by the cold wire snare is in quite general use, but on account of the great vascularity of these tumors and the consequent operative hemorrhage the electric snare recommends itself, since it sears over the tissues and closes the mouths of the blood-vessels with coagula as the tissues are being severed. For the same reason, in those cases in which the form and position of the attachments of these neoplasms lend themselves to such a procedure, the use of the electric knife at a white heat is advantageous. Torsion can be practised when the tumor is distinctly pedunculated.

Certain cases of pharyngeal fibromata can be

operated on through the natural oral or nasal passageways by the method mentioned above. Others, either on account of peculiarities of attachment or by reason of excessive or irregular development, must be removed through the soft or hard palate, or by means of resecting the nasal bones or the superior maxilla. Sufficient room for operating may be obtained by dividing the nose along the side of the septum, beginning at the nasal process and cutting from within outward. If more room is required, the nasal process is resected; still better access is afforded by incising the upper lip in the middle line and separating its attachments liberally. The tumor is then detached by one of the methods already described, or by the periosteal elevator, or by blunt-pointed scissors, when it is drawn out with strong forceps. These are very bloody and dangerous operations, and may require a preliminary tracheotomy and ligation of the common carotid artery. P. Hellat discards the buccal and facial routes for operations on the nasopharyngeal region, as being too mutilating. He prefers to operate through the mouth, in several sittings, if necessary. By this method, hemorrhage is controlled with greater facility. Harms Smith advocates the employment of monochloroacetic acid, beginning with two minims and running up to five minims, injected at varying intervals. Dr. McPherson, acting on the suggestion of Jonathan Wright, has used Smith's syringe for injecting monochloroacetic acid in two cases. There was no external sloughing of the tissues, but they gradually contracted and disappeared and there was no recurrence. This method is preferable to the use of the snare or forceps, for the use of the latter leaves the field of operation dirty, and the growths return.

At a meeting of the American Laryngological, Rhinological and Otological society in June, 1911, Walter A. Wells reported three cases of fibrous polypi of the nasopharynx, operated upon by means of the wire snare. The hemorrhage was slight and there was no shock or recurrence of the tumor.

D. Bryson Delavan strongly favors the employment of electricity both for the purpose of cutting off the blood supply of fibromata and shrinking them preparatory to their removal, and for their extirpation as well. Electrolysis is recommended, either by the unipolar or by the bipolar method. Either one is attended with pain. The first is the more painful and slower of the two. The bipolar method is less painful and more rapid and extensive in its destructive effect. Some operators make use of so strong a current as from 80 to 340 milliamperes. After reducing the volume of the tumor it is removed, preferably, by the incandescent wire snare, with the electric current of sufficient strength to burn its way slowly, so as to destroy the tissues thoroughly at the attachment, and to close the mouths of the severed blood-vessels. Delavan gives credit to Lincoln for introducing this method into America after the suggestions of Voltolini and Michel, and he presents, in addition to many cases collected by others, statistical data compiled by himself, which bear out the claims for the superiority of operations by the electrolytic needles and the electric snare through the natural passageways.

The statistical tables referred to cover the decade from 1891 to 1901, and include 30 cases operated upon by various surgeons who performed preliminary operations, such as resections of the nose, the superior maxilla, and the palate. There were 106 cases in which the method of operating was through the natural passages. Of these, 48 are classed as surgical and 58 as electrical procedures. Eliminating all of those cases in which the operators forgot to inform their readers regarding the nature of the results of their work, we have remaining 89 cases which are of actual value in determining the relative merits of the various methods employed. This shows 13 operations involving a preliminary intervention, with 54 per cent. of cures, 23 per cent. of deaths 23 per cent. of grave hemorrhages, and 17 per cent. of recurrences of the tumors. There were 29 cases in which various surgical procedures through the natural passages were resorted to, and the results were made known. The cures amounted to 86 per cent., the failures about 7 per cent., the hemorrhages about 17 per cent., and there were no deaths reported. There were 47 cases in which electrical operations were performed and the results recorded. The percentages were as follows: Cured, 81 per cent.; improved, 16 per cent.; failures, 2 per cent. No deaths were recorded. By combining all of those operations which were performed by way of the natural passages, for the purpose of comparing the results with those obtained after preliminary procedures, it will be found that the percentages are as follows: Cured, 83 per cent.; improved, 9 per cent. A comparison of the various methods is afforded by the following table.

Analysis of Methods.

	Total cases	Less cases in which results are not given.	Total complete histories.	Cured.	Improved.	Died.	Failure.	Hemorrhage.	Recurrence.
Resection of palate	9	− 3	6	3	..	..	..	1	3
Resection of superior maxilla.	10	− 4	6	4	...	2	..	1	1
Resection of nose...	11	−10	1		.	1	.	1	1
Total.....	30	−17	13	7	..	3		3	5
Evulsion.	27	− 9	18	16	..			3	
Cold snare	21	−10	11	9	.		2	2	
Total.. . .	48	−19	29	25	..		2	5	
Electrolysis	34	− 3	31	23	7	..	1		
Galvanocautery loop.	15	− 8	7	7					
Galvanocautery loop with electrolysis.	1	− 0	1	1					
Galvanocautery ...	4	− 0	4	3					1
Galvanocautery with evulsion.	4	0	4	4					
Total.....	58	−11	47	38	7		1	.	1

Lipoma.—A lipoma is a tumor composed of fatty tissue produced from a matrix of lipoblasts and may be either circumscribed or diffuse. Its occurrence in the pharynx is exceedingly rare, and the symptoms to which it gives rise are characteristic of a foreign body in the throat. When the growth is soft, it may be mistaken for an abscess; but the symptoms and history of pus formation are lacking, and an exploratory puncture is decisive of this question.

If the tumor is pedunculated, it can be removed by one of the methods described for fibroma, viz., by the cold or the hot snare or by the electric knife; otherwise electrolysis is to be preferred.

Angioma.—This term is used in a broad sense by throat specialists to include all vascular tumors, in conformity with the classification of Virchow. Strictly speaking, the growth consists of new blood-vessels that communicate with the surrounding vessels, of interstitial tissue like that from which the tumor springs, and of the blood within the vascular spaces. In contradistinction to this definition, tumors that are made up of lymphatic vessels are designated as lymphangiomata. The oval group of veins beneath the mucous membrane at the back of the pharynx, known as Cruveilhier's submucous venous plexus, has been found so greatly engorged and tumefied as to cause a sensation as if a foreign body were in the throat, and an annoying cough. The surface presents a hard, lobulated, and purple appearance. Varicose veins

are not uncommonly met with in the pharynx, and they may become so numerous and distended as to form groups that are comparable to clusters of currants or blackberries. Hemorrhages may be expected from these growths, particularly following any irritation, such as a digital examination.

Treatment.—If angiomata attain to a considerable size they may cause much discomfort and apprehension on the part of the patient, and they may even so encroach upon the surrounding parts as to impair their functions. A constant desire to swallow, embarrassed respiration and deglutition are not the worst features to consider, but profuse hemorrhages may demand an operation in order to insure the safety of the patient. In such cases the tumor should be completely extirpated. It is rarely sufficiently pedunculated to admit of removal with the cold or the hot snare; hence electrolysis is the most feasible method. Should thyrotomy be resorted to, it may be necessary to perform a preparatory tracheotomy.

Sarcoma.—As a primary disease of the pharynx sarcoma is rarely seen. It springs from the submucous connective tissue, and generally depends from the inferior surface of the body of the sphenoid bone into the pharynx. It is an atypical proliferation of connective-tissue cells from a matrix of fibroblasts of congenital or postnatal origin. Owing to the rich supply of lymphatic structure in this locality and its invasion by the sarcomatous cells the tumor may show a transition into the variety termed lymphosarcoma.

Like fibroma, a sarcomatous growth produces symptoms referable to respiration, swallowing, and the voice in degrees commensurate with the location, size, and shape of the tumor. The nasopharyngeal secretions are increased in quantity, to which is added, after ulceration occurs, a viscid, foul, and bloody discharge. If pain is present, it is in proportion to the amount of pressure exerted on adjacent structures. Although the discharge, which appears after ulceration takes place, is of a sanguineous character, the history of the growth may not present hemorrhages to a serious extent. In order to make a positive differential diagnosis, resort should be had to the microscope. The prognosis is unfavorable; the progress is toward a fatal termination.

L. Clerc cites a case of primary lymphosarcoma of the nasopharynx, which occupied the whole nasopharyngeal cavity, penetrated the right eustachian tube and external auditory canal and appeared there in the form of a polypus. An operation afforded only temporary relief, but radium therapy had a favorable effect upon the lymph glands at first. They decreased somewhat in size, but the termination was fatal.

Francis Patten Emerson reported to the American Laryngological, Rhinological and Otological society in May, 1907, a case of lymphosarcoma of the pharynx. The growth, which seemed to be an extension of the postpalatine folds, was seen in the lateral walls of the pharynx as large as the little finger, with a central plaque between. This central mass protruded at the lower third of the pharynx. It was resistent to the finger, and was of a grayish color. Iodides, mercury, and arsenic were administered, the former on the theory that the growth might be syphilitic. Later arsenic was given over a long period. Some of the symptoms were ameliorated, but the patient succumbed after several years.

Treatment.—If all of the diseased tissue can be removed, this should be done, provided that metastasis has not occurred. It is useless to operate if a part of the growth be left, for rapid reproduction will occur; and if metastatic tumors have formed in other situations nothing will avail from operative procedures on the primary tumor. But if the growth can be enucleated from a circumscribing pseudo-capsule, leaving no remnant of diseased tissue, and if no metastasis has occurred to render nugatory the result of the operation, it should be performed. Otherwise there is little to be accomplished beyond making the conditions as tolerable as possible by the use of cleansing, disinfecting, and astringent applications.

Seth Scott Bishop.

Phenacetin.—See *Acetphenetidinum.*

Phenalgin—ammonio-phenylacetamide—is a fine white powder of ammoniacal odor and slightly alkaline taste. With water it makes an alkaline solution. It is a proprietary remedy of the same order as antikamnia, of uncertain composition, stated to be an efficient analgesic, antipyretic, and antiperiodic. The ammonia present is intended to prevent depression of heart and respiration. Dose gr. v.–xx. (0.3–1.3).

W. A. Bastedo.
R. J. E. Scott.

Phenocoll.—(Amido-acet-para-phenetidin.) The hydrochloride of phenocoll was introduced as being superior to phenacetine as an analgesic and antipyretic drug. It did not prove to be in any way more desirable and is now rarely employed.

Beaumont Small.

Phenol.—*Carbolic Acid, Hydroxybenzene,* C_6H_5OH. This important substance, though commonly called an acid, is, properly, not an acid at all, but a member of the group of *phenols*, bodies regarded as derivatives of hydrocarbons of the benzene series by the replacement of one or more atoms of hydrogen of the principal chain by hydroxyl (OH). In phenol or carbolic acid a single hydrogen atom of benzene itself is so replaced, so that this derivative is the simplest possible phenol in point of chemical constitution. Being also the best-known member of the group it is chemically entitled *phenol*, simply. Carbolic acid is an ingredient of coal tar, and is obtained therefrom. The tar abounds in phenols, and by fractional distillation and certain special manipulations carbolic acid is separable from the other constituents in varying degrees of purity. In the markets may be found pure carbolic acid, crystalline at ordinary temperatures, and impure acids of different grades, of which the best are crystalline, but the others fluid. These impure acids consist of carbolic acid (phenol) and the closely related phenol "cresylic acid" (cresol), and other phenols in admixture. The lower grades, indeed, may contain but little carbolic acid, but yet are efficient, since the other phenols of coal tar possess properties similar to those of carbolic acid. The United States Pharmacopœia recognizes as official pure phenol, and liquefied phenol. And since the Pharmacopœia now uses the term *phenol* and not *carbolic acid*, it would be well to abandon the use of the latter term.

Phenol is either obtained from coal tar by fractional distillation and subsequent purification, or is made synthetically. It should contain when assayed not less than ninety-six per cent. of absolute phenol. It should be kept in dark amber-colored, well-stoppered bottles. "Colorless interlaced or separate, needle-shaped crystals, or a white, crystalline mass, sometimes acquiring a reddish tint; having a characteristic, somewhat aromatic odor; when copiously diluted with water it has a sweetish taste with a slightly burning after-taste, and when undiluted, cauterizes and whitens the skin and mucous membrane. Soluble in 19.6 parts of water at 25° C. (77° F.), the solubility varying according to the degree of hydration of the phenol; very soluble in alcohol, ether, chloroform, benzene, carbon disulphide, glycerin, fixed and volatile oils. Almost insoluble in petroleum benzin. When gently heated, phenol melts, forming a highly refractive liquid. It is

also liquefied by the addition of about eight per cent. of water. If the phenol be liquefied by a gentle heat, and then slowly cooled, under constant stirring, until it is partly recrystallized the semi-liquid mass should have a temperature (remaining stationary for a short time) not lower than 40° C. (104° F.). Phenol should have a boiling point not higher than 188° C. (370.4° F.). A lower boiling point, or a higher melting point, indicates a less hydrated phenol. When heated upon a water bath, it should be volatilized without leaving a residue. The vapor is inflammable. Phenol is faintly acid to blue litmus paper" (U. S. P.).

As regards the color of phenol, the tendency to acquire a pink tinge is the stronger the purer and more anhydrous the sample (Squibb). Good specimens, therefore, unless recently made, are more likely than not to be of pinkish hue. As regards the odor, it is much less rank and disagreeable than that of other associated phenols, a fact that, apart from other considerations, constitutes a good reason for selecting a chemically pure phenol for surgical use. An absence of creosote-like odor is a good practical test of the purity of a given sample of phenol. The reaction between phenol and water is peculiar. On adding water to phenol in small measure, the crystals first liquefy by the solution of the water, forming a transparent fluid. The proportion of water thus soluble in phenol seems to be variable. The pharmacopœial description states that phenol "is liquefied by the addition of about eight per cent. of water," but Squibb has reported samples of pure phenol dissolving as much as thirty-five per cent. of water.

Phenol Liquefactum, Liquefied Phenol (U. S. P.). The article is thus officially defined and described: "A liquid composed of not less than 86.4 per cent., by weight, of absolute phenol (C_6H_5OH = 93.34), and about 13.6 per cent., by weight of water. A colorless liquid which may develop a slight reddish tint upon keeping, having a characteristic, somewhat aromatic odor, and when copiously diluted with water, a sweetish taste with a slightly burning after-taste and when undiluted, cauterizing and whitening the skin and mucous membrane. Soluble in 12 parts of water at 25° C. (77° F.). Miscible with alcohol, ether, and glycerin in all proportions" (U. S. P.).

The *effects* of phenol which the physician needs to note may be divided into three categories for practical study, as follows: (1) antiseptic action; (2) local effects; and (3) constitutional effects.

Antiseptic Action.—By immersion in phenol solutions microbes may suffer temporary arrest or permanent loss of vital activity, the degree of the effect depending partly on the strength of the solution and partly on the vital tenacity of the particular organism, or even of the special stage of being of the organism under observation. To determine the exact toxic power of phenol in this direction, an enormous number of experiments have been made, attacking the problem in a variety of ways. Of the more reliable of these experiments the results substantially agree in the following broad statements: 1. Rod forms of bacteria and allied organisms soaking in aqueous solution of phenol tend to suffer arrest of vital activity when the strength of the solution reaches a point between one-fifth and one-half of one per cent., and to suffer death when the strength rises to one per cent. 2. Spore forms, such as the spores of the anthrax bacillus, are much more tenacious of life, requiring for their certain killing a solution of from four to five per cent. strength, and a soakage of from two to three days' duration (Koch). 3. Aqueous solutions of phenol are far more toxic to microbes than solutions in oil or alcohol (Koch). 4. Exposure to *vapor* of phenol under the conditions obtaining in practical disinfection is practically without effect upon microbes or disease germs, whether these be in rod form or spore form, and whether moist or dry.

Local Effects.—Prudden has observed the effect upon leucocytes and ciliated cells of soakage in phenol solutions, with the following results: Under soakage in solutions ranging between one-thirty-second and one-fourth per cent. strengths, ameboid and ciliary movements slow or stop, but resume activity upon withdrawal of the carbolized fluid, and its replacement by a normal one. Under soakage in solutions of from one to five per cent. strength, however, the bodies under observation speedily lose their power of movement, without possibility of resumption, and their protoplasm soon suffers disintegration. Applied to the human skin, comparatively weak solutions, such as the one and two per cent. solutions used in surgery, objectively cause a whitening and shrivelling of the cuticle, and subjectively a conjoint numbness and prickling sensation, followed, if the application be prolonged beyond a few minutes, by smarting. These painful sensations Squibb declares to be aggravated by elevating, and alleviated by depressing, the affected part—phenomena contrary to those which usually obtain under circumstances of painful irritation. After withdrawal of the application, the skin gradually resumes its normal appearance and tactile sensibility, recovery from the numbness, however, being slower than the return to natural appearance. Touched with the undiluted phenol, the skin immediately whitens, while the circumjacent parts redden by irritation. Sharp pain, passing over into numbness, is experienced, the pain gradually subsiding after an hour's lapse, and the surface presenting the dry, scaly exudation so often seen on surgeons' hands in the days when operating under a carbolized spray was in vogue. The results of a continuous application of pure phenol are exemplified in a case reported, in which, through a misunderstanding, a finger was wrapped in cloths soaked in undiluted carbolic acid, and kept so dressed throughout a night. The next morning the dressings were removed, and on the third day, when first seen by the reporter, the tissues of the finger were found black as jet, hard as wood, wrinkled and shrivelled, cold, and absolutely anesthetic, and with a pronounced line of demarcation between the unaffected and the mummified portion. Strange to say, however, under careful treatment the parts recovered.

Constitutional Effects.—Phenol is very poisonous to all living things. In man, in mild poisoning, such as may follow slight absorption from carbolized dressings in surgical cases, the symptoms are restlessness and rise of temperature—symptoms easily mistaken for those of the very septic infection sought to be averted by the use of the drug; or in other cases occur headache, loss of appetite, languor, and cough, followed, if the poisoning continue, by persistent bronchial irritation, itching of the skin, dragging lumbar pains and a sense of heaviness, and want of power in the legs. In severe poisoning, such as may occur again from absorption from surgical dressings, or as will certainly result if any considerable quantity of phenol be swallowed, the toxic action falls heavily upon the central nervous system. The sufferer passes rapidly into a condition of coma, with loss of reflex irritability, and occasionally, but exceptionally, with convulsions. Convulsions, however, are common in cases of poisoning of the lower animals. The breathing is stertorous, the hearts' action disordered—pulse at first unduly slow, afterward rapid, and, perhaps, intermittent, and the arterial pressure diminished. The skin is covered with sweat, the lips and hands are livid, and the whole aspect is that of great prostration. When the poisoning has occurred from swallowing the phenol in concentrated condition, there are added to the above symptoms burning pain, extending from mouth

to stomach, experienced at the moment of swallowing, and nausea and vomiting—symptoms due to the local action of the poison upon the mucous membrane of the alimentary canal. Phenol poisoning may result in death, which may begin either at the heart or at the lungs. In such cases the lesions, apart from the local effects when the stronger phenol has been swallowed, are not characteristic. There is a tendency to congestion of the great viscera; the blood may seem unduly dark and fluid, and there may be some fatty degeneration of the liver and kidneys, especially the latter, but yet none of these changes are invariable.

Analysis of phenol poisoning in man and animals points to the following specific derangements as wrought by the agent: As regards the nervous system, *coma* and *convulsions*—the latter phenomenon of spinal origin—and *modification of reflex activity*, such activity being at first increased, but, later, lessened and finally abolished. As regards the *circulation*, the heart's action may at first be intensified, but, in the later stages of the poisoning, is always enfeebled. Death is frequently by cardiac failure, and the heart is commonly found, postmortem, in diastole, with flabby walls. Similarly the arterial pressure, which may be increased in the earlier stages of the poisoning, particularly if convulsions be present, notably sinks as the case progresses, apparently through paralysis of the vasomotor center. Upon *respiration* the action more commonly than not is opposite at the two extremes of the poisoning, the breathing at first being unnaturally rapid and shallow, whereas, later, it becomes slow, deep, and markedly stertorous. Duly devised experiments seem to show that these effects are due to a primary excitation of both the pneumogastric peripheries and centers followed by a secondary paralysis. *Body temperature*, in poisoning in the normal human subject, is variably affected, in some instances rising, in others falling, and in still others remaining unchanged. When, however, carbolic acid is administered to a fevered subject, a considerable fall of temperature may occur, accompanied by sweating. In such case the loss of heat is probably independent of any effect in that direction wrought by the sweating, since a temperature reduction has been observed in cases in which all action of the sweat glands was held in abeyance by duboisine (Raymond).

The fate of absorbed phenol is obscure. Some of it is undoubtedly excreted, since it has been found by a number of observers in the urine, by Hoppe-Seyler in the saliva, and is believed by Lemaire to be present in the breath. Other portions are probably chemically transformed within the system. A result of excretion by the kidneys is to produce peculiar coloration of the urine, a fact furnishing a valuable clue to diagnosis in obscure cases of poisoning. The tint of the urine varies in different cases, in some being brownish, in others greenish black, and in others olive green, turning a smoky black upon standing. Such urines may or may not have an adventitious odor, aromatic, or even distinctly that of phenol. Exceptionally, furthermore, albumin, blood, or excess of urates may be present. These altered urines probably contain both phenol under its own form and some product or products of its chemical transformation; but what these latter substances may be has not yet satisfactorily been determined.

Death has followed absorption of phenol from the unbroken skin or a mucous surface to which it had been applied as an antiseptic dressing.

When swallowed there is at once a hot, burning sensation in the mouth, throat, and stomach. The lining membrane of the mouth is whitened by the contact of the phenol, while the lips are usually more or less brown where the liquid has come in contact with them.

The skin is dry and livid, the pulse is feeble, the pupils very much contracted, the breathing noisy, and the breath smells more or less strongly of the poison.

Death usually occurs within two to eight hours; in some instances it has occurred within a few minutes and in other cases it has been delayed for several days.

The amount necessary to cause death is unknown. Recovery has taken place after four ounces had been swallowed, and death has followed the ingestion of twenty-three grains.

The *treatment* consists in the use of the stomach tube, the administration of saccharate of lime and of soluble sulphates, and, recently, very excellent results have been obtained by the use of strong alcohol after the stomach tube has taken out the most of the poison. Lavage, with solution of sodium sulphate, or with plain water, is the best procedure. Alcohol has proved useful also to check the action of the poison when applied to the skin. Stimulants are to be used to combat symptoms of collapse.

In fatal cases the lips where the phenol has come in contact with them are stained brown, the mucous membrane of the mouth is dirty white or brown; the stomach is contracted, and its mucous membrane in folds and white in some places, and in some spots greatly inflamed. The odor of phenol is generally noticeable on opening the stomach. The brain, lungs, liver, and kidneys usually show marks of congestion. The left ventricle of the heart is usually contracted, while the right is flaccid. The blood throughout the body is dark colored and fluid. When phenol is absorbed by the skin there are no characteristic internal postmortem changes.

The odor of phenol gives the best indication of its presence, but chemical tests in addition should be made to make the identification certain. To this end the material for examination is made acid with sulphuric acid and distilled. The distillate may or may not give the odor of phenol.

In a portion of the distillate place a splinter of pine wood, and on removal from the distillate moisten the splinter with hydrochloric acid. If phenol is present the splinter will turn blue or green. This test should be corroborated by a known solution of phenol.

To a small portion of the distillate add about one-fourth its volume of ammonium hydroxide and then a small quantity of a solution of calcium hypochlorite. A blue color appears at once or on standing for a time in the presence of phenol.

To a portion of the distillate add bromine. If phenol be present a white precipitate of bromophenol is formed. This may be further tested, after it has been thoroughly washed, by treating it with sodium amalgam (prepared by dissolving sodium in mercury), and then making the solution acid. If phenol be present, the characteristic odor of phenol will be developed.

THERAPEUTICS.—The therapeutic applications of phenol are utilizations of its *antiseptic*, *disinfectant*, *anesthetic*, and *antipyretic* powers. As regards the *antiseptic* use, it is to be noted that phenol is decidedly inferior in antiseptic power to quite a number of available substances, and that for surgical employment it has the positively objectionable features of strong odor, disagreeable action upon the skin, and capability of absorption to the point of producing dangerous and even fatal constitutional poisoning. For surgical purposes aqueous solutions are commonly employed, of strengths ranging from one to five per cent., the weaker for dressings to remain in contact with tissue, the stronger for occasional use or to disinfect hands, instruments, ligatures, etc. As a *disinfectant*, phenol operates, of course, exclusively by its germicidal action. For certainty of disinfection, as has been seen already, actual soakage of the culprit germ in a phenol solution of at least two per cent. strength is essential. Dainty sprinklings of phenol lotions are

therefore futile, and the hanging about a chamber of carbolized cloths with a view of aërial disinfection by the fumes therefrom is but a noisome advertisement of ignorance or stupidity. Legitimately and thoroughly used, a two per cent. solution of phenol is an efficient disinfectant, with the advantage of cheapness, but with the ever-present disadvantage of a rank and even offensive odor. A solution of two per cent. strength does not injure textile fabrics. The *anesthetic* action of phenol is most strikingly utilizable for the relief of the pain of burns, for which purpose nothing is better than one-half or one per cent. aqueous solution of phenol applied on thin cloths. Similar lotions may palliate also the itching and burning of skin disease or the irritation from catarrhs of mucous membranes. Thus in bronchitis the inhalation of the fumes of a bowl of boiling water charged with a few drops of phenol may allay pain and cough considerably. So, again, irritability of the stomach may be quieted by this agent, and phenol in small doses ranks among the standard means for arrest of vomiting. As an *antipyretic* phenol is undoubtedly powerful, but its poisonousness will probably always defeat it in competition with such potent and at the same time innocent antipyretics as sodium salicylate, the cinchona alkaloids, antipyrin, etc.

For *internal administration* phenol may be given in pills, with liquorice powder, and tragacanth; it may also be given in the form of a mixture, with spirits of chloroform. The dose of *Phenol* is one grain (0.06), of *Phenol Liquefactum* one minim (0.06). Under the title, *Glyceritum Phenolis*, Glycerite of phenol, the United States Pharmacopœia makes official a twenty per cent. (by weight) solution of phenol in glycerin.

For *external uses* there is official in the United States Pharmacopœia a preparation entitled *Unguentum Phenolis* Ointment of Phenol, which consists of White Petrolatum charged with three per cent. of phenol.

R. J. E. Scott.

Phenol-bismuth—$C_6H_5O.Bi(OH)_2$ may be prepared by mixing a solution of bismuth nitrate with an alkaline solution of phenol. It is a practically odorless and tasteless, white, non-irritant, and non-toxic powder, containing nineteen per cent. of phenol, and sixty-nine per cent. of bismuth oxide. Like other bismuth preparations, it is used as a mechanical sedative and antiseptic to the gastro-intestinal tract, but in addition, as shown by the urine, sets free some of its phenol. No poisonous effects have been noticed (Jasenski) from taking gr. lxxv. (5.0) a day for three weeks. R. W. Wilcox says that it is superior to all other forms of bismuth in fermentative dyspepsias and in chronic gastritis marked by pyrosis, or boulimia. The dose is gr. xv.–lxxv. (1.0–5.0) daily.

W. A. Bastedo.
R. J. E. Scott.

Phenolphthalein — $C_6H_4.CO.C(C_6H_4OH)_2.O$ — is prepared by digesting ten parts of phenol, five parts phthalic anhydride, and four parts concentrated sulphuric acid for several hours, boiling the residue with water to remove soluble matter, and then boiling the remaining resinous substance in benzol. Phenolphthalein is a yellowish-brown powder, which, in one to thirty alcoholic solution, serves as an acid-alkali indicator in volumetric analysis. Colorless in acid solutions, it turns a brilliant pink on neutralization with an alkali. It is not, however, a safe indicator for the carbonated alkalies.

Phenolphthalein is given internally as a purgative, its action being exerted directly on the mucous membrane. It may safely be employed in renal disease as it is excreted by the intestines and not by the kidneys. The dose is gr. iiss.–xv. (0.15–1.0) in tablets, gr. v. being usually sufficient to purge an adult.

W. A. Bastedo.
R. J. E. Scott.

Phenolsulphonates.—Sulphocarbolates.—Carbolic acid (*phenol*), added to strong sulphuric acid, dissolves with the formation of the acid body, $C_6H_4(OH).SO_3H$, termed *phenolsulphonic acid* by the chemist, but commonly known as *sulphocarbolic acid*. Phenolsulphonic acid unites with bases to the formation of salts, and in these salts it was hoped there might be found substances which would retain the therapeutic powers of phenol while free from the poisonous properties of that body. So far as observation has gone, however, this hope does not seem to have been realized. Two salts of phenolsulphonic acid are official in the United States Pharmacopœia, as follows:

Sodii Phenolsulphonas.—*Sodium Phenolsulphonate* $NaC_6H_5O_4S + 2H_2O$.—This salt occurs in colorless, transparent, rhombic prisms, which effloresce somewhat in dry air. It is odorless, with a cooling, saline, and bitterish taste. It dissolves in 4.8 parts of water at 25° C. (77° F.), and readily in boiling water. It dissolves in 130 parts of cold alcohol and in 10 parts of boiling alcohol.

Sodium phenolsulphonate is a bland salt, producing but little constitutional disturbance in ordinary medicinal doses beyond some lightness of the head. It has been prescribed in doses ranging from gr. x. to xxx. (0.6–2.0) for the purpose of gastrointestinal antisepsis.

Zinci Phenolsulphonas.—*Zinc Phenolsulphonate* $Zn(C_6H_5O_4S)_2 + 8H_2O$. It occurs in colorless, transparent, rhombic prisms, or crystals, which effloresce on exposure to air. It is odorless, with a metallic taste, and dissolves in 1.7 parts water. It is used as an astringent and antiseptic lotion, and has been administered internally in cases of intestinal fermentation and diarrhea. The dose is gr. i. to v. (0.06–0.3).

Edward Curtis.
R. J. E. Scott.

Phenolsulphonephthalein Test.—Phenolsulphonephthalein is a bright red crystalline powder which is non-toxic and non-irritant locally, and which is excreted practically entirely by the kidneys and with great rapidity. In alkaline solution it has a bright purplish-red color which is well adapted for quantitative colorimetric estimation. Such a dye is well suited for administration in an effort to determine the ability of the kidney to excrete it. The use of this substance as a means for the estimation of renal function was introduced in 1909 by Abel and Rowntree and was further studied and advocated by Rowntree and Geraghty during the following years.

The method of performing the test as developed by Rowntree and Geraghty is as follows: Twenty minutes to half an hour before beginning the test, the patient is given 200 to 400 c.c. of water in order to secure free urinary activity. Under proper precautions a catheter is introduced into the bladder and the urine completely withdrawn. The time is noted and 1 c.c. of a solution of phenolsulphonephthalein containing six milligrams to the cubic centimeter is injected intramuscularly. The urine is allowed to drain into a test-tube which contains a drop of twenty-five per cent. sodium hydrate solution and the time of the appearance of the first faint pink color is noted. The catheter is now corked and the urine collected at the end of the first hour and again at the end of the second hour, care being taken to empty the bladder completely on each occasion. Each sample of urine is measured, the specific gravity taken and then sufficient sodium hydrate added to bring out the full color. The specimen is then diluted to one liter with distilled water and the amount of drug estimated by comparison

with a standard solution either in the Dubosq colorimeter or some of the several colorimeters now designed for this test. The standard solution is made by diluting 1 c.c. of the solution such as administered, to one liter with distilled water containing sufficient sodium hydrate (twenty-five per cent.) to bring out the maximum color. In the average normal person the drug first appears in the urine in from eight to ten minutes after its injection, about fifty per cent. is excreted in the first hour and sixty-five per cent. in the first two hours. The site of choice for the injection is into the lumbar muscles though the gluteal muscles or the deltoid may be used. Absorption is somewhat slower when the injection is made subcutaneously and more rapid when it is injected directly into a vein.

The technique has been varied in some places by omitting the time of the first appearance of the drug. The patient is given 200 to 400 c.c. of water and empties his bladder. The injection is given and exactly two hours later the patient again empties his bladder as completely as possible. An excretion of fifty per cent. or more is considered to be within the normal limits. When the collected urine has been made alkaline it is necessary to make the estimation within a few hours since the red color may fade gradually. If it is necessary to postpone the estimation, the urine should be made acid in which case the phthalein remains unchanged. It must, of course, be rendered alkaline again when the estimation is made. In some instances the urine is highly colored and it may be difficult to get a satisfactory reading since the colors do not match well. Under these circumstances it is sometimes possible to obtain better results by reflecting the light through the standard solution from a piece of yellow paper.

The phenolsulphonephthalein test is more used and more useful than any other one method of estimating renal function. It is easy of application and in the great majority of cases parallels not only the results obtained by other tests but also the autopsy findings. It is probably excreted through the cells of the tubules. The amount of the phthalein excretion roughly parallels the severity of the renal lesion and if the amount is very low the prognosis is generally bad. Exceptions do occur, of course, and numbers of fatal cases of uremia have been reported in which the phthalein excretion has been approximately normal. In other cases a diminution in the phthalein excretion has remained without confirmation by clinical signs. Nevertheless, as we have said, in the great majority of cases the results can be relied upon. It must be remembered that this test reveals the functional power of the kidney at the time the test is made and it does not necessarily indicate the reserve power of the organ. One important use of the test is in surgical cases in which it is necessary to determine the kidney function before a decision as to operation can be made. Moreover the repeated use of the test may enable a surgeon to select a favorable time for operation. This test may also be used in connection with ureteral catheterization when it is often injected intravenously so as to shorten the time of observation. A half-hour period is generally selected. Under normal conditions the drug appears from the two kidneys at the same time and the amount excreted by the two organs is practically the same. The test is, most certainly, not a perfect one but its use has aided tremendously in the study of nephritis, and the convenience of its application renders it a method by which any physician may gain some insight into the functional power of the kidney.

RALPH G. STILLMAN.

Phenoltetrachlorphthalein Test.—In 1909 Abel and Rowntree conducted animal experiments with phenoltetrachlorphthalein and found that when it was injected intravenously it was excreted in the bile. Further study showed that when the liver was subjected to injury, the excretion of the drug was interfered with and it might even take place in part through the kidneys. It was then suggested that this substance might be used in a test of the liver function and application of the test clinically gave at first rather promising results.

The manner of applying the test is as follows: The preparation of the dye must be fresh and is made by placing one gram of the substance in a 200 c.c. Erlenmeyer flask, adding 2 c.c. of twice normal sodium hydrate solution and 18 c.c. of distilled water. This is boiled for twenty minutes under a reflux condenser and after filtration is then ready for use. Eight cubic centimeters, approximately 400 milligrams of the dye, are used for the test. Active catharsis is instituted before and during the time of the test. Eight cubic centimeters of the dye preparation are injected into the vein by gravity using about 100 c.c. of salt solution to wash through the apparatus and make sure that the whole quantity has been administered. The stools are collected for forty-eight hours and the urine for twenty-four hours after the administration of the drug. The total forty-eight hour quantity of feces is placed in a two-liter bottle and diluted to one or one and a half liters. The bottle is then shaken vigorously for from five to twenty minutes. Without allowing time for sedimentation, one-tenth of the total quantity is placed in a 1,000 c.c. flask, 5 c.c. of forty per cent. sodium hydrate added and water added to a liter. The flask is thoroughly shaken and 100 c.c. removed and placed in a 200 c.c. flask. Five cubic centimeters of lead acetate are added and also 5 c.c. of forty per cent. sodium hydrate which restores the red color. If necessary more of the sodium hydrate is added in order that the maximum intensity of color may be elicited. The contents are then made up to 200 c.c., the flask shaken and the contents filtered. The clear red filtrate is then compared in a colorimeter with a standard solution of the dye containing twenty milligrams to the liter (that is, 0.4 c.c. of the original solution plus sufficient sodium hydrate to assure maximum color plus water up to one liter). With these dilutions the amount of dye present is indicated directly in percentages. In normal health there is never any appearance of the red color in the urine.

Rowntree, Marshall, and Chesney found that the average normal person and the average patient suffering from diseases which did not affect the liver excreted thirty per cent. or more of the dye in the stools during forty-eight hours. They also found that in the majority of patients in whom there was some lesion of the liver there was a decrease in the output and they were able to confirm their observations by autopsy on a number of the patients. Other investigators have not been able to obtain as valuable results in their work and some (Kahn and Johnston) even go so far as to say that the test "does not give any information that should be of clinical value." Certainly it does not approach in value the kidney function tests. Liver function tests are all more or less unsatisfactory and while the work which has been done on this one has not been sufficient in extent to allow us to form a final opinion, it is doubtful if the phenoltetrachlorphthalein test will prove more useful than the lactose, urobilinogen, fibrinogen, or the other tests that have been proposed from time to time.

RALPH G. STILLMAN.

Phenylhydrazine.—This substance ($C_6H_5.NH.NH_2$) occurs in colorless tabular crystals, slightly soluble in water, very soluble in alcohol. Its toxic action is too marked to allow of its employment as a therapeutic agent. It is used as a test for the presence of sugar in urine, which is known as Fischer's test. This was discovered by Prof. Emil Fischer, and depends upon the property of the sugar forming, in the presence of phenylhydrazine, crystals of phenylglucosazone.

BEAUMONT SMALL.

Phenylis Salicylas.—Salol. $C_6H_4.OH.COO.C_6H_5$. Phenyl salicylate is the name given to the salicylic ester of phenyl. It is compounded of salicylic acid and phenol and represents sixty per cent. of the former substance and forty per cent. of the latter. It is official in the United States Pharmacopœia under the title Phenyl Salicylate. It is a white crystalline powder having a faint, aromatic odor, and a slight, but characteristic taste. It is soluble in 2,333 parts of water, and in five parts of alcohol at 25° C. (77° F.); very soluble in hot alcohol, and in ether, chloroform, and fixed and volatile oils.

Salol is used as a substitute for the common salicylate salts, on the grounds that it is equally effective as a medicine, while at the same time, in medicinal doses, it is much less deranging to digestion on the one hand, and less productive of constitutional toxic effects on the other. It is insoluble in the fluids present in the stomach—whence the lack of gastric derangement in its employment—but suffers solution by chemical decomposition in the small intestine through the action of the pancreatic juice, resolving into salicylic acid and carbolic acid (phenol). Constitutionally, salol, in ordinary dosage, has produced little disturbance beyond an occasional and trifling ringing in the ears. In experimenting, however, with a dosage exceeding a dram and a half (six grams) distributed over the twenty-four hours, toxic symptoms have been observed, as might be expected, considering that the medicine is nearly one-half carbolic acid. Salol, taken internally, imparts to the urine of the subject the peculiar coloration seen after ingestion of phenol, a phenomenon that may persist for several days after discontinuance of the medicine. The average medicinal dose of salol for an antirheumatic or antipyretic effect is about seven and one-half grains (0.5), given twice, or thrice, daily.

Because of the fact that salol only gradually suffers resolution into its constituents, the substance makes a useful intestinal disinfectant in diarrhea or typhoid fever. In putrefactive fermentations and as a urinary antiseptic in gonorrhea, salol is particularly valuable; but it should not be given when there is any disease of the kidneys, because of the carbolic acid of its constitution.

Edward Curtis.
R. J. E. Scott.

Phidippus.—A genus of jumping-spiders, *Attidæ*, which build no web, but stalk their prey. Some of the larger species have been claimed to give poisonous bites. See *Arachnida*.

A. S. P.

Philadelphia.—Philadelphia, founded by William Penn, was the first capital of the United States. The population was estimated July 1, 1914, at 1,657,810. The city, situated at the confluence of the Delaware and Schuylkill Rivers, in latitude 30° 57′ north, is nearly on a line with Madrid and Lisbon, and is about sixty miles from the sea in a direct line. The intervening portion of the State of New Jersey is almost a level plain, abounding in pine, oak, and other timber of second growth. To the westward the land rises gradually and the nearest mountain ridges are from fifty to one hundred miles distant. The highest elevation within the limits of Philadelphia is 450 feet. The mean annual temperature is 54° F., with extremes of −6° F. (1889) to 103° F. (1901). The extremes in 1914 were 0° F., January 14, and 96° F. July 23. Precipitation, 39 inches. Days with precipitation of 0.01 inch or more, 103. Snowfall, 34 inches, distributed as follows: January, 2.2 inches; February, 15.7 inches; March, 15.2 inches; December, 1 inch.

Clear days, 119; partly cloudy, 115; cloudy, 131. Thunderstorms, April, 1; May, 3; June 9; July, 11; August, 9; August, 4; September, 3; total, 31.

The prevailing direction of the wind was northwest and the maximum velocity was 47 miles an hour, from the northeast on January 3. While the mean temperature for the year is about 5.7° F. higher than at London, the mean for January is 3° F. lower, and for July 15° F. higher. The relative humidity at 8 A.M. and 8 P.M. is 75 per cent. and 68 per cent. The rainfall averages 42 inches, considerably greater than that of London (24.84 inches). London, however, exceeds Philadelphia, as well as New York, Boston, Chicago, and all the principal cities of the United States in the number of rainy days. There are about 129 clear days each year in Philadelphia, which is less than at Baltimore (141), at Denver (150), or at Phœnix, Arizona (259). The spring opens in Philadelphia two or three weeks earlier than at Boston, and autumn lasts longer. Roses may bloom through November. The winters are not generally severe. Philadelphia has 36 parks, the largest, Fairmount Park, containing over 3,300 acres, through which flows the Schuylkill River, spanned by four bridges. Within the limits of the park the river reaches a width of about one-fourth of a mile. At the northernmost boundary of the East Park the romantic Wissahickon stream empties into the Schuylkill, and the beautiful paths along its borders are favorite resorts for driving, riding, motoring, and walking, while the well-wooded hills that rise just beyond are attractive places for picnics. There is excellent boating on the Schuylkill and on the Wissahickon. Throughout the park at convenient places are houses of rest, restaurants, dairies, and playgrounds. The natural beauties of the grounds are preserved as far as possible. At the southwestern border of the park is the extensive Zoological Garden.

Fairmount Park is of inestimable value to the citizens of Philadelphia, and doubtless exerts a controlling influence on the death rate, particularly among children.

The general death rate of Philadelphia in 1914 was 16.25 per 1,000 population. It was higher than that of New York City (14.74). It is, however, to the credit of the Health Department that the deaths from typhoid fever fell from 255 in 1913 to 124 in 1914. Typhoid fever is steadily diminishing by reason of better filtration of water and better sanitation. Vaccination is rigidly enforced. There were no deaths from smallpox in 1913 or 1914. In these two years scarlet fever mortality dropped from 162 to 130 and measles from 199 to 73. On the other hand, whooping-cough, influenza and bronchitis increased in mortality. Tuberculosis of the lungs caused 2,606 deaths in 1913 and 2,699 in 1914 and was second only to heart disease. The systematic efforts of the State Department of Health have done much to reduce mortality from tuberculosis in Philadelphia and in the State of Pennsylvania through 122 State dispensaries, public clinics, sanatoria, and the dissemination of information as to the means of prevention. The gift of Mr. Andrew Carnegie of 1,500,000 for thirty branches of the Free Library of Philadelphia, and the Boy's High School, a building which cost with its equipment $1,500,000, probably the finest school building in the world, are notable steps toward the city's progress in education. The University of Pennsylvania, covering an area of over sixty acres in West Philadelphia, has an enrollment of students in its undergraduate departments and professional schools of 7,069, with a teaching staff of nearly 600. The library contains 400,000 volumes. The living alumni number 22,000. The Academy of the Natural Sciences, founded in 1814, is one of the notable scientific centers in this country.

Philadelphia is in a transition state with reference to great municipal improvements. Chief of these is the construction of enormous filtration beds at Torresdale, on the Delaware front, in the northeastern portion of the city, at Roxborough in the northern portion, and at Belmont in the western portion. These are completed at a cost of over $17,000,000, and they insure a satisfactory water supply.

The Philadelphia Hospital, with its insane department and almshouse, is situated on the lower Schuylkill, and comprises within its walls a total population of about 6,000. Steps have recently been taken to remove the hospital for the insane and the almshouse to a new location below Torresdale, and on the property known as Blockley a new Philadelphia General Hospital will be erected. The original buildings constructed in 1834 will be torn down and new buildings erected in accordance with modern plans.

The Municipal Hospital for Contagious diseases has been removed to a new site in the northeastern portion of the city. There are over fifty hospitals in Philadelphia. Chief of these is the Pennsylvania Hospital, the oldest institution of the kind in the United States.

The Medical Department of the University of Pennsylvania was established in 1765 by Dr. John Morgan, Dr. William Shippen, Dr. Adam Kuhn, and Dr. Benjamin Rush, who constituted the first medical faculty in America. The number of its graduates is 14,061, and with the sister schools of Jefferson College, the Medico-Chirurgical, and the Women's Medical College, this school has had a strong influence in maintaining the high standard of medical education in the United States.

Philadelphia has long been famous for its teachers of medicine and surgery, and their contributions to medical literature, issued by the well-known medical publishers of the city, have carried the fame of American medicine throughout the world. The names of Benjamin Rush, Shippen, Physick, Wistar and Horner, Barton, Chapman, Pancoast, Gross, Stillé, Hodge, Pepper, Wood, Da Costa, Agnew, Leidy, McClellan, and Mitchell are houshold names in the medical history of our country. GUY HINSDALE.

Philippine Islands.—The Philippine Archipelago is situated between 4° 40′ and 21° 10′ north latitude and 116° 4′ and 126° 4′ east longitude, Greenwich. On the east and northeast is the Pacific Ocean and on the west and northwest, the China Sea. On the south is the Celebes Sea. In general shape the archipelago may be likened to an inverted Y, having its base, the island of Luzon, to the north, its major branch, the islands of Samar, Panay, Negros, and Mindanao, diverging to the southeastward, and its minor branch, the narrow island of Palawan, diverging to the southwestward. Between these two branches is the Sulu Sea, partly enclosed to the southward by the northeast shore of the large island of Borneo and a chain of small islands stretching from Borneo to the southwest extremity of Mindanao, the Sulu archipelago. Farther south of the archipelago, about 300 miles, are the Celebes, and a little less distant on its north is the island of Formosa. The nearest point to the China coast is 390 miles from the most northern extremity of Luzon. The number of islands comprised in the cession to the United States was estimated by the Philippine Commission in 1901 as 1,400; subsequent enumeration places the number at 3,141. By far the most of the members of the archipelago are small, and very many are insignificant both in size and economic importance, more than 2,750 of them being less than one square mile in area. The total estimated area is, in round numbers, a little more than 115,000 square miles. The principal islands of the Philippine group are:

	Sq. miles.		Sq. miles.
Luzon	40,969	Leyte	2,722
Mindanao	36,292	Negros	4,881
Samar	5,301	Cebu	1,762
Panay	4,611	Masbate	1,236
Palawan	4,027	Bohol	1,441
Mindoro	3,851		

The Sulus Islands, or archipelago, are estimated as containing 1,500 square miles.

Geology.—From a geological basis of reckoning, the archipelago is of modern formation. Evidences of existing elevation and subsidence are to be seen in many places. Prof. Dean C. Worcester states that it is not unusual to have a native assure one that he now fishes where his grandfather used to live, or lives where his grandfather used to fish. Volcanoes are numerous and found in many localities. There are at present twelve active, and many extinct or dormant. Four of the active volcanoes are in Luzon; one of them, Mayon volcano, in the southern part of the island, is one of the few perfect cones in the world, its summit rising 7,916 feet above sea-level. Taal volcano, in the middle of Lake Bombon, is not far from the city of Manila, and is specially noted for its disastrous eruption in 1911, which caused the death of more than 1,330 persons and the injury of nearly 200 more, besides great destruction of property and cattle. Earthquakes are of frequent occurrence. More than 200 have been recorded since 1599. However, most of them have been of minor severity and only now and then destructive of life and property. The most destructive earthquake, so far known, occurred in 1863, when it was estimated that 400 people were killed and many more injured; 46 public buildings and 1,100 private houses were damaged or completely wrecked. Another very disastrous earthquake occurred in 1897. All of the islands are in general mountainous, though as far as known no elevations in excess of 9,000 feet have been discovered. Most of the ranges apparently do not exceed 2,500 to 4,000 feet in general elevation. The usual direction of the mountains is north and south. The archipelago is well watered and many of the streams are of good size. Although the Philippines have been known to Europeans more than three centuries, very little exact knowledge was possessed with regard to either their geology or their flora and fauna till after the American occupation of the islands. Since then although much has been done to add to our stock of information, yet what is known at present is too indefinite to warrant more than the briefest itemization. Coal of good quality has but recently been discovered in Cebu, and in fact nearly all the islands contain coal of one quality or another. Excellent lignite has been long known to exist in Luzon, Cebu, Masbate, and Mindanao. Copper ore and galena occur in Luzon and some other parts of the archipelago. Gold has been crudely mined in small quantities by the natives for centuries. Modern methods of extraction are being installed in several places and will doubtless greatly increase the output of this metal. Excellent iron ore is found in Luzon, but so far it has not been developed. Marble and gypsum are found in many of the islands. Free-flowing petroleum has been discovered within a few years past in Cebu, Tayabas, Iloilo, Capriz, and Leyte provinces, and sulphur exists almost everywhere in inexhaustible quantities.

FAUNA.—The mammalian fauna of the Philippines is scant in indigenous varieties compared with other islands of the great Australasian group. There are no carnivorous animals of any considerable size. A small wildcat, two civet cats, and the binturong, a related species, are the most conspicuous. One species of monkey, twenty varieties of bats, a few squirrels, a species of porcupine, and several varieties of rats may also be mentioned. Several species of deer exist. The agricultural animals are the water buffalo, or native carabao, the hog, the goat, and a small pony. Cattle of an inferior variety are also found and are extensively raised for beef. The water buffalo is the native beast of all work. The ponies are excellent for travel, but are too light for heavy loads. They are supposed to be descendants of an early Spanish stock. Birds are numerous and in great variety. Jungle fowl, hornbills, and fruit pigeons are in abundance and are hunted for and much relished as food.

Snipe are plentiful in rice fields and a species of swift, whose nest is prized by the Chinese for food, is found on some of the precipitous island coasts. Alligators, or crocodiles, are common and frequently attain large size. The natives show very little fear of them, although they state that when the crocodile has once tasted human flesh it will then have no other. Snakes are numerous and venomous species are found. Cobras exist in Samar and Mindanao, and pythons, though of small size, are found generally throughout the archipelago. Fish are plentiful and in great variety. The marine fish form one of the chief sources of food supply, but the fresh-water varieties are not so important in this respect. Shellfish are likewise numerous. Extensive beds of pearl oysters are fished near the Sulu Islands. From a variety of oyster are obtained the "concha," thin squares of shell used in dwellings in place of the common window glass.

Locusts, termites, and mosquitos are much in evidence. The first two are very destructive and the third most annoying. There are also other insect pests, two species of which cause much damage to the rice crop. Bees of three varieties are found. Butterflies, beetles, spiders, and many other forms of insect life are seen in great profusion.

Flora.—A rich soil and favorable climatic conditions give a flora of magnificent variety and abundance. The agricultural possibilities of the islands were not developed by the primitive methods of cultivation in vogue under Spanish rule. Improvements have been introduced since the archipelago has been under American control, that are developing the rich possibilities of the islands and greatly increasing their agricultural wealth and economic importance. So far, attention has been mainly devoted to the production of hemp, sugar, and tobacco. Rice is grown fairly successfully and forms a staple food of the natives. Coffee grows readily and its quality is excellent. Recently, however, the coffee plants have been virtually ruined by the attacks of the Ceylon coffee blight—a disease caused by a microscopic fungus growing on the leaves of the plant. It is stated that this fungus can be controlled by the use of Bordeaux mixture. Cotton of an inferior quality grows wild. Long-staple cotton was at one time introduced, but it was abandoned because the authorities preferred the natives to grow tobacco, then a government monopoly. Cacao, castor oil bean, cocoanuts, gutta-percha, potatoes, maize, rattan, and many varieties of useful palms are grown in greater or less quantities. In fact, it appears that there is no limit to the variety of agricultural products, tropical, semi-tropical, and even many of the varieties of colder climates, that may not be profitably cultivated under intelligent supervision.

The forests abound in many valuable woods. More than 2,500 different species of timber trees have been classified and, so far, over 200 kinds have been considered worthy of industrial use. Fifty or more species of hard woods are known, some four of which sink in water. Many of these woods, owing to their hardness, take beautiful polishes and are, therefore, excellently adapted for cabinet work. Others possess qualities that will suit them for general industrial use.

Of plants, more than 7,000 species are at present known. Among these are some of importance, though not as many as the great number of species would apparently imply. Subsequent investigation may show others to be of commercial value that are now regarded as of no importance.

Climate.—The climate of the Philippine Islands is tropical, that is, it is characterized by high and steady temperature and humidity, and an abundant rainfall. Statistically it is known mainly from the excellent series of metereological observations made by the Jesuits priests at their observatory of Manila up to the cession of the archipelago to the United States. Since the transfer of the islands in 1898 and the establishment of the present insular government, an official weather service has been created. The Manila Observatory was made the central office of this service. Many observing stations have been located throughout the islands and a good series of observations is accumulating. However, it will be some while yet before the climatology of the islands can be definitely described. Local influences, such as elevation, mountain ranges, valleys, etc., play relatively a so much more important part in determining the weather as actually felt in the tropics than do the same agencies in temperate regions, that a comprehensive account of the climate of the Philippines will have to await the accumulation of a larger mass of data than is at present available.

Table I.—Climatological Data for Manila.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Temperature (F.°)—													
*Mean monthly	77	78	80	83	83	82	81	81	80	80	79	77	80
Mean of warmest	79	81	82	85	87	85	82	82	82	82	81	80	82
Mean of coolest	74	76	79	81	82	81	79	80	79	79	77	75	79
Highest recorded	91	96	96	99	100	98	95	94	94	95	94	92	100
Lowest recorded	60	61	65	66	71	70	70	69	71	69	63	60	60
Mean maximum	86	87	90	92	92	90	87	87	87	88	86	85	
Mean minimum	69	69	72	74	76	76	75	75	75	74	73	71	
Mean daily range	17	18	18	18	16	14	12	12	12	14	13	14	
Greatest daily range	22	27	27	30	24	22	20	20	20	20	22	25	
Least daily range	4	5	4	8	4	3	3	3	2	3	3	2	
Humidity—													
Mean relative, per cent	77	73	71	70	75	80	84	84	85	82	80	80	78
Mean absolute, grains per cubic feet	7.75	7.60	7.90	8.42	9.27	9.39	9.33	9.53	9.33	9.24	8.59	8.06	8.75
Wind movement in miles —													
Mean daily	98	115	132	145	144	138	182	165	192	111	94	93	134
Prevailing wind direction	N. E.	E.	E.	S. E.	S. E.	S. E.	S. W.	S. W.	S. W.	N. E.	N. E.	N. E.	
Cloudiness, per cent	45	37	35	32	47	65	74	68	72	58	54	53	53
Days with rain, number of	4.3	2.2	3.4	3.5	9.2	15.4	22.1	19.8	20.7	14.4	11.3	8.4	135
*Rainfall in inches—													
Mean monthly	1.06	0.42	.73	1.27	4.36	9.21	15.69	14.16	14.16	7.43	5.15	2.38	76.02
Greatest monthly	7.59	1.97	3.94	5.37	10.11	25.81	29.71	43.20	61.43	23.65	15.27	13.67	120.98
Least monthly	0.02	0.00	0.00	0.00	0.00	0.98	5.28	5.15	2.00	0.90	1.17	0.01	35.65

* Mean temperature for thirty-seven years rainfall record for forty-seven years, 1865–1912. Other data for seventeen years, 1880–96, with exception of mean maximum and minimum daily ranges, which are for fourteen years.

However, in a general way the salient features of the Philippine climate can be given. The sea-level temperature regimen may be represented fairly well by that of Manila, as also the humidity, and with less constancy, though still with a fair degree of accuracy, the wind directions and wind movement. The rainfall regimen is subject to decidedly less regularity. However, broadly stated the larger islands are divided by the general north and south trend of the mountain ranges into an eastern and a western rainfall regimen. While rain is most prevalent in one, less rain or even dry weather is prevalent in the other. The Manila rainfall distribution will serve as a type of the western coastal rainfall and that of San Antonio as a type of the eastern coastal rainfall. (See Table III.) The effect of elevation in modifying temperature (and also upon rainfall though not so noticeably) will be seen in contrasting Manila, at sea-level, with Baguio, 5,000 feet above sea-level, and about 150 miles north of Manila.

The climate of Manila and vicinity is shown in detail in Table I. Table II gives the monthly average and the highest and lowest temperatures, the average rainfall and number of rainy days at Baguio, in the mountains of Luzon, 5,000 feet above sea-level. The temperatures are determined from three years' observations—too short for accurate data—but give an idea of the mountain climates that may be found in the islands. The rainfall data are from a twelve-year record. Tables III and IV give the average rainfall and average number of rainy days at several selected stations.

Table II.—Temperature and Rainfall at Baguio.
(Elevation 5,000 feet).

Three years record.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean temperature	63	61	66	68	67	66	66	65	66	67	66	65	65
Highest recorded	75	74	78	80	79	78	80	76	74	76	76	75	80
Lowest recorded	49	46	51	52	53	58	56	55	57	55	52	55	46
Average rainfall (inches)	1.49	0.61	1.53	4.58	17.61	15.88	39.50	40.45	34.85	17.98	3.55	2.14	179.3
Average number rainy days	5	3	6	9	19	21	27	27	25	18	8	4	173.7

Temperature.—The average temperature of the year at Manila is 80° F. In describing the climate of Manila the year may be divided into a hot season, an intermediate season, and a cool season. April, May, and June constitute the hot season, with an average temperature for the three months of 83°; July, August, September and October, the intermediate season, with an average temperature of 80°; and November to March, inclusive, the cool season, with an average temperature of 78°. May is the hottest month of the year, having an average temperature of 83°, and December and January are the coolest months, with average temperatures of 77°. The highest thermometer reading so far recorded is 100°. The lowest reading ever recorded is 60°. The average temperature of Baguio, the summer capital of the islands, is 65°. The highest temperature so far reported is 80° and the lowest 46°. On an average Baguio is 15° cooler than Manila. Blankets are said to be comfortable even on the warmest nights. As previously stated, three years is too short a period to determine accurately the temperature of Baguio, and the data are given only because no better are available. For the general law of temperature decrease with elevation the article "Climate" in vol. iii. may be consulted. For comparison with other tropical and subtropical places, see tables in articles *Cuba* and *Hawaii*.

Humidity.—The average relative humidity is 78 per cent. The average absolute humidity is 8.8 grains per cubic foot. The humidity is greatest during the months of July, August, and September when its average is 84 per cent., and least during March and April when its average is 70 per cent.

Rainfall.—The average rainfall, from a record of forty-seven years, is 76.02 inches. The year is usually divided into a rainy season and a dry season, although the Spaniards characterized the seasons epigrammatically as "*seis meses de polvo, seis meses de lodo, seis meses de todo*" (six months of dust, six months of mud, and six months of everything). The wet season begins with June and extends to October, inclusive, during which 80 per cent. of the total rainfall occurs. The dry season takes up the rest of the year during which but 20 per cent. of the rainfall occurs. The month of July has the largest average rainfall, 15.69 inches, and February the smallest average fall, 0.42 inch. The heaviest rainfall ever recorded in any one month is 63.43 inches in the month of September. It is not unusual for the months of February, March, April, and May to pass with no rainfall whatever. A consideration of the record of forty-seven years reveals the fact that there are many departures from the average rainfall, and in some instances the departures are remarkable. For example, in one year as much as 120.98 inches fell and in another year as little as 35.65 inches. Still more remarkable, however, are the departures from the averages of individual months. In the case of September, with an average rainfall of 14.16 inches, as little as but 2 inches has fallen.

The rainfall varies much in other places in the archipelago. From an inspection of Tables III and IV it will be observed that the rainy season is not synchron-

Table. III—Rainfall Statistics at Several Stations in the Philippines.
(Rainfall in inches.)

Stations.	Length of Record.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Vigan (N. W. coast Luzon)	12 yr.	0.02	0.12	0.22	1.28	8.53	13.57	27.27	28.05	22.60	7.31	0.79	0.37
Aparri (N. coast Luzon)	12 yr.	7.32	3.15	1.86	4.77	5.54	5.54	8.03	9.63	11.62	12.87	11.88	9.43
San Antonio (E. coast Luzon)	7 yr.	7.41	4.15	4.80	4.19	6.65	7.61	10.75	10.43	14.15	13.86	14.84	13.20
Manila (W coast Luzon)	47 yr.	1.06	0.42	0.73	1.27	4.36	9.21	15.69	14.16	14.16	7.43	5.15	2.38
Legazpi (S. E. coast Luzon)	12 yr.	14.72	11.70	6.73	6.70	4.98	6.75	10.18	6.81	9.75	13.42	13.61	18.88
San Jose (W. coast Panay)	12 yr.	0.83	0.42	0.54	1.38	5.55	13.00	22.91	20.17	21.31	12.32	7.06	1.79
Cebu (E. coast Cebu)	12 yr.	2.80	2.31	1.41	1.17	2.65	6.51	7.22	6.31	7.02	8.54	6.32	5.81
Baguio (N. central Luzon)	12 yr.	1.49	0.61	1.53	4.58	17.61	15.88	39.50	40.45	34.85	17.98	3.55	2.14

TABLE IV.—AVERAGE NUMBER OF RAINY DAYS AT SEVERAL STATIONS IN THE PHILIPPINES.
(Twelve Years Record.)

Stations.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec
Vigan	2	1	1	2	9	18	22	22	19	9	2	2
Aparri	14	11	6	5	9	10	12	15	15	16	17	18
San Antonio	16	10	13	8	14	16	17	19	19	19	12	23
Manila	5	3	3	4	10	16	21	21	20	16	22	9
Legazpi	21	17	14	14	13	13	19	19	19	19	20	24
San Jose	3	3	3	4	12	20	24	22	20	15	10	7
Cebu	12	11	8	7	10	16	18	15	16	17	14	16
Baguio	5	3	6	9	19	21	27	27	25	18	8	4

ous in all parts of the archipelago. Indeed, it is practicable by moving from place to place to have rainy or fair weather almost as one chooses. In Tables III and IV the stations of Manila and Vigan are on the western, Aparri on the north, and San Antonio and Legazpi on the east coasts of Luzon. San Antonio is almost due east of Manila. San Jose is on the west coast of Panay, and Cebu is on the east coast of the island of Cebu.

Storms.—Thunder storms are of frequent, almost daily, occurrence during the wet season. The electrical display and the rainfall of these storms are much more intense than in the storms of temperate latitudes. However, but little damage results. The most destructive and most dreaded storm of the eastern waters is the typhoon, a cyclonic storm similar in respect to origin, course, and season, and destructiveness to all things in its path, to the West India hurricanes of the Atlantic. The season of maximum typhoon prevalence is from June to October.

HEALTH.—One of the most interesting questions pertains to the health of Americans and Europeans in the archipelago. While a definite answer cannot be given to all phases of the health question, yet sufficient evidence is at hand to justify the statement that the white races from the temperate zones can preserve a very fair degree of health; and the better acquainted we become with the causes of tropical ill health the more and more evident becomes the fact that we can control these causes, and that too without any considerable effort over and above that required for health in the temperate latitudes. Spanish sanitary arrangements in the Philippines were as notoriously bad as they had been found to be in Cuba and in Porto Rico at the time of the American occupation of these islands. Much of the ill health and most of the pestilential diseases found prevalent in the Philippines in 1898 were unquestionably due to the neglect of the most elementary principles of public and private hygiene and sanitation. Since the Philippines have been under the control of the United States, wonderful improvement has taken place in the lowering of the death rate, eradication of the pestilential diseases smallpox and plague, and control of malarial, typhoid, dengue, and other fevers and disorders due to parasitic infection or insect carriage. This is well shown in the following tabular statement of the annual mortality rate in Manila since 1904, the date of the first official census.

Mortality rate, Manila. Population 219,941:

1904, 46.83;	1908, 47.62;	1912, 33.35;
1905, 39.74;	1909, 35.50;	1913, 23.82.
1906, 41.74;	1910, 34.25;	
1907, 32.59;	1911, 35.09;	

The above rates are calculated on the official census of 1904 and the estimated increased population since then as determined by accepted methods of calculating such increase.

The annual report of the Philippine Bureau of Health, 1914, estimates that there were 60,000 fewer deaths in 1913 than there were in 1905, and that this reduction has been entirely among the preventable diseases. However, tuberculosis, malaria, beriberi and intestinal disorders are still responsible for 100,000 deaths annually. The prevalent infectious diseases are tuberculosis, malarial fever, dengue, and beriberi, the latter confined almost exclusively to the natives. Heat and sunstroke are relatively infrequent notwithstanding the high temperature and humidity of the climate. For visitors, the question of clothing and diet is one deserving of consideration but cannot be discussed here. But one admonition can be given—clothing, food, and habits adapted for temperate zones must be greatly modified for the tropics. Pure drinking water, properly cooked food, and screening against insects are imperative.

HISTORY.—The Philippines were discovered by Magellan, March 12, 1521, in his memorable voyage of circumnavigation, and on April 27 of the same year he was ingloriously killed in a skirmish with the natives on the little island of Mactan, off the east coast of Cebu. Magellan took possession of the archipelago in the name of the king of Spain. In 1565 Legazpi founded in the island of Cebu the first Spanish settlement, and in 1571 fixed the capital of the islands at Manila. The archipelago was for some time known under several appellations. Its present name (*Islas Filipinas*) was suggested by Villalobos in 1543, but it first appeared in written form in 1567 in a letter of Legazpi's. The archipelago appears from the first to have been virtually turned over by Spain to the different orders of the Roman Catholic missionaries, and its conquest and civilization from thence on were practically accomplished by them. The political history of the islands, so far as relates to their foreign relations, with the exception of the capture of Manila by the English in 1762, and its subsequent restoration in 1764, is uneventful until the year 1898. The United States having declared war against Spain, April 24, 1898, Admiral (then Commodore) Dewey, commanding the United States naval forces in Asiatic waters, entered Manila Bay, May 1, 1898, and in one of the signal engagements in naval annals completely destroyed the Spanish fleet gathered for the defense of the Philippines. The city of Manila was then closely invested by the United States naval vessels on water and by the insurgent Filipino forces on land. Upon the arrival of land troops from America, a combined land and water attack, more a demonstration to satisfy Spanish honor, was made and Manila surrendered to the United States forces August 13, 1898. By the treaty of Paris, December 18, 1898, Spain ceded the Philippines to the United States. In 1899 the Filipinos, who had been in a chronic state of insurrection against Spain since 1896, becoming dissatisfied with the American policy, commenced overt hostilities February 4, 1899. Engagements of more or less seriousness between the Americans and the insurgents occurred with the discomfiture of the insurgents, in nearly every instance. The latter, after their first few unsuccessful engagements in open battle, abandoned any attempt at organized warfare and resorted to that of the guerilla and bushwhacker. This kind of warfare lingered on, much to the distrac-

tion of business in the islands, until March, 1901, when the chief leader of the insurgents, Aguinaldo, was captured. The insurrection collapsed and peace and order were thereafter soon restored.

Government.—From the American occupation of the islands in 1898 till July 4, 1901, the Philippines were under military control and governed by a military officer, as Governor. July 4, 1901, the first civil Philippine Commission Government was installed with William Howard Taft (subsequently President of the United States) as Governor-General. This form of government with some additions and modifications is the existing goverment at the present time. It consists of a Governor-General and several commissioners appointed by the President of the United States by and with the consent of the Senate. The Commission forms the upper house of the legislature as well as the executive branch of the government. Also it is the exclusive legislative authority over what is known as the non-Christian tribes and the territory occupied by them. With this exception all legislative power is vested in a legislature consisting of the Commission as the upper house and an elective lower house or Assembly. The present Philippine Commission consists of four Americans and four Filipinos. The Assembly membership must not be less than fifty and not more than 100, and be apportioned according to population.

The first session of the Assembly was inaugurated in 1907. Two resident Commissioners to the United States are elected every four years. By a somewhat recent act of Congress these Commissioners are extended the privileges of the floor of Congress and the right to participate in debate.

The judicial organization consists of three grades, namely, the supreme court, the courts of first instance, and those of justices of the peace. A civil service commission was established in 1901 and has jurisdiction over the civil employees of the government.

The executive work of the general insular government is divided among the several commissioners, each presiding over a separate department.

Commerce and Industries.—At the time of the cession of the Philippines to the United States, very little had been done to develop the commercial and agricultural possibilities of the islands. The only railroad extended from Manila to Dagupan in north Luzon, a distance of 120 miles. Ordinary roads could hardly be said to exist. Those laid down on the maps were little better than trails, impassable during the wet season. Extensive improvements have been made since the United States has been in control. In 1913 there were more than 1,200 miles of first-class roads, the equal of any in America, about the same mileage of second-class roads, and nearly 2,000 miles of third-class roads. The total number of durable bridges and culverts at the close of 1913 was 5,660. The railroad mileage had increased from 120 miles in 1898 to more than 700 miles in 1913. Telephone systems have been installed extensively, more than 17,000 stations being in operation in 1913 and placing service at the disposal of nearly 3,000,000 population. The land telegraph mileage in 1913 was 6,358 miles, and that of the interisland marine cables 4,787 miles.

An equal improvement has taken place in the harbors. At the occupation of Manila in 1898, vessels drawing more than sixteen feet of water were compelled to lie two or more miles off-shore and lighter cargo. To-day Manila harbor has thirty feet of water at its wharves. Other harbors have been or are being improved in proportion to their importance. It would exceed the limits of this article to itemize comparatively the numerous improvements in all developmental directions that have taken place under American control. A wise and far-sighted public policy has been maintained under the Philippine Commission and the islands are coming into the enjoyment of the advantages that their climate and soil have for centuries rendered potential. The chief articles entering into the foreign trade of the islands are exports of hemp, copra (dried cocoanut), cocoanut oil, sugar and tobacco; imports of cotton and cotton fabrics, machinery, rice, flour, and wearing apparel constitute the chief articles from abroad.

Evidence of the great advances made is indicated in the following comparative tabular summary of the value of the exports and imports, under Spanish and under American control:

Year.	Control.	Imports.	Exports.	Percentage of total value going to or coming from United States.	
				Imports.	Export.
1892	Spanish	16,341,901	19,163,950	1	15
1894	Spanish	14,250,717	16,541,842	3	22
1900	United States	24,863,799	22,990,373	9	13
1904	United States	29,577,731	29,149,500	17	40
1912	United States	61,667,951	54,784,738	39	42

Facilities for interisland communication have been established, the latest reports (1914) showing eleven regular steamship lines in operation between the islands. Two ocean cables connect the Philippines with the United States.

Population.—At the time the islands passed to the United States, the population was estimated at 8,000,000. The first official census taken in 1904 showed a population of 7,635,426. It was classified as follows:

	Civilized	6,987,868
	Wild	647,740
By races		
	Malayan or brown	7,539,632
	Yellow	42,097
	Black	24,016
	White	14,271
	Mixed breeds	15,419

What may be called the native population, is made up of three distinct races, in varying degrees of purity, namely, Negrito or black, probably the Aborigenal, Indonasian, and Malay. The Negrito, the lowest race in the ethnologic scale, is now found pure only in the forests of the high mountains of Luzon, Panay, Negros, and Mindanao. From present indications the race will soon become extinct. The Negrito is small in stature, from 4.2 to 5.2 feet in height, with skin intensely black, hair short, crisp, curly and of a sooty blackness, lips thick, nose of medium size, flattened and broad at its base. Making no preparation for future wants, content to sleep where night overtakes him, armed only with a bow and arrows, the Negrito is the typical nomad and savage. The pure Indonesian is found only, as far as known, in Mindanao. The type is described by Dr. Montano as of considerable height, muscular development, high forehead, aquiline nose, wavy hair, and in the male abundant beard. The color of the skin is quite light, the individual clever and intelligent. The Malayan is difficult to characterize, because of more or less intermixture that has taken place in the race with that of the Negrito, Chinese, and Indonesian. On the whole, the Malayan is not so tall as the Indonesian, his skin is darker and his nose straighter. He has a medium to large-sized mouth, thick lips, black, straight, thick, and coarse hair, and in the male little or no beard. His intelligence is intermediate between perhaps the Negrito and the Chinese. The European mestizo is intellectually and politically the most important mem-

ber of the native population, and is found everywhere throughout the archipelago, but is most numerous in the important cities and towns.

With the exception of tribes in the interior of the larger islands most of the Filipinos are civilized and in a certain sense Christianized. At and for a period after American occupation, human sacrifices were stated to be practised by at least two tribes in central Mindanao, and head hunting to be engaged in by some of the north Luzon tribes. These practices are now believed to be abandoned entirely. One of the most important civilizing agencies in this, as in other uncivilized practices and habits, has undoubtedly been the influence exerted by the medical and sanitary work of the insular government. Hospitals have been established throughout the islands and physicians and nurses have gone among the tribes helping the poor and afflicted and by example showing that practical sympathy and kindness that appeals as strongly to the savage as to the civilized.

Education.—The condition of secondary education under Spanish rule was very poor. On paper the provisions appeared good, but in practice they were ineffective and impotent. Comparisons of enrollment of students in the schools under Spanish and American controls cannot be made because of lack of statistics for the Spanish period. In 1904 there were 2,285 public schools in operation with 4,690 teachers and 227,600 students; in 1912 there were 3,685 schools, 8,363 teachers, and 429,380 students. The quality of instruction compares favorably with schools of the same grade in the United States. All instruction is given in the English language. Normal, technical and trade schools are also provided.

For higher education under Spanish rule a better provision was made and carried out than for primary and secondary instruction. The following schools were in existence and did a fair grade of instruction: The Royal and Pontifical University of Santo Tomes conferred degrees in theology, philosophy, jurisprudence, and physics and chemistry. The College of San José also gave philosophical instruction, and from 1875 it conferred degrees in both medicine and pharmacy. Other schools, such as the School of Arts and Trades, of Agriculture, of Painting and Sculpture, and the Nautical School, and several theological schools may be mentioned. The standard of these schools, however, was not that of institutions of the same apparent rank in either Europe or America. Higher education is now well provided for in the University of the Philippines, which gives, under a competent faculty, courses in the arts and sciences and the professions.

The student enrollment in 1912 was 1,400.

City of Manila.—The capital of the islands is situated on the west coast of the island of Luzon, on the shore of Manila Bay, a somewhat circular body of water, about thirty miles across. At the entrance of the bay is Corregidor island, one of the strongly fortified places of the world. The harbor proper of Manila is behind a breakwater, one and three-quarters miles long, affording a safe and commodious anchorage for ocean going vessels of all drafts. Since American occupation the harbor facilities have been greatly improved, both in depth of water and in wharfage front. Vessels of thirty feet draft may now come alongside the wharves, whereas, under Spanish domination, such vessels could not have come nearer than two miles of shore. To-day the harbor facilities of Manila are the equal, if not the best, of any others in the Far East.

The city embraces an area of 14.9 square miles. Flowing through the city is the Passig River, from which many canals (esteros) extend into different parts of the city and its suburbs. Since American occupation forty-one miles of streets and many bridges across the Passig River and its canals have been constructed. About 35,000 square yards of street have been paved with bituminous macadam or wood blocks. There are at present about 300 acres of parks improved and maintained, and work has been begun on an additional 600 acres. Eight public markets are established. Stores and shops compare favorably with those of cities of like size in this country. A modern fire department, in every respect the equal of the best in this country, and a well-organized police service protect the city from violence and conflagrations, while an excellent health service takes care of public and private sanitation and hygiene.

The population of Manila, according to the latest official census, 1904, was 219,941, made up as follows: Filipinos, 189,782; Chinese, 22,125; Americans, 4,389; all others, 3,645.

Manila has much to interest the traveller. However, it would be beyond the scope and intent of this article to enter into any detailed description of the items that a tourist would find worth while examining. To such as desire more detailed information, it may be had upon request addressed to the Bureau of Insular Affairs, War Department, Washington, D. C., or directly of the Philippine Commission, Manila.

W. F. R. Phillips.

Phlebotominæ.—A family of little biting flies. The species of one genus, *Phlebotomus*, are widely distributed and attack man. These flies are believed to carry pappatici fever, and verruga peruviana. See *Insects, parasitic.*

A. S. P.

Phlegmons.—A phlegmon is an attenuated or virulent infection of connective-tissue networks and their interspaces which shows no tendency to self-limitation. An ordinary carbuncle—so familiar to all—represents an infection of the phlegmon-type.

The characteristic signs of this variety of infection are a peculiar doughy, boggy feel, attended by deep soreness on pressure, but rarely a distinct sense of fluctuation, with a variable amount of surface redness, perhaps a brawny thickening of the skin over the affected part, and a tendency to surface gangrene, in patches, from cutting off of the vascular supply of the skin. Incision through such an inflamed area reveals a soft-solid condition of the subcutaneous layer, the meshes of which seem distended with fluid exudation of varying consistence, with softer portions of evidently dead tissue resembling wet tow and bathed in pus, and sometimes softened and dead strings of fascia, tendon or muscle.

Behind a screen of pyogenic streptococci the way is cleared for the advance of pyogenic staphylococci. The former soon die; their work is done. The latter, not encountering polymorph resistance, sweep through the tissues, their fibrolytic ferments destroying connective-tissue septa, and their toxins paralyzing the vessels and provoking infiltration of connective-tissue interspaces with plasma and disintegrated products of pus-metabolism. This simple pathological process forms the foundation upon which is built the superstructure consisting of the characteristic signs mentioned above, while the constitutional effects upon the patient may readily be imagined. Symptoms due to absorption of bacterial toxins, such as chill, hectic, sweats, etc., are too commonplace to mention.

An infection of this type, unbridled and in a debilitated person, attacks structures indiscriminately, entering blood-vessels (secondary hemorrhage, septic thrombosis, embolism, pyemia), necrotizing tissues, and exposing bones.

The *treatment* of a phlegmon—whether subcutaneous or subfascial—can be only by free incisions to the depths of the infected area, leaving the wound exposed to the air and washed by a continual saline drip.

Woody Phlegmon.—The attenuated-infection type of phlegmon is that which was described by Reclus, in 1894. A cold, board-like induration (ligneous phlegmon) makes its way slowly and laboriously around the subcutaneous tissues of the neck, or of the abdomen. By its late reddish-violet hue it simulates cancer *en cuirasse*, while its hardness suggests granulomatous infiltration.

The *treatment* of Reclus's phlegmon is based upon a correct diagnosis; it consists of supportive measures only.

Progressive Emphysematous Necrosis.—This is the name suggested by Surgeon A. M. Fauntleroy, U. S. N. (*Annals of Surgery*, January, 1916) in substitution for the older terms "gaseous phlegmon," "gas gangrene," as being more clearly expressive of the pathology of the disease caused by *B. perfringens*. In fact, studies of this disease in the European strife have shown that the brawny induration or "phlegmon" appears first when circulatory disturbances take place in the second stage of the second grade of the malady.

Fauntleroy states that the causative organism is harbored in the soil throughout the entire western European war area, which is intensively cultivated and fertilizer-laden. *B. perfringens*, which is anaërobic, thrives best in the presence of necrotic tissue, so that it becomes active in wounds in which there is more or less pulpifaction of the tissues, usually a fractured bone, and always more or less circulatory disturbance. The toxins exert a special selective action on the planes of connective tissue, the necrosis traveling with greater rapidity along fascial planes. Thus a vicious circle is rapidly established in which necrosis follows bacterial activity while the latter increases and becomes more virulent as a result of the necrosis. Deep wounds of the buttocks are especially prone to gas bacillus infection, and next, in the order of preference, is the thigh, then the leg, arm, forearm, and foot.

Progressive emphysematous necrosis may be divided into three clinical grades of which the first two have three stages each, and a fatal case is one that has passed through all these stages progressively. They may be tabulated thus:

First grade.	Second grade.
1. Injury.	1. Progressive gas production.
2. Infection.	2. Circulatory disturbance.
3. Localized necrosis.	3. Increased virulence.

Third grade.
Septicemia.

Pathologically, there is marked parenchymatous degeneration of the muscles above and below the wound, and more or less marked edematous infiltration interspersed with gas bubbles of varying size. At times the tension is so increased when the gas becomes pocketed, that incision of the pocket causes a distinct explosive sound, reminding one of the small boy bursting an inflated paper bag. The outer walls of the regional blood-vessels are specifically acted upon by the toxins, accounting for the extravasated blood which, in turn, gives rise to the superficial mottling or discoloration.

Symptoms.—In the earlier stages nothing is usually apparent externally, beyond the nature of the wound, to indicate the gravity of the process. In from two to five days, however, there is apparent a certain though small degree of swelling; palpation will usually elicit the presence of gas in the tissues, as indicated by the crepitation; a slowly progressive copper-colored mottling becoming a brawny induration; fetid odor; thin, serosanguineous discharge (unless there is mixed infection); and finally the more or less sudden appearance of crops of vesicles which vary in size from that of a pea to several inches in diameter. Although during the earlier stages of the infection a pulse may be noted in one of the arteries distal to the wound, it becomes progressively weaker and in the last stage is always absent.

An examination of the deeper infiltrating serous fluid invariably shows the presence—rarely in pure culture—of the characteristic bacillus. In some of the fatal cases the infection rapidly travels up the limb and makes its emphysematous appearance in the tissues of the abdominal or chest wall. In certain cases involving the lower extremity the local tissue changes seemed to have been arrested at Poupart's ligament, although the blood was later found to be full of bacteria. In all fatal cases, the heart and larger blood-vessels of the body and brain were found to contain large numbers of gas bubbles. Aside from the septicemic process, the presence of so much gas in the blood stream probably is the dominant factor in the almost sudden deaths to be noted in certain of the rapidly progressive fatal cases.

The symptoms which characterize the successive stages have a direct relation, first, to the character of the wound, as regards size, situation, and degree of trauma; second, to the time elapsing between the reception of the injury and the institution of efficient surgical intervention; and, third, to the care with which the after-treatment is conducted. So, too, the prognosis has to be regarded from the viewpoint of the progressive nature of the process.

The *treatment* is prophylactic, abortive, and curative.

The prophylactic measures are obvious, and in modern warfare have to do with the construction and the disinfection of the trenches. After the receipt of an injury, at the first-aid stations iodine should be freely used. Carrel recommends the injection of Dakin's fluid (chlorinated lime) into narrow wounds and also dressing the large wounds with gauze saturated with the same solution.

The abortive treatment of this progressive infection contemplates being able thoroughly to treat the wound within twelve hours after the receipt of the injury. The principles of this abortive treatment are twofold, mechanical, and chemical. The mechanical process calls for the prompt and delicate removal of all foreign bodies, such as projectiles, fragments of clothing, and unattached splinters of bone. The chemical part of the abortive treatment is best accomplished by the Dakin fluid, which is antiseptic, highly germicidal, and practically non-irritative. This fluid is introduced into large wounds through long, fenestrated narrow rubber tubes passed to the depths of the wound. The fluid is injected every one or two hours into the tubes or the latter may be coupled to a Murphy drip apparatus. The object is to keep the gauze in the wound thoroughly saturated with the fluid. This is kept up sometimes for as long as forty-eight hours, depending upon the size and character of the wound. At the end of this time if the treatment has been thoroughly carried out, the wound will be sterilized in the great majority of cases.

The curative treatment in the beginning may be an intensified continuation of the abortive treatment, or it may take the form of any special surgical procedure individually preferred by the surgeon.

The indications for amputation are largely a matter of surgical judgment and experience. In view of the combined evidence of a beginning progressive local and constitutional decline, however, the surgeon is thoroughly warranted in deciding upon an amputation. The latter must be performed with the utmost despatch, consistent with the recognized principles of good surgery. The stump should be left wide open and no effort made to limit the size of the wound by the introduction of sutures. This latter admonition is highly important in view of the paramount necessity of making sure that aërobic conditions will prevail in the wound.

Morris Booth Miller.

Phlorhizin or Phloridzin.—Phlorhizin is a glucoside which is found in the root-bark of the apple, pear, cherry, and plum tree. Its chemical formula is $C_{21}H_{24}O_{10} + 2H_2O$. Phlorhizin is of interest in that when given to man or animals it causes glycosuria. Glycosuria is produced most readily after subcutaneous injection. The glycosuria is undoubtedly induced by a more or less specific action upon the renal cells whereby the latter are rendered more permeable for blood sugar. In accordance with this idea blood sugar is either normal or hypoglycemia obtains during phlorhizin glycosuria. Phlorhizin has been employed extensively as a means of studying carbohydrate metabolism in animals under various conditions, and it has also been used as a measure of renal efficiency in man. F. P. U.

Phobias.—Under this broad general title one often speaks of pathological fears, but fear is such a widespread phenomenon that to group all fears as phobias would be nonsense. To obtain an insight into the various types of fears that arise in the human mind reference may be made in the first place to an exhaustive study on "A Synthetic, Genetic Study of Fear" by G. Stanley Hall,[1] appearing in the *American Journal of Psychology* in the year 1914. Here the student will find a comprehensive résumé of the entire problem, a brief condensation of which will be here attempted.

Bailey[2] has well said, "pleasure, pain, desire, and fear, whatever purpose may be at the root of them, are essentials without which no man can live. In the successive developing layers of the nervous system they have moulded grooves so deep that impulses of self-preservation flow along them in channels of least resistance, forming habits from which he dare not and cannot free himself. The organic origin of pleasure-loving and pain-avoiding is almost self-evident. Every living organism is confronted by things that it must have to live, and by things that would kill it, and it survives by striving for the one and by avoiding the other.

"In primitive organisms, possessing no consciousness comparable to our own, these strivings and avoidings, continuations of the first vital filip, the mysterious impulse, have the appearance of simple reflex or trophic actions, which take place mechanically, independent of the feelings. But even in them, movements conducive to welfare must be followed by a certain agreeableness in performance and disagreeableness when performance is prevented. It would be as futile to deny a glow of pleasure to the geranium, which has twisted itself to bathe in the sunlight, as it would be to deny the sense of organic satisfaction at the physiological functioning of any human organ, which is the glow of exercise.

"The earliest pleasure conceivable is the pleasure of performance; the earliest displeasure is the checking of it. Both of these forerunners of emotion secure a stronger foothold during the course of racial and individual upbuilding through the help of the organic memory of movement, which is stamped into physical structure by the constant interplay of contractile parts in harmonious workings to an end. When to the organic memory of coordinated movement are added a higher intellectual memory of the advantage previously gained by getting and of the discomfort which resulted from a failure to avoid, the emotional springs of action become idealized by anticipation and are governed to a certain degree by choice."

Fear is the anticipation of pain, and from the standpoint of this present summary is an evolutionary outgrowth from it.

For practical purposes the nervous system may be conceived of as acting through three levels. This is a rough metaphor. At the lowest, that is the phylogenetically oldest, physical and chemical forces acting within themselves determine the first energy transformations which constitute metabolism.

With advancing complexity from primitive organisms, a new type of action rises through the nervous system, by which sensations from the external or internal world are responded to by proper actions by means of the reflex arc. This constitutes the second level of activity, the sensori-motor level. The energy interplay of the physicochemical level is brought about through those energy transformers which are conveniently spoken of under the term, hormones. The new transformers at the next level, the sensori-motor level, are termed reflexes. With still greater complexity in organization the human being passes over into relation with other human beings, and social needs determine the necessity for another type of energy transformer. In response to this need language and ideation arose and the symbol becomes the transformer at the psychical level. Thus the hormone, the reflex and the symbol become the dynamic elements in the control of the individual in his social adaptation, expressed at advancing levels of his evolution.

Fears are symbols of noxious influences at the psychical level. Morbid fears are present in everybody. They constitute the racial background of insecurity; but they have not all the same importance nor do they always oppress an individual so constantly as to constitute an illness. When they become very great or inconvenient they are spoken of as pathological. They are classified as phobias and medical science is called upon to study their compensatory motor manifestations, which are called compulsions. Thus when the fears give rise to compulsive activities of sufficient intensity to interfere with the orderly living of life, creating perhaps more disturbance in human life than in almost any group of illness, they are spoken of as pathological, and, according to the most practical concepts for dealing with them, as *compulsion neuroses*.

Phobias, however, are found in a large group of other psychoneurotic or neurotic manifestations. They are accompaniments of many somatic processes and they cover an enormous field. If one should attempt to make a list of them, as Hall has done, we should find that people are afraid of a variety of things, of darkness, sharpness, of air, open spaces, points, sounds, carriages, dust, wind, human beings, floods, spiders, financial ruin, cats, reptiles, needles, etc., etc., etc. If one wishes to attach a Greek name to these, simply for the sake of appearing pedantic, he could, but it does not change the matter at all. Hall tells us that no good classification of phobias exists, but a study of the partial libido trends of Freud would show us that it would be possible to make an excellent classification of these fears along other genetic lines—a study that is attempted by Hall, but not completed.

The characteristics of a compulsion neurosis consists in the presence in the mind of certain compulsive tendencies to act or think in various ways. The patient is forced against his conscious desires, and without any apparent reason, to think certain thoughts or to do certain acts. The sense of unrest continues until the act is performed or the desire yielded to. Then a certain period of calm of variable length follows, when the compulsion again manifests itself and must again be relieved by yielding. It is characteristic of the compulsion neurosis for the patient to have insight into the whole procedure. He knows that it is silly but he simply cannot help it.

The mechanism of the compulsion neurosis is complicated (see Psychanalysis). In hysteria, for example, the repressed material that is forced into the unconscious manifests itself by its conversion into a physical sign, the unconscious wish not to see a thing, for instance, produces by a complicated process, a psychical blindness; the unconscious demanded not to do

something produces a psychical paralysis. The accumulated emotional stress of the split-off complex is unloaded through the bodily innervation. Thus the affects are deprived of their emotional load. An hysterical attack thus may be seen to be a sort of a wishfulfilling delirium which brings to pass by a process of allegorical dramatization symbolic fulfillment of both elements in the conflict.

In the compulsion neurosis, however, there is no such psychical conversion. It is a deeper process, and usually goes further back into the life of the individual. This is one reason why a compulsion neurosis mechanism is more difficult to treat than an hysterical process. The affect of the repressed complex is attached to something entirely indifferent and more or less individual. It is not unloaded through bodily innervation but finds a substitute by a process of displacement. This distortion serves to disguise from the patient the real source of the emotional conflict. It thus enables him to more effectually keep his neurosis, which by much secondary elaboration becomes a veritable work of art.

It is furthermore characteristic of a compulsion neurosis that by reason of its peculiar mechanism of distortion it cannot satisfy both elements of the conflict at the same time, which therapeutically speaking in hysteria is a much more successful adaptation than in the compulsion neurosis. In hysteria both elements of the conflict, that is the better element of the individual striving for an ethical adaptation to social needs, as well as the antisocial egoistic striving of the primitive feeling, are combined and reach a compromise in the same symptom, whereas in the compulsion neurosis there is a constant alternation. First the conscious attempt to adapt is manifest, then the instinctive falling back. The surface indication, therefore, is a constant alternation between the two factors in the conflict. These two factors nearly always can be resolved back to love and hate. It is a defense mechanism throughout. The compulsive acts are to be interpreted in terms of ceremonials, and are only comprehended through an understanding of the rich symbolism which makes up man's social evolution.

Thus if the physician wishes to understand why a patient with a compulsion neurosis goes through certain activities, these activities must be studied in the light of any other complicated ceremonial, and must be traced back to their origins. Thus the modern student, let us say of baptism or of the communion, would have to trace back to their very origins all of the steps, which have led up to the present-day complicated ceremonial.

It is only by a process of psychoanalysis that such a complete knowledge of the compulsion neurosis can be obtained. It is impossible here to even indicate the extreme wealth of symptoms found in the compulsion neurosis. In Hall's list of fears some two hundred are given, but the so-called peculiar manifestations of the compulsive acts far outnumber these. In a personal experience of ten years in psychoanalytic investigation of various compulsion neuroses over 500 different compulsions are recorded.

The only thoroughgoing analyses are those of Freud and his school, and psychoanalysis offers the best mode of approach to the interpretation of the complicated acts of a compulsion neurosis. Many cases of compulsion neurosis cited in the literature, which have been cured by drugs or other forms of psychotherapy are not compulsion neurosis. Many of them have been attacks of manic depressive psychosis (*q.v.*) which always has a tendency to spontaneous recovery. Others are abortive types of other psychoneurotic disturbances. Janet's psychasthenia (*q.v.*) is only one aspect of this group.

SMITH ELY JELLIFFE.

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Phosphatides.—The phosphatides are included in the group of lipoids (which see) and may be defined as ester combinations between nitrogenous bases and fatty acid-glycerophosphoric acid. The nitrogenous base is generally choline. The phosphatides may be divided into groups according to the number of phosphoric acid radicles in the molecule, thus a molecule with one phosphoric acid is called monophosphatide, with two, diphosphatide. Again phosphatides may be divided into groups according to the number of nitrogen atoms contained in the molecule. Thus, we may have monoamino, diamino, triamino, monophosphatides, etc. The lecithins stand as the most well-defined examples of monoamino-monophosphatides. In the brain, bile and yolk of egg examples of diaminomonophosphatides have been found and in general they seem to be widely distributed. A triaminomonophosphatide, *neottin*, is present in egg yolk and in ox bile a tetra-aminomonophosphatide occurs. *Cuorin* may be mentioned as an example of the monoaminodiphosphatides.

The phosphatides are included in the group of lipoids because of their solubilities which in general are those of the fats, although it is well recognized that among themselves the phosphatides may show striking dissimilarities with regard to solubility in a specific solvent. FRANK P. UNDERHILL.

Phosphoproteins.—Phosphoproteins belong to the group of conjugated proteins and may be defined as compounds of the protein molecule with some, as yet undefined, phosphorus-containing substances other than a nucleic acid or a lecithin. The best defined examples of phosphoproteins are caseinogen of milk and vitellin of the egg. F. P. U.

Phosote—creosote phosphate—is a colorless syrupy liquid, containing eighty per cent. of creosote, but with only a slight odor and taste of this substance. Phosote probably passes through the stomach unchanged, and is broken up in the intestine with liberation of creosote. It is employed in tuberculosis as an easily borne form of creosote, and is given in dose of gr. x.–xx. (0.6–1.3) three times a day. W. A. BASTEDO.
R. J. E. SCOTT.

Phosphoric Acid.—By *phosphoric acid* is signified, in medicine, a solution of common or orthophosphoric acid H_3PO_4 or $PO(OH)_3$ in water. Two grades of strength of such solution are official in the United States Pharmacopœia, as follows:

Acidum Phosphoricum, Phosphoric Acid. This preparation represents eighty-five per cent., by weight, of absolute orthophosphoric acid and fifteen per cent. of water. It is a colorless liquid of a syrupy consistence, without odor, and having a strongly acid taste. Its specific gravity is about 1.707 at 25° C. (77° F.). It mixes in all proportions with water or alcohol. It should be preserved in glass-stoppered bottles.

Phosphoric acid is intensely acid and irritant, but does not immediately corrode living tissues and coagulate albumin, as do the majority of the strong mineral acids. In any considerable quantity, however, this grade of the acid would prove a sharp, and very likely fatal, irritant poison if swallowed without

dilution. This strength of acid is rarely prescribed in medicine, being official simply as a convenient solution to be kept in stock by the druggist for the making of the following, the commonly prescribed preparation:

Acidum Phosphoricum Dilutum, Diluted Phosphoric Acid. This grade of the acid is compounded by mixing one part, by weight, of the foregoing strong acid with seven and a half parts of distilled water. The solution thus contains ten per cent. of orthophosphoric acid, and has the specific gravity 1.057. This acid resembles in general properties the other diluted mineral acids (see *Sulphuric Acid*), but is distinguished by having a pleasanter flavor (its acidity resembling that of the fruit acids) and by being, as a rule, better borne by the stomach than its congeners. It may, therefore, be used for the common purposes of the mineral acids, to allay thirst, improve digestion, repress tendencies to sour fermentation of the contents of stomach or bowels, and to check morbid sweating. By many it is further claimed that phosphoric acid, ingested, tends to revive an exhausted nervous system, to excite the sexual function, and generally to enhance nervous activity and power. By such claimants the acid is regarded as the therapeutic equivalent of uncombined phosphorus; but certainly it fails in that most pronounced therapeusis of free phosphorus, the frequent cure of neuralgia. A special claim for phosphoric acid, of capability to lessen the excretion of sugar in diabetes, is now generally abandoned. Diluted phosphoric acid may be given in doses of from twenty drops to a teaspoonful or more, three times a day, the dose to be largely diluted with water, or with syrup and water. The precaution obtaining with the giving of other mineral acids, of taking the draught through a tube and rinsing the mouth after the swallowing, need not be insisted upon in the case of this acid.

EDWARD CURTIS.
R. J. E. SCOTT.

Phosphoridrosis.—Luminous sweating is a decidedly rare affection. Cases have been reported in which this curious phenomenon was observed after the ingestion of phosphorus and the eating of phosphorescent fish. It is probable that the phosphorescence is due to bacilli; for several species of photobacteria have been found, most of them being derived from fish.

CHARLES TOWNSHEND DADE.

Phosphorus.—Phosphorus is official in the United States Pharmacopœia. It is a solid body, of the appearance and consistence of white wax. It has a peculiar and disagreeable odor. On exposure to air, it gives off white fumes, luminous in the dark and of a garlicky odor. Phosphorus is insoluble in water, but dissolves in 350 parts of absolute alcohol at 15° C. (59° F.), in 240 parts of boiling absolute alcohol, in 80 parts of absolute ether, in about 50 parts of any fatty oil, and very abundantly in carbon disulphide, the latter yielding a solution which must be handled with the greatest care to prevent danger from fire. If left exposed to the air, phosphorus takes fire spontaneously. Accordingly it must be kept carefully under water, in a secure and moderately cool place, protected from light.

Phosphorus exists in four allotropic forms: (1) *Yellow phosphorus*, which is the ordinary phosphorus of commerce. It is a yellowish, wax-like solid, is luminous in the dark, and gives off white fumes when exposed to the air.

(2) *White phosphorus*, which occurs as a white pellicle on the surface of yellow phosphorus when this latter is exposed to light under aerated water.

(3) *Black phosphorus*, which is formed when yellow phosphorus is heated to about 160° F. and suddenly cooled.

(4) *Red phosphorus*, which does not fume in the air, nor dissolve in the solvents of yellow phosphorus. It is not luminous at ordinary temperatures, and differs from the other varieties in not being poisonous and in being but little liable to cause injury by burning. It probably owes its non-toxic properties to its insolubility.

In its physiological relations, as in its chemical, phosphorus is unique. It is locally exceedingly irritant—even corrosive, although, strangely enough, in some experiments bits of solid phosphorus have lain embedded in the connective tissue of animals for weeks without exciting any local reaction. Ordinarily, however, upon skin or mucous membrane phosphorus in substance excites inflammation, possibly followed by ulceration and gangrene of the area exposed to contact. Even the fumes of phosphorus may inflame exposed mucous membranes, such as the conjunctiva and the mucous membrane of the mouth and respiratory tract, and inflame even to consecutive necrosis any accessible periosteum. Thus used to arise in match factories, in the days before the use of an allotropic form of phosphorus, cases of necrosis of the jaw, the periosteum being generally reached by the poisonous fumes through the avenue of some defective tooth. Taken internally, even therapeutic doses are very apt to irritate the stomach, as shown by loss of appetite, nausea, uneasiness, and even pain and tenderness at the epigastrium, or, in higher grade, by the additional symptoms of vomiting and diarrhea. Flatulence and eructations of phosphoreted gases are further disagreeable local effects of the medicine upon the digestive apparatus.

In therapeutic dosage in health there is ordinarily little obvious derangement beyond what may be a reflex of the gastric irritation set up by the drug; and, anatomically, the most striking result of the medication is a tendency toward increased development of bone. Cartilaginous epiphyses ossify with undue speed and completeness, spongy bone tissues increase in thickness, and compact bone in hardness. And there is a similar special tendency toward nutritive activity in nervous tissues. A special aphrodisiac action has been claimed for phosphorus, but in health it probably does not produce any direct aphrodisiac effect.

In overdoses phosphorus profoundly deranges nutrition, inducing fatty degeneration of glandular and other tissues, and hemorrhages. Death may result, or an impairment of health from which recovery is slow and difficult.

The therapeutic application of phosphorus is for the bettering of deranged conditions of the nervous and the bony structures. Thus it is among the standard remedies to try in neuralgia, but unless relief comes within forty-eight hours, the medicine will probably fail (Ashburton Thompson). In other nerve derangements it may be said, broadly, that in such as belong to the category of the naturally curable ones, recovery may perhaps be hastened by the use of phosphorus; but that in the incurable or difficultly curable nervous diseases the agent generally does little or no good. The high hopes at one time formed of the avail of phosphorus in such maladies as epilepsy and locomotor ataxia have utterly failed of realization; but in such conditions as so-called nervous prostration, or incipient dementia, the drug is often of distinct benefit. Similarly phosphorus has been praised in osteomalacia and in rickets.

In the matter of *dosage* there is much difference in the practice of different physicians. Some confine their dosage to gr. $\frac{1}{100}$ (0.0006), thrice daily, while others begin at once with gr. $\frac{1}{20}$ (0.003), given with the same frequency, and aim to increase to double the amount, under guidance of the effects wrought—curative to the disease on the one hand, or irritative to the stomach on the other.

Mode of Administration.—In general, phosphorus

must not be given in substance, no matter how extreme the subdivision, because of irritation. The most generally serviceable solvent is a fixed oil, freed from contaminating oxygen and water by a preliminary superheating. Squibb has strongly advocated cod-liver oil. Sweet almond oil is, however, the most generally selected of fatty solvents, and was formerly adopted by the United States Pharmacopœia as the basis of an official oily preparation. Absolute alcohol can be made the basis of an efficient fluid mixture. For pills of phosphorus the plan should be followed of dissolving the phosphorus in some fluid, which either itself hardens, by cooling, to a solid, or which, incorporated with some indifferent powder, will form a pill mass. The pharmacopœial procedure given below is probably as free from objection as any.

In whatever form or dose phosphorus be given, a cardinal rule is that the administration should never be upon an empty stomach, nor *immediately* after eating.

There is one preparation of phosphorus official in the United States Pharmacopœia:

Pilulæ Phosphori, pills of phosphorus. Phosphorus is dissolved in chloroform by gentle heat and the solution added to a mixture of acacia and althæa in a mortar. A littly glycerin and a little water are next poured on, and the whole is rapidly beaten to a pill mass, which is immediately cut up into the proper number of pills. Each pill is then coated with a solution of balsam of Tolu in ether, and when the coating is dry the pills are put up in well-stoppered bottles. These pills contain, each, gr. $\frac{1}{100}$ (0.0006) of phosphorus, and from one to five pills will constitute a dose.

Under no circumstances should phosphorus be prescribed as an ingredient of extemporaneous medicinal mixtures.

Zinc Phosphide: Zn_3P_2. A peculiar compound of phosphorus, which practically amounts to a medicinal preparation of the element itself, is what was formerly official in the United States Pharmacopœia under the title *Zinci Phosphidum*, zinc phosphide. This appears as a finely crystalline powder, or as crystalline lumps. It is gray black in color, with a metallic sheen on broken pieces, and gives faintly the odor and taste of phosphorus. It is insoluble in water or alcohol, but dissolves in sulphuric or hydrochloric acid, with evolution of hydrogen phosphide. Zinc phosphide must be kept in small glass-stoppered vials.

This compound is lacking in the vigorously irritant action of phosphorus, yet even in therapeutic doses may easily upset the stomach and even excite vomiting. From its ready decomposition by acids it yields, in the stomach, some medicinally active condition of phosphorus, and its administration is therefore followed by therapeutic results similar to those attained by the use of the uncombined element. Zinc phosphide contains one-fourth of its weight of phosphorus, and the dose therefore ranges from gr. $\frac{1}{10}$ to gr. $\frac{1}{4}$ (0.003–0.016). It may be given in pill form, and, unlike phosphorus, may be prescribed in combination with other medicines, avoiding only acids, which decompose it. After swallowing, however, the certainty of medicinal action will be enhanced by effecting this same decomposition through the agency of an acid draught, such as lemonade or a little vinegar. The most disagreeable features of the drug are a tendency to eructations of phosphoreted hydrogen and to disturbance of the stomach. With the larger of the doses mentioned above nausea is not at all unlikely.

EDWARD CURTIS.
R. J. E. SCOTT.

Phosphorus, Poisoning By.—The disappearance of yellow phosphorus matches from the commerce of the world as a result of statutes forbidding their manufacture, has relegated phosphorus to the class of poisons of little importance to the average physician. It is but a few years ago, however, that this substance occupied such an important position in our list of noxious materials that it is doubtful if there is another substance among the many common poisons which is of so much interest to the toxicologist as is phosphorus—an interest arising because of the desire to discover the mysterious causes of its insidious action on living organisms. Moreover, we meet with the anomaly that, unlike most of the other inorganic poisons, and especially arsenic, antimony, and nitrogen, members of the same group in the Periodic System, this element is toxic in its free or elemental state, while its compounds, save the hydrides of phosphorus and the phosphides of certain elements such as calcium and zinc, are practically non-toxic.

Phosphorus was unknown to the layman as a poison prior to 1830. Shortly after the popularization of matches, about the year 1833, the public became acquainted with its deadly nature, and poisonings by phosphorus became alarmingly frequent.

Yellow Phosphorus.—In water pure phosphorus is practically insoluble; in fact, it has been asserted that what are thought to be solutions are in reality colloidal suspensions or solutions of the vapor. In oils its solubility varies from 1 in 100, to 1 in 10,000 parts, according to the nature of the oil and various conditions, such as temperature, etc. In bile phosphorus is readily soluble, 100 parts of this fluid dissolving 15 to 25 parts.

Because of the low solubility of phosphorus in most of the fluids of the body, only slight action generally follows the ingestion of large fragments of this substance. When taken, however, in a finely divided condition the action is very violent.

Poisoning by phosphorus usually results from phosphorus pastes (vermin killers), or phosphorus oil (Oleum phosphoratum). Formerly most of the cases of acute phosphorus poisonings were the result of matches.

Matches.—The modern red phosphorus matches, invented by Böttger in 1852, are usually harmless, so far as poisoning by phosphorus is concerned, owing to the fact that they are made of non-toxic red phosphorus and an oxidizing agent, such as potassium chlorate.

Phosphorus pastes are employed for destroying rats and other vermin. Here the phosphorus exists very finely divided with flour, lard, and sugar or molasses as a basis. They contain, on an average, about two per cent. of phosphorus, but may contain as high as five per cent.

Phosphine.—The hydride H_3P is the only one of importance. One-fourth to one-half per cent. in air causes death in animals in twenty to thirty minutes, while 0.2 per cent. will produce symptoms of asphyxia in a few minutes. In man, when it is breathed in very small amount in air for any length of time, the symptoms closely resemble those produced by phosphorus vapors. It has been suggested that there sometimes results a reduction of phosphates to hydrides of phosphorus in the intestines by bacteria giving rise to a form of autointoxication similar to that met with in the case of reduction of sulphates to hydrogen sulphide. Some have even gone so far as to claim that acute yellow atrophy of the liver is due to this cause. This action of bacteria is well established for sulphur, arsenic, and antimony compounds; but although it is to be expected for compounds of phosphorus by analogy, all investigations have thus far given negative results with pure cultures of powerfully reducing bacteria, the reduction being carried only to phosphites.

Fatal Dose.—The weight of phosphorus which constitutes a fatal dose is quite uncertain. It seems

to depend, more than is the case with most other inorganic poisons, upon the nature of the material containing the poison, the state of division of the phosphorus, the nature of the material in the alimentary canal, and the idiosyncrasy of the individual.

In the case of Oleum phosphoratum it is probable that a dose of 500 to 600 milligrams (about gr. vij.–ix.) will almost invariably prove fatal.

Phosphorus itself, finely divided in hot water, has in a few instances been employed for homicidal and suicidal purposes. Although the smallest fatal dose recorded is about 8 milligrams (gr. $\frac{1}{8}$), this is abnormally low. It is believed that the toxic dose of exceedingly finely divided phosphorus is probably about 15 milligrams (gr. 0.23), and that the fatal dose lies in the neighborhood of 150 milligrams (gr. ij.–iij.). Recovery has followed a dose of over 300 milligrams. Occasionally cases are met with which seem to indicate that phosphorus may at times have a slight accumulative tendency.

Fatal Period.—Phosphorus must be classed as a slow poison. The usual period lies between one and four or five days, with most deaths falling on the second or the third day; yet life may sometimes be prolonged until the seventh day. Several cases of remarkably rapid death are recorded. Caspar cites the case of a young woman who took 194 milligrams (gr. iij.) of phosphorus in an electuary and died in twelve hours, while Habershon is authority for the statement that death has taken place in thirty minutes.

Symptoms.—In what may be called a typical case of acute poisoning, the victim first complains of pain in the throat; this pain extends downward with increasing severity, and is most marked in the epigastrium and abdomen. The tongue is enlarged and coated. Nausea sets in, followed later by vomiting of material of a mucous and bilious character. Very rarely at this stage is the vomit tinged with blood, but the ejected material is generally phosphorescent in the dark. There may be annoying eructations with an alliaceous odor and taste. Colic and diarrhea set in at this stage, in about thirty per cent. of the cases. The pulse may for a short period be accelerated with anaccompanying slight rise in temperature, but soon it becomes small, weak, slow, and often irregular. The temperature may fall as much as 3° or even 4° C. Respiration becomes slow, oppressed, and sometimes stertorous. This train of symptoms continues for from twenty-four to forty-eight hours when a period of apparent convalescence supervenes for two or three days; then suddenly, when all seems to be going well, the victim is stricken down with most alarming symptoms. Icterus appears, accompanied by hemorrhages, increasing in number and severity, in which practically all channels of elimination are affected. The ejected matters are bloody in character and may at times consist almost wholly of blood; there is bleeding at the nose and even at the ears, and in women there is almost invariably more or less uterine hemorrhage. Accompanying the hemorrhages are seen anemic cachexia and urticaria and a blotched skin. The eyes are icteric, blood-shot, and prominent. There may be, in the last stages of the disease, involuntary expulsion of urine and feces. The urine is apt to be suppressed, and when discharged or drawn will be found to contain albumin, peptones, hemoglobin, bile pigments, biliary acids, fibrin and hyaline cylinders, fatty droplets, often leucin and tyrosin, almost invariably sarcolactic acid, subnormal urea, and abnormal ammonium salts, phosphates, and sulphates. Death takes place in coma or syncope, occasionally in convulsions preceded by delirium.

In addition to the above-mentioned symptoms there is often quite marked paralysis of the voluntary muscles, especially those of the legs. Occasionally there is anesthesia of the lower extremities, but otherwise, there seems to be no loss of sensation.

Phosphorus cannot be classed, as is very evident from the above, as a rapid or even moderately rapid poison; and, on the other hand, evidence is lacking which would justify its being credited with any truly latent action.

Chronic poisoning is almost invariably the result of breathing air containing vapors of phosphorus, and is therefore seen in workmen engaged in industries using phosphorus, such as the manufacture of "sulphur" matches, phosphor bronze, etc. In the days of the extensive manufacture of sulphur matches chronic poisoning was so constantly met with, especially among workmen in the "drying rooms," that laws have been passed forbidding the manufacture of this kind of match.

Chronic poisoning is characterized by bronchial catarrh, chronic gastroenteritis, loss of appetite, constipation often followed by diarrhea, exquisite toothache, chronic periostitis passing into necrosis of the maxillary bones, cachexia, and fever. In general, we have all the symptoms of acute poisoning, but in much less violent form and coming on slowly and insidiously.

Usually it is the lower maxillary which is first attacked; but as the disease progresses both jaws become diseased. In the case of severe necrosis the mortality seems to range in the neighborhood of forty-five per cent. Workmen having carious teeth suffer most from maxillary necrosis. In fact, there is reason to believe that, in the absence of penetrating caries, necrosis of the jaw bones is rarely if ever met with. It has, therefore, become an established custom in all well-conducted phosphorus industries to employ only men and women having sound teeth.

Antidotes.—The most satisfactory chemical antidotes are copper sulphate, and oxidizing substances such as *old* turpentine, hydrogen peroxide, potassium permanganate, etc. In the case of acute poisoning administer copper sulphate, three grains every five minutes until the stomach has been sufficiently cleared. Follow this by one of the oxidizing agents, as, for example, old turpentine in emulsion, one dram every half hour combined with the inhalation of turpentine vapor, or wash out the stomach with 0.2- or 0.3-per-cent. solution of potassium permanganate, or with a 1- to 3-per-cent. solution of peroxide of hydrogen. The efficacy of copper sulphate depends upon its property of reacting with phosphorus to form an insoluble copper phosphide and in part to oxidize the phosphorus. With old (oxidized) turpentine a turpentine-phosphoric acid of low toxicity results, while with permanganate and peroxide the phosphorus is oxidized to non-poisonous phosphoric acid. Administer ice and cold demulcent drinks. The paralysis and the sinking of blood pressure must be counteracted by excitants. All substances and foods containing *fats or oils* must be forbidden.

Prophylaxis.—In all industries using phosphorus, exceptionally good ventilation is imperative. Every workman should be required to wash and bathe frequently and thoroughly, and especially always to wash the hands before eating. Medical examinations should be made compulsory at stated intervals, and all cases of sore mouth, toothache, etc., should be at once excluded from the workrooms.

Postmortem Appearances.—The appearances after death are striking and characteristic. Acute yellow atrophy and cirrhosis of the liver are practically the only diseases which yield lesions that can be confused with poisoning by phosphorus.

There is often corrosion and ulceration of the stomach and duodenum. The mucosa of the stomach is soft, swollen, mammillated, and degenerated.

The most characteristic feature, however, is the remarkable icteric condition and fatty degeneration of the liver and kidneys in particular, but also of the heart, of the glands of the stomach and intestines, and even of the muscles. Multiple hemorrhages are

sometimes found in the lungs, heart, and throughout the alimentary canal.

Although slow poisoning by ammonia, alcohol, arsenic, antimony, cyanides, sulphocyanates, etc., also gives rise to fatty degeneration, the steatosis is seldom so extensive, so marked, nor of so rapid formation as in poisoning by phosphorus. Cases are recorded in which death from phosphorus took place in forty-eight hours, yet in this short period there was marked steatosis of the liver, kidneys, heart, and glands of the stomach.

Mechanism of Action.—Because of the lesions and remarkable effects of phosphorus, this substance has long been a most interesting and fruitful field of research for toxicologists and pharmacologists, yet in spite of the many investigations the mechanism of its action is still an *ignis fatuus.*

Phosphorus seems to be resorbed without change and is carried by the blood either colloidal or the element is vaporized by the heat of the body and the vapor dissolved by the blood. It suffers, because of the high partial pressure of the oxygen in the blood, little or no immediate oxidation. The hypothesis that hydrides of phosphorus are formed and carried by the blood and are the primary cause of illness seems to be no more tenable than the oxidation theory.

It has been shown repeatedly that while from a chemical viewpoint phosphorus should not be able to exist as such for any length of time in arterial blood, not only is such the fact, but, as already stated, it suffers but little change.

All experiments go to show that phosphorus is to be classed as one of a group of poisons chiefly affecting the metabolism, of which group hydrocyanic acid, oxalic acid, and carbon monoxide are the other best-known types. Bauer has pointed out that the oxygen taken up and the carbon dioxide given off in acute poisoning are always abnormally low (eight to eleven per cent. CO_2 instead of twenty-four to twenty-seven per cent.), and that the respiration curve indicates a powerful disturbance of the metabolism. Moreover, this is further borne out by the fact that peptone-like digestion products are usually eliminated in the urine, that the urea is subnormal, and that the albumin of the food, and also to a certain extent of the organism, is decomposed, and goes to form fat, leucin, tyrosin, and probably sarcolactic acid. The decrease in the amount of urea has been explained on the theory that owing to the formation of acids (lactic acid?) a great part of the nitrogen, which would otherwise be converted into urea, goes to form ammonia to neutralize the acids. Because of this neutralizing action the alkalinity of the blood falls and probably countless blood corpuscles are destroyed; for this latter reason phosphorus is also classed, by some authorities, in the group of so-called "blood poisons." Following a destruction of the red blood corpuscles—which, it is assumed, takes place at some stage in poisoning by phosphorus—an abnormal secretion of bile pigments takes place. To account for the direct cause of icterus several theories have been advanced: one ascribing it to catarrh of the duodenum and cutting off of the ductus choledochus; another to the compression of the tiny bile ducts by the swelling of the liver; still another that the mucosa of the biliary passages becomes diseased, and that there is finally a clogging of these passages through fatty degeneration and rupture of the walls of the vessels. It is likely that all these causes contribute to the retardation of the flow of the bile, and that this fluid overflows into the lymphatics.

Selmi has succeeded in isolating toxic compounds from the urine, and has given them the name phosphoptomains, while Van den Corput has called them toxicomains. According to this latter investigator most of the ill-effects of phosphorus are due to the formation of these retention toxicoses.

No satisfactory explanation of the cause of the corrosion and ulceration of the mucosa of the alimentary canal has yet been found.

As to phosphorus necrosis, little can be said save that it follows periostitis. It is not the mineral stroma which is attacked, but the cells of osseous tissue.

Clinical Tests for Phosphorus.—Expose to the vapors given off from the warmed material two strips of filter paper, one of which has been moistened with silver-nitrate solution, the other with lead-acetate solution. If phosphorus is present, the silver paper blackens while the lead paper should remain unchanged. If both papers blacken, hydrogen sulphide is present and must first be removed before testing. In such an event add to the material to be tested sufficient lead-acetate solution to precipitate all the hydrogen sulphide as lead sulphide, and test with the two papers as before. The blackening of the silver-nitrate paper is due to the formation of silver phosphide and metallic silver.

If possible the suspected material should always be tested in the laboratory by the Mitscherlich distillation method.

There are reasons for believing that phosphorus can exist in the cadaver in the free state for about eight weeks. After twelve weeks it can still be detected in the form of phosphorous acid, but after about fifteen weeks it is probable that all the elemental phosphorus has been oxidized to phosphoric acid.

EMILE MONNIN CHAMOT.

Phototherapy.—The therapeutics of radiant light and heat. The luminous sources of radiant energy as employed in therapeutics are the sun, the electric arc, the incandescent lamp, and the mercury vapor lamp. Light is defined as an ether vibration of varying rates of very high frequency as included in the solar spectrum—the visible frequencies—the prismatic colors—ranging from red to violet, with the invisible spectrum—the infra-red or so-called heat rays and the ultra-violet or radiations of high frequency. The invisible spectrum in the higher frequencies, the ultra-violet, is demonstrated on the photographic film as a wide band of nearly one-half the width of the visible spectrum and producing marked effects upon the silver salts, for which reason they have been termed the chemical rays.

The infra-red rays are demonstrated by the heat produced upon the thermostat and are in width nearly equal to the width of ultra-violet. The spectrum of the electric arc is practically the same as that of the sun's light, though richer in the ultra-violet frequencies, and may be rendered still more intense in the higher frequencies by the use of iron electrodes, or iron-cored carbon electrodes.

The incandescent lamps are of two types: the tungsten, which is rich in luminous frequencies but relatively low in the frequencies of the infra-red; and the carbon-filament lamp which is rich in the lower frequencies and less intense in the higher and luminous frequencies. The glass incandescent bulbs do not permit the passage of the ultra-violet rays and are used only for the effects of the luminous and thermic radiations.

The mercury vapor lamps of the Kronmayer type, provided with rock crystal windows, are practically devoid of infra-red but very rich in the ultra-violet and violet radiations.

These various sources of light are each rendered valuable for some specific purpose in therapeutics. The effects of radiant energy, which are important in therapeutics are, (1) the production of heat far into the tissues, (2) the luminous effects, and (3) the limited antiseptic action of the ultra-violet.

The law of penetration is that "the penetration of the different radiation is relative to the wave length and inversely as the frequency." The exception to this

law as it pertains to the ether vibrations is the *x*-ray which goes straight on with great penetrating power being neither reflected nor refracted.

The transformation of radiant energy into heat is the important physical operation upon which its greatest value in therapeutics depends as well as in nature.

The physics of heat recognizes it as a molecular motion in matter of a requisite amplitude and intensity. When radiant energy from luminous sources in the form of ether vibrations falls upon inert matter through which it does not penetrate, as it does through the air and water, it sets up molecular motion in such matter and heat is produced. Then transformation of energy takes place and the intense ether vibrations of high frequency are converted into heat, in matter. It is a process of transformation of energy—a stepping down process—which converts light and the radiations of the invisible spectum into units of heat, and is usually termed absorption.

This transformation suggests strictly the substance of the ether, the corpuscular theory of light and possible correctness of the theory of Sir Isaac Newton.

The effects of heat produced by radiation upon the human body must be considered from (1) the standpoint of penetration and transformation of energy with the production of heat in the tissues, (2) the complex operation of circulation through the stimulation of the vasomotor mechanism by the action on the end organs, (3) from the effects other than heat upon the tissues, and (4) from the effects upon micro-organisms in the tissues.

The different frequencies of radiant energy must be recognized as varying in their effects produced upon the tissues. While all produce heat the greater heat effects come from the lower frequencies, the infra-red, and are diminished as the frequency increased in the ascending scale of the spectrum, as the wave length diminishes. The ultra-violet of the highest frequency and shortest wave length produces practically no heat and no power of penetration except under conditions of great volume, and with the tissues rendered anemic by pressure, and then not to the deeper layers of the skin.

The effect of heating the tissues is to increase their vascularity. The harmonious workings of the vasomotor mechanism whereby, when heat is applied, the vessels dilate and greater volumes of blood pass through the heated tissues and carry away the excess of heat, maintain a normal temperature up to the maximum capacity of the channels of circulation to convey the heat away. The heated blood passing on sets up a general glow of warmth throughout the organism, which produces general activities with the induction of perspiration, which will maintain an equalization of temperature.

By this process valuable effects upon sluggish metabolism are produced: (1) the local hyperemia induced at the site of application produces remarkable effects upon local metabolism; (2) waste matter is eliminated; (3) active tissue repair is carried on with general improvement of local tissue resistance; (4) the influx of a greater volume of fresh arterial blood furnishes the material for tissue building; and (5) the presence of a greater number of leucocytes and lymphocytes renders infection impossible, and, where already present, destroys the germs. The normal functions are thereby restored or rendered more active. There is no agent more effective in the production of superficial hyperemia, and hyperemia produced in no other way is more beneficial than that produced by radiant light and heat.

The actinic effects of light reside chiefly in the higher frequencies, particularly in the ultra-violet range of the spectrum. It performs valuable service in Nature, purifying the air and water from germs. It is an important observation that if sunlight is to render valuable service for sanitation it should enter the room of the house through the open window as glass filters out the rays which produce this valuable antizymotic effect.

Heliotherapy.—The employment of the sun's rays in therapeutics dates back to the earliest times when it was made use of in solaria and sun baths on the house tops, the ancient Greeks and Romans employing it as a hygienic routine. The uses of the sun's rays in therapeutics for treatment of special conditions, however, belongs more particularly to the eighteenth century.

Finsen began with the successful treatment of lupus vulgaris and lupus erythematosis, employing the sun's rays; but he soon adopted the electric arc which produces radiation of practically the same character as the rays of the sun and richer in the ultra-violet frequencies of the spectrum. More recently the employment of the sun's rays by Dr. Rollier in Switzerland for the open air treatment of tuberculous joint, affections in children, has been one of the most important advances in modern therapeutics (see article *Heliotheraphy*).

The use of the mercury vapor lamp, the specially constructed lamp of Kronmayer, in which the rays are passed through a window of rock crystal, the crystal not filtering out the ultra-violet rays has made it possible to project intense radiations very rich in ultra-violet rays, more so than from the sunlight or focussed arc as employed by Finsen or with the so-called London Hospital lamp. With this lamp it is possible to produce very violent reactions from short exposures. It is possible to affect under pressure not only the outer layers but the deeper structures of the corium, thereby sterilizing and when desirable destroying the diseased tissues. Under such heroic plan of operation, a slough of the external diseased tissues is produced, which is soon replaced by new tissue free from disease. The treatment seems rather heroic, but under careful management and skilful technique it is possible by this means to remove angioma, rosacea, patches of lupus, and similar conditions in a practical manner. Its use, however, is limited to this class of cases.

The work of Dr. Schuyler Clark of New York in the treatment of lupus erythematosus and lupus vulgaris, and that of Dr. William L. Clark of Philadelphia, in the treatment of lupus and angioma have established the value of this lamp. Their work seems to have demonstrated beyond question the practicability of this method of treatment in the class of cases referred to. The writer is also employing it with success in the treatment of tinea tonsurans, and believes that it is applicable to the treatment of all superficial fungoid affections, removing the disease without destroying the hair follicles, as is done by the *x*-ray. It is necessary to carry it to the point of reaction when the fungus may be promptly destroyed. It has also been claimed that this agent, a special mercury vapor lamp being employed, has been valuable in stimulating the hair growth in alopecia.

The field of greatest value in the employment of radiant energy is in the use of therapeutic incandescent lamps. Suitable lamps of 500 candle power and less are made for this purpose. The lowest power of practical utility seems to be the fifty candle power stereopticon lamp provided with a parabolic reflector, having the bulb so placed that it reflects parallel rays. Lamps of higher candle power employ both the tungsten and the carbon filaments, the relative value of which will depend upon the condition for which they are employed. In skin diseases, and other superficial conditions, the tungsten lamp will be adequate and effective; but as this lamp produces few of the rays of lower frequency—the infra-red rays—they will not penetrate to relieve the deeper seated condition, whereas the lamps provided with the carbon filament produce radiations rich in the infra-red and the other lower frequencies, which penetrate, according to Kellogg, to a depth of fully six inches.

The principles of therapeutic action of these radiations are, first the induction of hyperemia by the heating of the tissues through which they penetrate, by the transformation of radiant energy into heat units. The greater intensity of heat with all lamps is nearest the surface; but as the rays penetrate, spending their energy as they pass inward, considerable hyperemia is produced at depths of at least two to four inches which must be attributed chiefly to the infra-red rays. The effects which are more or less deleterious to germ life are from the luminous rays and higher frequencies. It is a well-established fact that certain bacteria will not develop well in culture media in a light room, and such germs are correspondingly affected by the luminous rays of light.

The principle of action of hyperemia as produced by light or other means is one of the most interesting subjects in therapeutics and one to which due attention has not been given. The methods of Bier as published do not compare favorably, however, with the employment of radiant light and heat and the d'Arsonval current.

Hyperemia as produced by the thermic methods has three important influences upon tissues; (1) the increased flux of blood into a part in which metabolism is impaired when induced by heat is followed by a prompt institution of active circulation and local cell activity. In other words, the tissues are so induced to take on greater activity that sluggish functions are accelerated locally under the application of radiant light and heat. The administrations should be prolong corresponding to the requirements of the condition. The employment of radiant energy should be considered as fraught with no danger whatever to the tissues if employed within the toleration of the skin to the temperature employed. (2) With the hyperemia produced there is a corresponding increase of nutrition conveyed to the part. (3) The increased quantity of blood conveys to the tissues an increased number of phagocytes which thereby increase the local tissue resistance, warding off an infection, and when infection is present, serving to destroy the germs and terminate the process in many cases of pyogenic infection.

It will be readily seen from the foregoing that the field of indications for the employment of radiant energy is very large, both for the relief of conditions of defective metabolism and also when infection is present. It is from this point of view that the value of radiant energy must be recognized. The intelligent layman, who learns the value of the small therapeutic lamp for the relief of aches and pains, and of the infections which arise, will become infatuated with it. In the family it entirely replaces the hot-water bag and the electric heating pad, when the commercial electric current is at hand.

The beneficial effects to be derived form the use of radiant energy are attributable more largely to the thermic effects, than to the luminous effects; and we repeat that for this reason the carbon filament incandescent lamp is of far greater value than the tungsten lamps for most therapeutic purposes.

In the treatment of *streptococcic and staphylococcic infections*, radiant energy is found to be one of the most important means. The results depend upon the three conjoint therapeutic effects of the radiations, increased nutrition, increased metabolism, and increased phagocytosis.

In *carbuncles*, radiant light and heat alone may be sufficient to abort the condition if applied in the very early stages for long periods—one or two hours. The joint use of the Röntgen ray, employing a massive dose, to be followed after twenty-four hours by one-hour applications of radiant light and heat at least twice daily will effectively abort the condition before pus has formed, in forty-eight hours. On the same principle, *boils, whitlows, felons, suppurative tonsillitis*, and *small abscesses* may be aborted in their early stages. In *sinus and antrum disease* and, in *otitis media*, acute or chronic, there is probably no agent more efficient than one-hour applications of radiant light and heat; the applications being made twice daily to advantage, and oftener in acute cases. It is possible by this means, wherever drainage is present, to relieve a chronic process when necrosis is not the cause. In acute cases after evacuation recovery is hastened by the same means.

In *tuberculous peritonitis* and other tuberculous conditions light is remarkably efficacious. It is usually customary, however, to precede the use of light by the use of the Röntgen ray, not on the same day, but for a period of time for sterilizing the germs, preceding the institution of applications of radiant energy. In tuberculous patients the employment of radiant light and heat for long periods over the abdomen for the purpose of improving the metabolism of the intestinal tract and thereby improving the general nutritive processes of digestion, absorption, elimination, and peristalsis, is invaluable even though other means are used for the treatment of local tuberculous condition.

In *intestinal stasis*, usually associated with a large measure of infection, long applications of radiant light and heat not only lessen the infection as present but also promote an increased peristalsis and muscular tone, and improve the secretory and excretory functions of the intestinal tract. Probably there is no agent which contributes more to the successful treatment of intestinal stasis, when properly employed, than daily applications of radiant light and heat. In childhood in the treatment of intestinal atony or constipation radiant light and heat alone will generally serve to institute the normal process of function of secretion, excretion, and peristalsis. In children no other method may be required, except the systematic regulation of diet. Each application should be made to the extent of producing a marked intense hyperemia over the abdomen, always employing the carbon filament lamps to insure penetration to the deeper parts. In the various toxic conditions in adults, and of children as well, long light applications over the abdomen are particularly valuable together with the adoption of other mechanical measures and diet.

In *chorea, epilepsy, endocarditis*, and *nephritis* in childhood there is probably no agent which serves better than prolonged applications of radiant light and heat to remove the causes by elimination and correction of metabolism. So also in the infectious stage of *anterior poliomyelitis* long applications of radiant energy to the whole body produce hyperemia adequate to cause a draught of blood from the congested areas to the skin.

In *lowered states*, where a weak heart and the impaired respiratory function indicate impairment of the cardiovascular respiratory centers, the peripheral applications of radiant light and heat will stimulate these functions to greater activity and, therefore, constitute an important part in the treatment of these cases.

In *rheumatoid arthritis* and other of the toxic arthroses of intestinal origin, long application of radiant light and heat to the abdomen together with the correction of diet are invaluable. It is not possible or reasonable to expect to accomplish a cure of arthritis from any cause unless the local causal conditions are removed and the exudation, which has formed during the active process is removed from the infiltrated tissues. There is but one agent that can be depended upon to effect the removal of exudation present with arthritis and that is the static current, properly employed which effectually removes the local stasis and infiltration, thereby relieving the pressure and pain and discomfort of the sufferer.

In *phlebitis and varicose ulcers* long applications of radiant light and heat form a very important part of treatment, and though not so efficient when employed alone as when used in conjunction with the static

brush-discharge, give greater relief than wet dressings or other external applications.

In *early local neuritis* before the establishment of a marked degree of exudation and infiltration it may be possible to relieve the condition with radiant light and heat, though in no case of any length of duration can it cure the condition, though relieving the local pain which effect is but temporary in character.

One other valuable use of radiant light and heat is in the treatment of *x-ray dermatitis*, that is, in the cases that arise in the course of treatment. When employed with sufficient energy prior to the ulcerative stage of an *x*-ray dermatitis, ulceration may in all cases be prevented. It requires prolonged applications, however, to offset the serious forms of *x*-ray dermatitis. After the ulcerative stage it is of comparatively little value at first as the slough must be removed before any active restitution can take place; that accomplished, however, there is probably no agent more effective in bringing about restitution than radiant light and heat.

The treatment of coryzas, colds in the head, or even chronic nasal catarrh, or laryngitis by prolonged use of radiant light and heat applied to the extent of toleration, that is, as hot as can be tolerated with the lamp suspended over the patient reclining, is remarkably effective. It will rarely require more than two such applications with a 50 c.p. therapeutic lamp to abort entirely an acute coryza.

In *acute laryngitis* the additional use of the static wave current will add greatly to the promptness of cure of the condition.

The incandescent light bath in conditions of *hypertension* and general depression of metabolism is one of the most useful means that can be employed, and properly belongs in the home of aged people and of those who wish to preserve their vigor and youthfulness. Light baths, taken daily or every alternate day, after the day's fatigue is refreshing and delightful. This followed by a shower, before retiring will insure in most cases a quiet slumber. By reducing the amount of fluid by perspiration and by relaxation of the peripheral arteries it affords great temporary relief in conditions of hypertension.

There are many other similar conditions which may be treated successfully with radiant light and heat. The foregoing, however, outlines the general principles, and the classes of cases in which they are indicated.

WILLIAM BENHAM SNOW.

Phrenic Nerve.—ANATOMY.—The phrenic nerve, or the internal respiratory nerve of Bell, is the principal motor nerve of the diaphragm. It originates in the ventral gray column of the spinal cord from the middle of the third to the sixth cervical segments. Its fibers leave the cord mainly in the fourth cervical roots, with usually some additions from the third or fifth root or both of these. Schroeder and Green give its origins as follows:

	Number of cases.	Fourth only.	Fourth and fifth.	Third, fourth, and fifth.	Third and fourth.
Luschka	32	12	7	7	6
Brook	16	4	9	3	0
Green	52	9	21	13	9
Total	100	25–25%	37–37%	23–23%	15–15%

When there is a single root, it is always from the fourth nerve.

The course of the nerve is somewhat different on the two sides. It passes downward in the neck over the scalenus anterior muscle; then diagonally downward and outward, it passes in front of the first part of the subclavian artery and behind the subclavian vein. In about four per cent. of cases, however, the nerve passes in front of the vein, and so lies immediately behind the clavicle. Two cases are on record in which the nerve passed through the vein. Passing into the thorax it lies, on the right side, external to and slightly behind the right innominate vein and the superior vena cava; on the left side, in front of the arch of the aorta. On both sides it passes between the pleura and the pericardium, anteriorly to the roots of the lungs; on the right side being in close contact with the root, and on the left side passing out and to the left, in order to pass around the heart. The right nerve has an almost vertical direction, and passes to the upper surface of the diaphragm, where it divides into from three to six branches, which pierce the diaphragm externally to and in front of the opening for the inferior vena cava. The left nerve has a more circuitous route, and generally divides in the substance of the diaphragm.

Branches.—1. Communicating: (1) From the upper ganglion of the cervical sympathetic gangliated cord. (2) Occasionally, from the loop formed by the descendens and communicans hypoglossi. (3) From the nerve to the subclavius. (4) The right nerve, at its termination, sends branches to the right semilunar ganglion of the celiac plexus. (5) The left communicates with the sympathetic plexus to the esophagus above the diaphragm.

2. Distribution: (1) On the right side, to the superior vena cava. (2) Pleural branches, from one to three in number. (3) Branches to the pericardium, usually three. (4) Luschka has described twigs to the right auricle. (5) Terminal branches to the diaphragm. This is the main distribution of the nerve. It supplies the entire diaphragm except an area along the costal margin, about three centimeters in width, which is supplied by the lower six intercostal nerves, and an indeterminate area on the crura, probably supplied by the vagus.

The innervation of the diaphragm by the phrenic nerve from the cervical spinal cord at a level above that from which the intercostal muscles are innervated (thoracic cord) is explained by the evolutionary history of the diaphragm, viz., its origin from muscles lying in the cervical region in Amphibia.

The phrenic nerve contains large and small myelinated fibers and also unmyelinated fibers. The motor end-plates in the diaphragm resemble those of other voluntary muscles (Aoyagi). Sensory fibers are known to occur in the phrenic nerve (see the review by L. J. Kidd in the *Review of Neurology and Psychiatry*, vol. ix., 1911, p. 587), and referred pains in the shoulder are frequent in visceral disease affecting this nerve. Nevertheless the stimulation of the central end of the divided phrenic nerve within the thorax of the rabbit causes no reflex movements of any sort (Porter and Turner, *Am. Jour. Physiol.*, vol. xxxii., 1913).

PHYSIOLOGY.—The chief physiological function of the nerve is that of the principal motor nerve supply to the diaphragm.

PATHOLOGY.—1. Paralysis of half of the diaphragm, as a result of inflammation or degeneration of the phrenic nerve on the corresponding side, from exposure, lead poisoning, or compression, may occasionally occur. The condition generally comes on slowly and is characterized by inversion of the type of respiration, which reduces intraabdominal pressure, causing difficulty in defecation, etc. Respiration is usually affected only during exertion, when dyspnea results.

2. Neuralgia. Some authorities describe a form of neuralgia characterized by pain in the lower and anterior part of the thorax, along the line of diaphragmatic attachment, extending up into the neck and along the inside of the arm, with painful areas at the points where the nerve becomes superficial. This

condition is said to complicate angina pectoris, Graves' disease, and some forms of cardiac disease.

3. Surgical Pathology. Injury to or division of the nerve may occur in gunshot wounds or stab wounds, or in the course of surgical operations. This complication has generally been regarded as fatal, and the statement has been generally made in the surgical literature that it is necessarily so. Schroeder and Green after a review of the literature show that there are only six cases on record in which the nerve was injured. In all other cases, usually reported as injuries of the phrenic nerve, an examination of the original article shows that some other adjacent structure had been injured instead of the phrenic. Of the six cases of actual injury to the nerve, in the first four (those reported by Schurmayer, Beck, Bardeleben, and Erichsen) there was also injury to some other important structure, which was alone sufficient to cause death. Of the two cases of injury to the nerve alone, the first (reported by Mackenzie) was instantly fatal. The second (reported by Schroeder in 1902) ended in recovery, with paralysis of the corresponding half of the diaphragm. Mackenzie's case was that of an Indian coolie, who suddenly fell dead, and on postmorten examination the reporter was unable to find any sufficient cause of death, except a rupture of the right phrenic nerve. It hardly follows, however, that the rupture of the nerve was the cause of death.

Schroeder's case, then, is the only one on record in which the phrenic was injured without injury to surrounding structures, and in which the exact extent of the injury was known. Schroeder and Green report the following experimental researches and summary:

1. On the Human Being. In eighteen cases of tuberculous glands of the neck, the nerve was pinched during operation with the following results: Contraction of the corresponding half of the diaphragm, with sudden rising of the anterior abdominal surface below the costal arch. In ten cases the right nerve was pinched and the left in eight. In one case on each side there was some pain in the region of the diaphragm, but it subsided in forty-eight hours. The symptoms usually attributed to irritation of the diaphragm (*i.e.* sneezing, coughing, and hiccoughing) were not observed in a single instance.

2. On Dogs. In the course of an extended series of experiments on dogs, the following results were obtained: After resecting as much as possible of the cervical portion of the nerve, it was found that after resection of one nerve only, there was an increased thoracic expansion and a slight abdominal retraction, changes which were more evident on the divided side than on the normal side. In case of a double resection there occurred an inverted type of respiration, *i.e.* decided retraction on inspiration and increased thoracic expansion, due to the action of the accessory respiratory muscles. In unilateral resection kymographic tracings showed that the normal half of the diaphragm rose half an inch on inspiration and fell the same distance on expiration, while the half of the diaphragm on the side on which the nerve had been resected moved only an eighth of an inch, as it was moved passively by the movements of the normal side. After division of the nerve, the diaphragm becomes relaxed and the muscle arches up into the thorax. The type of respiration becomes increasingly costal when one nerve is divided, and inverted when both nerves are cut. The accessory respiratory muscles become very active. There is no sneezing or coughing. In one case of double division the respiration became labored, but remained so for only a few days.

Postmortem Findings.—In cases in which the dogs were killed in from seven to fourteen days after resection of the nerve, the atrophy of the diaphragm was not great and the color was reddish yellow. When a longer time had elapsed, the atrophy was marked, the paralyzed part being thin and flabby, the color pale yellow, and in older cases translucent. In all cases there remained a margin from one-quarter to three-eighths of an inch in width at the costal border, which retained its normal color and thickness. This margin is supplied by the intercostal nerves.

Summary.—1. From clinical, experimental, and anatomical data it would seem that the diaphragm is not an essential muscle of respiration, and that the importance of injury to its principal nerve, the phrenic, has been exaggerated. Injury to the phrenic or division of one nerve is not necessarily fatal. It may, however, predispose to lung infection or be followed by diaphragmatic hernia.

2. While the diaphragm is supplied with branches from the lower six intercostal nerves, they are inferior to the phrenic in importance and unable to take the place of the phrenic after division of the latter.

A bibliography of fifty-nine titles is given in the article from which the preceding summary is taken (W. E. Schroeder and F. R. Green, Phrenic Nerve Injuries, *Am. Jour. of the Medical Sciences*, N. S., vol. cxxiii., p. 196, 1902). C. Judson Herrick.

Phrenosin is a cerebrin present in the nervous tissues which is probably identical with cerebron. See *Cerebrosides*. F. P. U.

Phthirius.—A genus of lice which contains *P. pubis* (*P. inguinalis*), the crab-louse. This insect usually infests the hairs of the pubic region, but may be found in the arm pits, or even in the beard, moustache, eyelids, or scalp. It is usually eliminated without difficulty by the use of mercurial ointment. See *Insects, parasitic*. A. S. P.

Physaloptera.—A genus of roundworms. Two species have each been reported once as parasites of man: *P. caucasia* in the Caucasus, *P. mordens* in Unganda. See *Nematoda*. A. S.P.

Physick, Philip Syng.—Born in Philadelphia, Pa., July 7, 1768. His early medical studies were prosecuted in his native city, but in 1789 he went to England and placed himself under the instruction of John Hunter, in London. Living, as he did, in the home of this great physiologist and surgeon, and being of an observant type of mind, he rapidly absorbed the best anatomical and surgical knowledge that was obtainable in London at that time. In 1790 he was given the post of House-Surgeon at St. George's Hospital, and remained on duty at that institution for one year. In May, 1792, he received the degree of Doctor of Medicine from the University of Edinburgh, and in September of the same year he returned to Philadelphia, and began the practice of his profession. In 1794 he was elected one of the attending surgeons of the Pennsylvania Hospital, and in 1805 he was given the independent Chair of Surgery in the University of Pennsylvania. This was the first separate Professorship of Surgery established in America, and Dr. Physick held the position during the following thirteen years. His success as a teacher of surgery was great, and justified fully the appellation of "Father of American Surgery" which was afterward bestowed upon him.

One of the most important contributions made by Dr. Physick (about the year 1800) to surgical therapeutics was his method of treating hip-joint disease. He died at his home in Philadelphia on Dec. 15, 1837. During a large part of his life he had been a frequent, almost a constant, sufferer from a variety of bodily ills. A. H. B.

Physostigma.—Calabar Bean, *Ordeal Bean, Chopnut.* "The seed of *Physostigma venenosum* Balfour (fam. *Leguminosæ*), yielding, when assayed by the U. S. P. process, not less than 0.15 per cent. of alkaloids soluble in ether" (U. S. P.). This plant is a large, climbing, perennial vine, with trifoliolate leaves and the general appearance of an enormous bean vine. The stem is woody below and often as large as the wrist. The showy purple flowers are nearly as large as those of the sweet-pea, and hang in loose racemes. The large pods contain two or three seeds each. The "beans" are very hard, oblong, slightly curved or kidney-shaped, from 2 to 3 centimeters in length, and about 1.5 centimeters broad (0.75 to 1.25 inch by 0.5 inch), and covered with a roughish but shining chocolate-brown or brownish-red testa. A broad, shallow, black groove or furrow extends along the convex border and around one end of the seed; it contains the raphe. The kernel is exalbuminous and consists mostly of the two large, white, brittle cotyledons, whose faces are concave and enclose an air space which enables the entire seeds to float upon water, although when broken the fragments are denser than water. The taste and odor of the seeds are simply bean-like, and give no suggestion of the deadly poison which they contain.

The plant grows about the mouths of the Old Calabar and Niger rivers in tropical West Africa. It has been transplanted to India, Brazil, and other places, where it flourishes. Physostigma is an ingredient of the poisonous mixture which persons accused of witchcraft or crime are compelled by the savage chiefs of these African tribes to take as an ordeal or punishment. The draught is usually rapidly fatal, unless vomiting occurs, this being greatly promoted by drinking water. It was first known in England about 1840 as a curiosity and poison, but not much employed in medicine until Fraser, of Edinburgh, about 1863, discovered its specific power of contracting the pupil, since when it has been in rather frequent use by oculists and in occasional use in internal medicine. Besides forty-eight per cent. of starch and about twenty of albuminoid matters, with a little oil and gum (substances which are contained as well in the common bean, and which are entirely inert), the drug in question contains three alkaloids, with *physosterin*, a fatty or cholesterin-like substance, which occurs in the Calabar bean in common with other leguminous seeds, and which is inert.

Physostigmine or *eserine* is the principal alkaloid. *Calabarine* is apparently a derivative of the former, while eseridine can be converted into physostigmine. The action of physostigmine dominates that of the drug, especially as that of eseridine is very similar. Calabarine acts antagonistically to the others, but is in such small amount as not greatly to modify the drugs's action. The action of Calabar bean will therefore be discussed under *Physostigmine.*

It has been rather thoroughly experimented with for its depressing action upon the nerve centers in various diseases involving central excitability, and especially in tetanus; but the results cannot be regarded as encouraging. Some benefit has resulted from its use in checking the paralysis of insanity, and it often does good as an intestinal laxative. We have an official extract, the dose of which is 0.006 to 0.03 gram (gr. $\frac{1}{10}$ to $\frac{1}{2}$), and a ten per cent. tincture, the dose of which is 0.6 to 2 c.c. (♏x. to xxx.).

Physostigmine or *Eserine* ($C_{15}H_{20}N_3O_2$). The chemistry of this alkaloid, and its relations to the bodies associated with it, are but imperfectly known. Formerly, the two names were believed to represent two alkaloids, but it was subsequently ascertained that one was merely an impure form of the other. It is almost always used in the form of its salts. The pure alkaloid occurs in the form of colorless crystals which are soluble in both alcohol and water, slowly in the latter. They are very hygroscopic and quickly lose their characters if exposed to dampness or light. Of the numerous salts, the most important are the hydrochloride, sulphate, and salicylate, the two last being official. The sulphate $(C_{15}H_{21}N_3O_2)_2,H_2SO_4$, a white or whitish crystalline powder, which is the salt most used, is very soluble in both water and alcohol. The salicylate, $C_{15}H_{21}N_3O_2,C_7H_6O_3$, in white crystals, is less soluble, namely, in 150 parts of water or twelve parts of alcohol. The hydrochloride, $C_{15}H_{20}N_3O_2$-HCl, is soluble in water.

Action.—The physiological action of eserine is powerful and characteristic, and has been very extensively studied. Except in large poisonous doses, its chief action is upon the secretion and involuntary muscular movements, through the cells and fibers, or their nerve endings, or both. The secretions of the entire alimentary system, excepting perhaps the bile, are markedly increased, in which particular a close similarity to pilocarpine has been noted. The perspiration and tears share in this increase. At the same time, the activity of the gastric and intestinal muscles is greatly augmented also. The effect upon the stomach may be such as to cause vomiting, especially by large doses, poisoning being thus avoided. More or less nausea is frequent. If vomiting does not occur, then purgation may, owing to a similar effect upon the intestinal muscles, combined with the increased secretion. Looseness of the bowels is an ordinary symptom. Uterine contractions may be induced. Coincident with these effects, and evidently of the same general nature, is the contraction of the pupil and ciliary muscle. In all these directions, the drug is directly antagonistic to atropine, and one drug can be used to counteract the other, to a great extent. Strychnine, while directly antagonistic to physostigmine in its central effects, strangely enough produces, through the spinal centers, many symptoms similar to those produced by the latter through peripheral action. In the voluntary muscular system, there is increased irritability of the fiber, and apparently stimulation of the nerve endings also. This produces muscular twitchings among the most prominent of the early symptoms of poisoning. It is apparently due to bronchial spasm that respiration is slightly interfered with. This interference acts as a respiratory stimulant, and the respirations are early increased both in number and force. At the same time there is a marked rise of blood pressure, though this is quite irregular. The heart is continuously and powerfully slowed from the start, due apparently to direct action upon it, but the beat is strong. There is the widest disagreement as to whether primary central stimulation occurs and is partly responsible for these symptoms. Whatever may be the primary central effect, depression of the motor centers is early and powerful. If the dose has been large, and is not vomited, paralysis may be very sudden. There may then be almost no preliminary symptoms, or the muscular twitchings may amount almost to convulsions. With increasing cardiac slowness, weakness and reduced blood pressure supervene; but this effect is not so marked as respiratory depression, which is the immediate cause of death.

Uses.—Physostigmine salts have been used, as already stated, for the same purposes as Calabar bean, in doses of gr. $\frac{1}{60}$ to $\frac{1}{20}$ (0.001 to 0.003). Their hypodermic use, as a purgative, is often very serviceable. Their chief use, however, is for instillation into the eye, in solution of one per cent. strength or weaker. The effect is to produce, at the end of a half hour, a very powerful contraction of the pupil, which lasts for ten or twelve hours, and markedly to decrease intraocular tension, after a brief increase. It thus becomes of service in overcoming the interference with vision induced by the use of atropine. Efforts

have been made, with some success, to destroy iritic adhesions by its use.

Pseudo-physostigmine is an alkaloid having apparently the same composition and properties; it is derived from cali-nuts or false Calabar beans, the botanical origin of which is doubtful.

HENRY H. RUSBY.

Phytin or *inosite-phosphoric acid*, is a substance occurring widely distributed in the plant kingdom which may be extracted from seeds by dilute acids. On decomposition it yields phosphoric acid and inosite. The term "phytin" is a trade name for the calcium compound.

For literature see Rose, A. R.; Biochemical Bull. 1912, 2, p. 21. F. P. U.

Phytolacca.—POKEROOT.—*Phytolaccæ radix*, and *Phytolaccæ fructus*, Scoke, Garget. These two drugs are defined respectively as "the dried root" and "the fruit" of *Phytolacca decandra* L. (fam. *Phytolaccaceæ*).

This plant is a very large perennial herb with a thick, fleshy root and bearing cylindrical racemes of dark-purple juicy berries. The root, at the crown, attains a diameter of several inches and divides into two or three large branches. It is brownish white externally and faintly yellowish white internally. It bears quite a close general resemblance to horseradish, a fact which has led to numerous fatal poisoning accidents. The stems, when young, are bland and juicy and are used by country people in some localities as a pot-herb. Great care must be taken to use them only in a very young state, since they become poisonous as they develop. They at length attain a height of one to two, in the Southern States three to four meters, are at first green, afterward red or purple, branched widely, are smooth and cylindrical and hollow when old, though with thin transverse partitions. The leaves are large, alternate, petioled, ovate or oblong, entire and smooth. The flowers are in terminal racemes, becoming lateral and extraaxillary by the growth of the stem. They are regular and perfect, having five sepals, ten stamens, and a ten-celled ovary. The fruit contains ten thin putamina, enveloped in a purple flesh, and each containing a single seed. The fruit, when fresh, is about one centimeter ($\frac{2}{5}$ inch) broad.

For medicinal purposes the root is gathered in the autumn, sliced lengthwise or crosswise, and dried. The berries are gathered when ripe and dried in the sun, in masses.

Description of the Root.—Consisting mostly of transverse or longitudinal slices of sparingly branched, cylindrical, somewhat tapering, usually twisted roots, rarely exceeding seven centimeters (3 inches) in diameter, externally of a rich or yellowish brown, finely wrinkled (longitudinally or spirally) and thickly annulate with lighter colored, low ridges; transverse slices exhibiting several concentric rings of interrupted wood wedges, the intervening zones much retracted; longitudinal slices exhibiting the wood bundles as bands, with the intervening medullary tissue greatly retracted; fracture fibrous; internally yellowish gray; inodorous, the powder highly sternutatory; taste sweetish, afterward highly acrid.

The Fruit.—The dried fruit forms a close and heavy, agglutinated, purple-black mass, the stones conspicuous as brightly shining particles, the odor slight, the taste fruity, but peculiar, acidulous and sweetish, somewhat acrid. The structure of an individual fruit is given above.

Poke root contains an actively poisonous, bitter and acrid, amorphous glucoside, which is believed to be saponin, a small amount of the white crystalline alkaloid *phytolaccine*, large amounts of sugar and starch, gum, a little fat, resin, etc. The tannin has been called *phytolaccin*. *Phytolaccic acid* occurs in the root and is, next to the coloring matter, the most important constituent of the fruit.

The juice of the fruit has been much used to color wines. Its effect is slightly laxative. The seeds are poisonous, unless they pass the alimentary canal intact.

ACTION AND USE.—All parts of the adult plant are active, and cause in sufficient doses vomiting and purging. It has also some narcotic or stupefying power, and in poisonous doses causes, in addition to the intestinal symptoms, convulsions and coma. Death frequently follows. Its action is slow, painful, and protracted. Poke root has been administered as an emetic, but the practice is exceedingly bad. It is also recommended in rheumatism, scrofula, inflamed breasts and testicles, and as a dressing for cancers and indolent ulcers, but is in very little favor in regular practice, probably not nearly so much as its properties warrant. Enough may be absorbed from washes and ointments to produce its constitutional effects. It is said to be useful as a parasiticide in sycosis, tinea capitis, the itch, etc., but there are doubtless many better drugs for this purpose.

The root has been given in gr. xv. (1.0), doses as an emetic, as an alterative in doses of gr. i. to v. (0.06–0.3), and the dose of the fluid extract should correspond. The fruit and its fluid extract are given in doses five or six times as large. The juice of the fresh fruit is often administered in country practice in doses of fl. ʒss.–i. (2.0–4.0), but its action is very weak indeed. HENRY H. RUSBY.

Picric Acid.—(*Carbazotic Acid, Trinitrophenol*), $C_6H_2(NO_2)_3.OH$. Picric acid is one of the phenol alcohols and may be formed by adding carbolic acid to fuming nitric acid and heating. It is also obtained by the action of nitric acid upon indigo, silk, salicin and many other vegetable products. It crystallizes in yellow, glistening, laminar or acicular scales. It is soluble in ninety-five parts of water, and in sixteen parts of alcohol. Picric acid and its salts form powerful explosives, and accidents have been due to their careless handling.

Picric acid and its salts may produce toxic effects when administered internally, or when absorbed from the skin or abraded surface. It has caused weakness and depression, diarrhea, colic, black urine, jaundice, convulsions, collapse, and death. It stains the tissues yellow and produces an alteration in the character of the blood. It also discolors the skin and has produced a vesicular rash and an erythematous condition resembling scarlet fever.

The internal administration of picric acid or its salts is now practically obsolete. On account of its absorption by the various tissues, it was recommended as a remedy in malarious diseases and in trichiniasis. In these conditions it has not proved of any service and is now never used.

Picric acid has marked antiseptic action and is of decided value when employed locally in the treatment of inflammatory affections of the skin, and for burns and scalds.

In erysipelas the application of a saturated solution, which has a strength of nearly one per cent., has proved of value. It is to be applied from five to ten times a day and the solution allowed to dry upon the part.

It is recommended in eczema when the inflammation is acute and superficial and accompanied by much itching and weeping. It is of less service in chronic forms accompanied by induration of the skin. A compress of the saturated solution is kept applied to the part for several days.

It is particularly recommended for the treatment of burns, abrasions, superficial wounds, bed sores, and

similar conditions, and has been extensively employed for this purpose. It is most serviceable in burns of the first and second degree. A layer of absorbent cotton, saturated with the solution, is kept applied to the part. Under this treatment the heat and pains subside and the superficial lesions quickly heal. Ointments of a strength up to five per cent. have been used, but it has been pointed out that where absorption and ill effects have occurred, these stronger preparations have been employed. The discoloration of the skin may be removed by washing with alcohol or with a solution of carbonate of lithium.

Picric acid has also been used in genito-urinary disorders, urethritis, ear and eye diseases, and many other conditions. BEAUMONT SMALL.

Picrotoxin.—*Picrotoxinum* (U. S. P. 1890). A neutral principle obtained from the seed of *Anamirta cocculus* (L.) W. et A. (*Menispermum* C., L.; *A. paniculata* Colebr. Fam. *Menispermaceæ*).

The origin of picrotoxin from fish-berries has been explained under *Cocculus Indicus*. The seed alone contains the active principle picrotoxin. This is extracted with boiling alcohol, the solution concentrated and cooled, the fat removed, and the residue treated with boiling water. The picrotoxin is crystallized out from the slightly acidulated decoction, and is afterward purified by the use of alcohol. Several associated alkaloids are liable to occur as impurities of picrotoxin. The substance was thus described by the Pharmacopœia:

Colorless, flexible, shining, prismatic crystals, or a microcrystalline powder, odorless, and having a very bitter taste; permanent in the air.

Soluble, at 15° C. (59° F.), in 240 parts of water, and in 9 parts of alcohol; in 25 parts of boiling water, and in 3 parts of boiling alcohol; also soluble in solutions of the alkalies, and in acids. Very slightly soluble in ether or chloroform.

Picrotoxin is neutral to litmus paper.

When heated to 200° C. (392° F.) picrotoxin melts, forming a yellow liquid, and upon ignition it is consumed, leaving no residue.

Concentrated sulphuric acid dissolves picrotoxin with a golden yellow color, very gradually changing to reddish brown, and showing a brown fluorescence.

On mixing about 0.2 gram of powdered sodium nitrate with three or four drops of sulphuric acid, in a small, flat-bottomed capsule, sprinkling a minute quantity of picrotoxin over it, and then adding, from a pipette, concentrated solution (1 in 4) of sodium hydrate, drop by drop, until it is in excess, the particles of picrotoxin will acquire a brick-red to deep red color which fades after some hours.

On diluting 2 c.c. of alkaline cupric tartrate V. S. with 10 c.c. of water, and adding a small portion of picrotoxin, red cuprous oxide will be separated within half an hour at ordinary temperatures, and much more rapidly upon the application of heat.

The aqueous solution of picrotoxin should remain unaffected by mercuric or platinic chloride T. S., tannic acid T. S., mercuric potassium iodide T. S., or other reagents for alkaloids (absence of *alkaloids*).

ACTION AND USES.—The most elaborate study of the action of picrotoxin was that made by Chirone and Testa, whose conclusions were as follows (*London Medical Recorder*): (1) Picrotoxin is capable of causing a true artificial epilepsy. (2) The epilepsy so induced is independent of the psychomotor centers, inasmuch as it is most intense after the removal of those centers. (3) Picrotoxin acts primarily on the bulb and on the commissural fibers between the cerebral and spinal centers, and secondarily on the spinal centers themselves. (4) It demonstrates the existence of a functional antagonism between the psychomotor and motor centers of the bulb and spinal cord. (5) The convulsive movements of the limbs induced by picrotoxin depend primarily upon the action of the drug on the bulb, which is thence propagated to the spinal marrow, and secondarily upon its direct action on the spinal centers. (6) In frogs the influence on the spinal functions is more marked than upon the cerebral, while in dogs and the higher animals the cerebral motor centers are the most acted upon. (7) By cinchonidine an epilepsy of cerebral, by picrotoxin an epilepsy of spinal origin, can be induced.

From the foregoing it is evident that the action of picrotoxin closely resembles that of strychnine. Besides the use of this substance for poisoning fish, it is said to be a constituent of some arrow poisons and to be employed for the poisoning of vermin. The flesh of fish poisoned by it is said to be dangerous unless early steps are taken to remove the poison from it.

The medicinal employment of picrotoxin is exceedingly limited. It has been recommended in paralysis, epilepsy, chorea, hystero-epilepsy, etc., but has not been very successful. As a retarder of the pulse it might be thought of, but we have already several safer remedies for this purpose. It has been used considerably for the prevention of the night sweats of phthisis; the hypodermic use of gr. $\frac{1}{100}$ to gr. $\frac{1}{50}$ proving very serviceable in many cases of this troublesome condition. It has been used locally in some cutaneous diseases, and as a parasiticide (in the form of an ointment); but it has no advantage for this purpose over less dangerous substances. "Convulsions and death have followed its application to the head" (Brunton); from one to two per cent. of picrotoxin in, say, petrolatum is of sufficient strength for pediculi, etc., if it is desired to use it. Dose, from gr. $\frac{1}{50}$ to gr. $\frac{1}{8}$ (0.001 to 0.01).

HENRY H. RUSBY.

Piedmont White Sulphur Springs.—Alameda County, California. These springs are located in a large private park, just outside of Oakland, with car line running directly to it. The waters have gained considerable local reputation in the treatment of rheumatic conditions, jaundice, liver and kidney troubles, and disorders of the stomach. There is a restaurant in the park, and its nearness to San Francisco makes it

ONE UNITED STATES GALLON CONTAINS:

Solids.	The Iron Spring. Grains.	The Sulphur Spring. Grains.
Sodium chloride	5.10	7.91
Sodium bicarbonate	11.70	9.40
Sodium carbonate	0.52	6.20
Potassium carbonate	3.15	0.76
Potassium iodide	Trace.	Trace.
Magnesium carbonate	6.37	3.17
Magnesium sulphate	1.03	17.80
Calcium carbonate	2.13	3.32
Calcium sulphate	1.60	7.09
Ferrous carbonate	1.73	Trace.
Alumina	0.45	Trace.
Borates	5.23	1.90
Silicates	4.19	5.06
Organic matter	Trace.	Trace.
Total solids	43.20	62.61
Gases.	**Cubic inches.**	**Cubic inches.**
Carbonic acid gas	7.25	4.60
Sulphureted hydrogen	Trace.	9.25
Temperature of water	58°	60°

available for residents of that city as a day resort. The situation on the western slope of the Berkeley Hills commands a most picturesque view over San Francisco Bay and the Golden Gate. The following analysis by Winslow Anderson shows the mineral ingredients of two of the springs:

These analyses show that the waters are valuable as a tonic, antacid, diuretic, and aperient; they are useful in dyspepsia, constipation, anemia, rheumatic troubles, and liver and kidney disorders.

EMMA E. WALKER

Piedra.—*Synonyms:* Trichosporie; Trichomycosis nodularis. There are two varieties of this disease. One occurs in the United States of Columbia, where it was first described, and which affects only the hair of the scalp. This is the original piedra. The other variety affects the hair of the beard usually, occurs in various parts of the world, and is called Piedra nostras.

SYMPTOMS.—The disease is characterized by the occurrence along the shaft of the hair of from one to ten small, dark brown nodes that are more easily felt than seen. They are very hard, so that when the hair is combed or shaken they rattle together like stones. This gave the name to the disease piedra, being the Spanish for stone. The hairs themselves are unaffected, the nodes being simply attached to the hair. The course of the disease is indefinite, it lasting until the nodes are mechanically removed.

ETIOLOGY.—Piedra occurs almost exclusively on the long hair of women, and in the warm valleys of the State of Cauca. Piedra nostras occurs on the hair of the beard in men in various parts of the world. Microscopical examination shows that the nodes are composed of a mass of pigmented spore-like bodies arising from one cell that sends out columns of cells radially in all directions. In piedra the *Trichosporon giganteum* is the fungus described by Bodin, while in piedra nostras Behrend found the *Trichosporon ovoide.*

DIAGNOSIS.—It differs from trichorexis nodosa in that the hair itself is unaffected. Its nodes differ from the nits of pediculi in their dark color, and in surrounding the hair rather than being on one side of it.

TREATMENT.—The nodes can be readily removed by soaking them in hot solution of bichloride of mercury, 1 in 1,000, and combing or pulling them off.

GEORGE T. JACKSON.

Pigments, Animal.—Aside from form, perhaps the most noteworthy feature of animal life is color. Many of the "species" and "varieties" of the zoologist differ only in color, or in the amount and location of the pigment. Some of these pigments undoubtedly play very important parts in life processes, others serve as reserve sources of energy or to afford protection from natural enemies, others seem to have no other purpose than to attract attention during the mating season, while still others seem to have no physiological function or else are excretory products.

It would be beyond the scope of this article to enter into the literature of the animal pigments in great detail, and unless some decomposition product is of great importance only the more important of the naturally occurring pigments will be mentioned.

CLASSIFICATION.—Unfortunately so little is known of the true nature of the animal pigments that a strict chemical classification is impossible. The writer believes that many of the pigments to which distinct names are now given will some day be shown to be identical or at least closely related, but for the present the following classification will serve: (1) Blood pigments (respiratory pigments). (2) Bile pigments. (3) Melanins. (4) Lipochromes. (5) Miscellaneous pigments.

1. BLOOD PIGMENTS.—Many of these coloring matters are of exceptional physiological importance inasmuch as they serve as carriers of oxygen, with which they unite loosely, receiving it through the thin walls of the capillaries in the organs of respiration and conveying it through the circulatory system to all parts of the body. In so far as is known all of the true oxygen-carrying pigments contain a protein nucleus.

Hemoglobin, the scarlet red coloring matter of blood is found in the blood corpuscles of all vertebrates and in the blood or hemolymph of many of the lower animals. Hemoglobin is composed of a protein, *globin*, combined with an iron-containing chromogen, *hematin*, $C_{34}H_{34}N_4O_5Fe$, and exists in two forms, as oxyhemoglobin in arterial blood and as reduced hemoglobin in venous blood. The hemoglobins from different animals crystallize in very different crystal form, although mostly in the rhombic system, this serving as one method to identify the source of unknown blood. The iron content lies around 0.335 per cent. Hemoglobin can be easily detected by its characteristics absorption spectra.

Carbon-monoxide-hemoglobin is formed from hemoglobin when illuminating gas or air containing carbon monoxide has been breathed. This hemoglobin no longer possesses the property of loosely uniting with oxygen and it is owing to this fact that illuminating gas is toxic. The pigment shows a characteristic absorption spectrum.

Methemoglobin is found in dried blood stains and clots, in some fluids of pathological cysts, in ovarian tumors, in the urine from potassium chlorate or amyl nitrite poisoning, etc. It is a decomposition product of hemoglobin and is found in circulating blood only in pathological conditions.

Hematin, an amorphous dark brown or bluish-black decomposition product of hemoglobin occurs in man as the *malarial pigment*, probably formed by the action of a proteolytic enzyme of the malaria parasite upon the hemoglobin of the red blood cells, and in the intestines after a diet of foods rich in blood. It may also occur in the urine in arsenical poisoning.

Hemochromogen, $C_{64}H_{64}Fe_2N_8O_7(?)$, is an amorphous dark red powder forming the pigmented nucleus of reduced hemoglobin. It has been found in nature only in the liver of snails, but can be easily prepared artificially by reducing hemoglobin.

Oxy-hemocyanin, a blue oxygen-carrying pigment, is similar to and replaces hemoglobin in the blood or hemolymphs of cephalopods, *e.g.* the octopus and squid, in the Lamellibranchiata or mussels, in the Gasteropoda, in the Crustacea, in the Arachnida, etc. Hemocyanin, the reduced pigment, is colorless and contains approximately 0.35 per cent. of copper instead of iron as in hemoglobin. This pigment is most easily prepared from the blood of the squid. It shows a characteristic absorption spectrum.

Pinnaglobin is a pigment analogous to hemoglobin which occurs in the blood of *Pinna squamosa.* It contains 0.35 per cent. of manganese.

Achroglobin is the oxygen carrier in the blood of the Doridida, Ascidia, and Chitonidæ. It differs from hemoglobin in not containing a metallic nucleus. Oxyachroglobin is colorless, the reduced pigment is brown.

Among other oxygen-containing pigments concerning which little is known are: *Hemerythrin*, 1.44 per cent. iron, the red pigment of the hemolymph of many worms especially the Gephyrea; *Chlorocrucin* (green) 0.45 per cent. iron in the hemolymph of the Chætopodæ, especially in the annelids or earthworms; *Echinochrom* (yellow or red), in the perivisceral fluids of sea urchins and star fish; *Æolosomine*, green, iron containing, in the cells of *Æolosoma tenebrarum*, etc.

Hematoporphyrin, $C_{34}H_{38}O_6N_4$, occurs in traces in the normal organism and in the urine of higher animals. In man it sometimes occurs in considerable quantity in the urine in fevers, and following poisoning by sulfonal or trional. It is closely related to certain chlorophyll derivatives and to bilirubin (see below). It is identified by means of the spectroscope. A reduced *hexahydro-hematoporphyrin* sometimes occurs in the urine in rheumatism and in Addison's disease.

Actinohematin is a little known red pigment occurring in the ectoderm and endoderm of Actinaria. It appears to be related to hematin. *Histohematin* is a brown or red-brown pigment widely distributed in nature. It is found in echinoderms, sponges, molluscs, jelly fishes, insects, fishes, amphibians (stomach wall, liver, and spleen), and in the spleen, liver, stomach wall, and kidneys of birds, guinea-pigs, cats, rabbits, dog, sheep, cow, and man. It always occurs associated with *hematin* or *hemochromogen*.

Myochrom and *myohematin* (possibly identical with myochrom) are the red pigments of the muscles. Both contain a protein nucleus and show characteristic absorption spectra. They are probably derivatives of hemoglobin.

2. Bile Pigments.—A very considerable number of bile pigments have been isolated and there are probably a number which are still unknown. The majority of the pigments of the bile are not normal constituents, but are formed by pathological or postmortem changes. Hemoglobin is probably the mother substance from which most of the bile pigments are derived. Old blood extravasations contain hematoidin which is probably identical with bilirubin. Bile pigments are formed chiefly in the liver, but they may be formed in other organs when the liver is not functioning. The more important of the naturally occurring pigments are:

Bilirubin, $C_{32}H_{36}N_4O_6$, is the chief coloring matter of the bile of vertebrates, occurring usually in the form of the sodium salt. It also occurs in small quantities in normal serum of the horse and man, in the shells of many bird eggs, in meconium, in large quantity in gallstones as the calcium salt, in the blood stream in icterus, in transudates and exudates, and in the urine. Only rarely does it occur in the cerebrospinal fluid. Bilirubin is apparently formed from hemoglobin in the liver. It crystallizes in dark red prisms, the solution is yellow brown, and shows characteristic absorption spectra.

Biliverdin, $(C_{16}H_{18}N_2O_4)_x$, an oxidation product of bilirubin occurs together with bilirubin in green biles as the sodium salt. Besides being present in bile it has been found in the intestines and stomach contents, in gallstones, in icterus in the urine, and in the shells of bird eggs. It has also been identified in the shells of molluscs and in tumors of the choroid. It forms a black green imperfectly crystalline powder and is very easily decomposed by chemical reagents.

Urobilin (stercobilin) a reddish-yellow to brown pigment occurs in all urines which have stood for some time. It is also found in bile, in stomach contents, in the feces, in cows' milk, etc. In pathological conditions it has been observed in the blood serum and in the cerebrospinal fluid. The urobilin of the urine is apparently formed from a colorless chromogen, *urobilinogen*, which occurs as a normal constituent of fresh urine.

Among the pigments which occur in smaller quantity are: *Cholelelin*, $C_{32}H_{36}N_4O_{12}$, an oxidation product of bilirubin and biliverdin, forming an amorphous brown powder. It sometimes occurs in normal urine. *Biliprasin*, a little known intermediate product in the oxidation of bilirubin to biliverdin, occurs in the bile of cattle and rabbits. *Choleprasin*, a green pigment, occurs in cattle bile. *Bilifusin* sometimes occurs in human gallstones. It forms a greenish-black powder, does not give the tests for bile pigments, and has no characteristic absorption spectrum. *Hydrobilirubin*, $C_{32}H_{40}N_4O_7$ (?), a reduced bilirubin, is found in feces, sometimes in the gall-bladder and in the dog's placenta. It is very closely allied to bilirubin. *Oocyan* is a blue pigment occurring as the calcium salt in the egg shells of many species of birds. It appears to be very closely allied to biliverdin.

3. Melanins.—Melanins may be defined as those amorphous black or brown pigments which occur in the skin, hair, epithelium cells of the retina, in amphibian eggs, in the ink sac of the squid, in certain pathological formations, and in the blood and urine in disease. They all contain nitrogen and all which have been tested give a positive test for the pyrrol ring. Some melanins appear to contain iron, most of them contain sulphur. No true melanin has been isolated from plant material, the so-called "phytomelanins," the brown pigments of the flower heads of the compositæ, do not contain nitrogen and therefore cannot be true melanins.

Although an immense amount of work has been done, the chemical nature of melanin is still obscure. Numerous pigments have been isolated by one means or another and to many of these distinctive names have been given. Thus the pigment from the tumors of the lymph sacs of the white horses has been designated "*hippomelanin*," the pigment from the melanosarcoma of the horse and man is known as "sarcomelanin," the hair pigment as "hairmelanin," etc. It seems very improbable, however, that any, or at least very few, pure melanins have been isolated.

All melanins are amorphous brown or black powders, insoluble in strong mineral acids and usually but *not invariably* insoluble in dilute acids and organic solvents. Morner (*Zeitschr. physiol. Chem.*, 11, 66) and the writer have prepared melanins which were soluble in fifty per cent. acetic acid. As a rule, the melanins are readily soluble in strong alkalis, but there are some which appear to be insoluble in all media.

Formation.—Although little is known of the melanin molecule it is certain that they are highly oxidized compounds. The mechanism of their formation has been investigated in the case of a number of insects and it has been shown to be due to an oxidation induced by the oxidizing enzyme *tyrosinase* acting on some colorless oxidizable chromogen in the presence of free oxygen. The exact nature of the chromogen has never been elucidated, but it appears possible that in certain instances it may be tyrosine or tryptophane, while in other instances it may be an entire protein molecule. Melanin formation proceeds for some time after death, but if the enzyme be destroyed by heat or inhibited by the action of chemicals, or by the replacement of the oxygen by an inert gas, pigmentation ceases at once.

Classification.—It is commonly assumed that the melanins are almost indestructible, that they may be boiled with fuming acids or concentrated alkalis without decomposition. Such, however, is not the case. On the other hand, some melanins are very easily broken down by caustic alkali. This fact allows the separation of the pigments into the two classes:

Melanoproteins.—These melanins contain a protein nucleus; as a rule, they are readily soluble in warm 0.2 per cent. sodium hydroxide. They have been shown to occur in black wool of sheep, in horse hair and cow hair, in red human hair, and in one instance in a pathological urine. In all probability they also occur in the pigmented epidermal structures of many animals. These pigments vary from a light brown to jet black and consist of a protein molecule with a pigmented nucleus. By the action of dilute sodium hydroxide they are easily converted into alkali albuminates and then dissolve in mineral acids when the concentration does not exceed tenth normal. On acid hydrolysis the pigmented nucleus is split off and the protein portion hydrolized to amino acids.

Melanins not Readily Soluble in Warm 0.2 Per Cent. NaOH.—This class includes the melanin from black

and brown human hair, crow feathers, black rabbit fur, of some (all ?) melanosarcomas, of amphibian eggs, etc. This pigment appears to be very similar to the pigmented nucleus of the melanoproteins, but the exact relationship is unknown. All melanins of this type are insoluble in acids of all concentrations. A few of the pigments of this type contain iron.

4. *Lipochromes.*—These yellow or red fat pigments are widely distributed in both the animal and vegetable kingdoms. The grouping of these pigments together is based on the fact that they are soluble in the usual fat solvents, ether, alcohol, and chloroform, rather than upon any similarity in their chemical constitution. Many of the animal lipochromes are undoubtedly of vegetable origin, having been taken in with the food and deposited in the animal fats without chemical change. Thus the yellow lipochrome, *luteins*, of milk, blood serum, the corpus luteum, and of egg yolk has been recently shown to be identical with the vegetable pigment *carotin*, $C_{40}H_{56}$, an unsaturated hydrocarbon, crystallizing in shining red rhombic prisms.

In this group as in the melanins little is known of many of the pigments which have been isolated in a more or less pure state and to which distinctive names have been assigned. A few of these are *cyanocrystallin*, a blue-gray pigment in the shells of lobsters and crabs which under the action of heat changes to the red *crustaceorubin* (tetronerythrin); *crustaceofulvin*, a yellow pigment associated with crustaceorubin; *chromophane* (retinal lipochrome), an orange to yellow pigment occurring in the retina of amphibians, some reptiles, birds, etc., *xanthophane* (yellow) and *rhodophane* (red) occur associated with chromophane.

5. Miscellaneous Pigments.—Aside from the above animal pigments there are a host of others which cannot be classified at present. Some of these are important enough to deserve consideration. Unfortunately here again it must be said that we know the chemical nature of only a few of the numerous pigments which bear distinctive names.

Structural Colors.—Many of the beautiful iridescent greens and blues seen on birds and insects are in reality due to structural causes. The pigment in most of these cases is a dull brown melanin, but the covering of chitin or keratin is so arranged as to reflect the light giving a false color effect. Light reflection also causes unpigmented hair to appear white.

Punicin or *Tyrian Purple* is secreted by molluscs of the families Purpura and Murex. It has recently been shown to have the composition $C_{16}H_8Br_2N_2O_2$, and to be 6.6. di-brom indigo. 1.4 grams were obtained from 12,000 molluscs (*Murex trunculus*).

Turacin, $C_{82}H_{81}N_9Cu_2O_{32}$ (7.01 per cent. copper) is a red-violet pigment of many bird feathers, especially of the classes Turacus, Gallirex, and Musophaga. The pure pigment is slightly soluble in cold water and is easily soluble in dilute alkalis and alkali carbonates, it appears to be related to hemoglobin. An *artificial turacin* (Cu = 6.99 per cent.) can be prepared from hematoporphyrin by boiling with a dilute ammoniacal copper solution.

Visual Purple (rhodopsin) and *Visual Red* (erythropsin) occur in the outer part of the rods of the retina. They are soluble in water, and destroyed by heat, alkalis and acids, ether, alcohol or chloroform. Inasmuch as they are easily destroyed by light they must be constantly regenerated. They are not essential to sight inasmuch as they do not occur in the retinal rods of hens and pigeons, and their physiological significance is unknown.

Carminic acid $C_{22}H_{22}O_{13}$, is present in large quantity in the female cochineal bug, *Coccus cacti coccineliferi*, L. It is a weak di-basic acid, crystallizing in dark red prismatic crystals and forms stable metallic salts, possessing a yellow color in acid solution and changing to a violet red on the addition of alkali. Because of this color change it is widely used as an indicator in acidimetry. The chemical constitution has not been definitely ascertained. Nitration causes the formation of 2.4.6. tri-nitro-oxy-toluic-acid. On oxidation *cochenillic acid* $C_{10}H_8O_7$, a tri-carboxyllic acid and *coccinic acid*, $C_9H_8O_5$, a di-carboxyllic acid of *m.* cresol are formed. Carminic acid is probably a naphthoquinone derivative.

Urochrome, an amorphous, brown, very hygroscopic pigment, is the chief coloring matter of normal and pathological urine. It sometimes occurs in the blood stream. In quantity it does not exceed 0.02 per cent. of the urine. The nature of the pigment is still uncertain. It contains nitrogen, but does not contain iron. Most preparations give the test for the pyrrol ring. It is easily soluble in water yielding yellow solutions, dissolves readily in dilute alcohol. Is insoluble in absolute alcohol, chloroform, or ether, is precipitated by many of the heavy metals such as lead acetate or silver nitrate, phosphotungstic acid, etc. Almost nothing is known of its physiological relationships.

Uroerythrin is the pigment which often gives the red color to urinary sediments (*sedimentum lateritium*). It occurs in small quantities in normal urine, and in larger quantity in fevers, diseases of the liver, alcoholism, malaria, gout, influenza, etc. It forms an amorphous bluish-red powder, contains no ash, is only slightly soluble in water, but readily soluble in amyl alcohol, less so in alcohol and chloroform. It has a characteristic absorption spectra. Regarding its chemical composition little is known.

Indigo blue or *Indigotin*, $C_{16}H_{10}O_2N_2$, identical with the indigo blue of plant origin, occurs in indigourea. It has been observed in urinary sediments, in stomach contents in carcinoma, in perspiration, etc. An isomer *Indirubin* or *indigo red* often occurs associated with indigo blue. Both of these pigments are formed from *indoxyl*, C_8H_7NO, which occurs in normal and pathological urines as *indoxyl sulphuric acid*, $C_8H_7NSO_4$, or *urinary indican*. This acid is derived from indol, a product of protein putrefaction.

Skatol red (*Urorosein* ?) is possibly present at times in normal and pathological urines. It occurs in the urine after the feeding of skatol *per os*. Indirubin has probably been mistaken sometimes for skatol red.

Lepidotic acid, a condensation product of uric acid occurs as a yellow pigment in the wings of many butterflies (*Pieridinæ*). Each wing contains about one milligram of the pigment. The pigment is insoluble in cold water, dilute acids, alcohol, ether, or chloroform. Soluble in hot water and in alkaline solutions. Its solution in hot water shows a green fluorescence on the addition of ammonia, changing to a blue with the addition of zinc chloride. Hydrolysis with nitric acid yields uric acid. On warming with dilute sulphuric acid it yields a purple substance, *Lepidoporphyrin*.

Lepidopteric acid is a little studied green pigment obtained from certain butterfly wings. It is a dibasic acid, $C_{11}H_{12}N_2O_{12}$. It is probably allied to lepidotic acid inasmuch as long boiling with water decomposes it into uric acid, alloxan, and carbon dioxide.

Chlorophyll, the respiratory pigment of plants, is often found in animal tissues. The hemolymph of leaf-eating insects and larvæ usually owes its green color to this pigment. The elytra of certain beetles, *e.g.* cantharides beetles, are colored green by chlorophyl. In *Hydra viridis* and *Stentor viridis* the green color is due to the chlorophyll of algæ which live in symbiotic relationship with the animals.

Chlorophyll is insoluble in water, soluble in alcohol and chloroform, and some of its derivatives are closely allied to decomposition products of hemoglobin. Chlorophyll differs from hemoglobin by containing magnesium instead of iron, and in being an ester of an unsaturated primary straight chain alcohol, phytol, $C_{20}H_{39}OH$, instead of being combined with a protein

radicle. There appear to be two chlorophylls, designated as chlorophyll (A) $C_{55}H_{72}O_5N_4Mg$ and chlorophyll (B) $C_{55}H_{70}O_6N_4Mg$. On reduction of either chlorophyll or hemin (prepared from hematin by the action of hydrochloric acid) the same hemopyrrols are formed. Ross Aiken Gortner.

Pilocarpus.—Jaborandi. "The leaflets of *Pilocarpus microphyllus* Stapf (Small-leaved Jaborandi) and of *Pilocarpus jaborandi* Holmes (Pernambuco Jaborandi (fam. *Rutaceæ*), yielding, when assayed by the following process, not less than 0.5 per cent. of alkaloid" U. S. P. The genus *Pilocarpus* Vahl. contains about fifteen species, all tropical American shrubs, having impari-pinnate leaves, occasionally of but one leaflet. A number of them are known to possess alkaloids similar to those of the official article, and to possess similar properties. *P. jaborandi* occurs in the Pernambuco region, and is exported thence. It is very shortly and stoutly petioluled, the blades six to one centimeter (2½ to 5 inches) long and two to four centimeters (¾ to 1½ inches) broad, oblong or oval, occasionally a very little narrower above or below the middle, usually slightly inequilateral at the base, blunt and retuse at the summit, entire and thinly revolute at the margin, yellowish or brownish green, smooth and slightly shining, especially underneath, thick and coriaceous, not much wrinkled, the reticulate venation prominent on both surfaces, especially underneath; strongly pellucid-punctate; somewhat peculiarly aromatic when crushed and warmed in the hand; taste bitterish, somewhat salty, aromatic, later somewhat pungent and sialagogue.

Even the powder is distinguished by a distinct yellowish-green tint, quite different from the dull green of the Rio Janeiro species (*P. selloaneus* Engler). The distinction of the better drug is in this case of unusual importance, and the physician may well supplement the knowledge of the pharmacist, who is usually very ill-informed concerning it. The Rio Janeiro leaflets are narrower and much more frequently oblanceolate than lanceolate or oblong. They are not so thick or so veiny and are of a dull but strong green. The Paraguay jaborandi (from *P. pennatifolius* Lem.) is of a gray-green, and the leaflets are mostly oblong, otherwise like the last. They are almost worthless. Very poor also are the velvety-hairy leaves of *P. trochylophus* Holmes. *P. spicatus*, "Aracati jaborandi," has unifoliolate leaves, and is quite worthless. Those of *P. microphyllus* Stapf, with obovate, strongly emarginate leaflets, acute at the base and only one to one and one-half inches in length, are of a quality almost equal to the best, and are now the most largely used.

Constituents.—The one-half per cent. of volatile oil is by no means inactive, but attention has not been attracted to it. Alkaloids to the extent of about three-fourths of one per cent. are the important constituents. The principal one is *pilocarpine* ($C_{11}H_{16}N_2O_2$), a colorless or yellowish syrupy liquid. It yields numerous crystalline salts, but we are not driven to their employment, since the alkaloid itself is soluble in both alcohol and water. It possesses the properties of the drug. The U. S. P. recognizes its hydrochloride and nitrate.

Pilocarpidine ($C_{10}H_{14}N_2O_2$) is also present, and can be artificially produced from the former. It is soluble in water. Its action differs in slight particulars from that of pilocarpine.

Jaborine ($C_{22}H_{32}N_4O_4$) is also a derivative of pilocarpine. It is yellowish and syrupy, or becomes a soft solid. It is soluble in alcohol, but only slightly in water. Although its action is opposed to that of the others, there is so little of it as not to interfere greatly when the entire drug, or a preparation which certainly contains all its constituents, is used.

Action.—In almost every particular jaborandi is directly antagonistic to belladonna. Its essential action is to stimulate the secretions, with the exception of those of the kidney and the mammary gland. In the liver, the production of sugar is increased, but not that of the bile. The secretions most affected are those of the skin, the salivary glands, and the pancreas, but those of eyes, ears, stomach,. and intestine all share markedly in the result. Salivation is the first to appear, and diaphoresis begins as that diminishes. The salivary, and especially the sudorific, increases are the greatest known in the case of any drug, and are sometimes quite phenomenal. The watery portion is most increased, but there is also some increase in the solid portion. The mode of operation appears to be the stimulation of the nerve endings in the gland. The growth of the hair is strongly stimulated and the color darkened, but the latter effect is liable to occur in patches. The production of leucocytes is notably increased. There is hyperemia of the tissues whose activity is increased, but this seems secondary to, and dependent upon, the former. Through the increased heat radiation there is a fall of temperature. The powerful contraction of the pupil, also through stimulation of the nerve endings, illustrates what takes place in many other involuntary muscles. The blood-vessels are not thus affected, so there is not the increase of blood pressure that we should expect. Neither is the heart so affected, but the terminal filaments of the vagus in this organ are usually stimulated and the movements of the heart as a whole are slowed. This effect is, however, quite uncertain. Nausea is apt to follow the other symptoms after large doses have been taken.

Use.—The uses of jaborandi, though already very important, are by no means developed, especially that as a stimulant to intestinal digestion, through increased pancreatic secretion. It will probably, in future, have a wide and important use in this direction. Its present use is almost wholly as a sudorific, and it seems to work well in all cases in which increased perspiration can be of service. It is especially valuable in removing dropsical accumulations, and, while not itself directly affecting the existing disease, the improved condition is often the cause of complete recovery. It is also of special value in uremia, in which condition it washes out from the skin accumulated waste and clears the way for further depurative action. By early relieving congestion, in case of a threatened cold, the latter can be averted, but the patient must be carefully protected. It promotes to a marked extent the nutrition of the nails and hair, as well as of the skin generally, and its use in cutaneous diseases is a still largely unworked field. It is often productive of great benefit in promoting a new growth of hair, even when locally applied. The hair at the same time becomes oily and is apt to become darker. Some well-known and curious accidents in producing dark spots upon white hair have occurred. The alkaloid is often used locally as a substitute for eserine in the eye, while its internal use relieves congested states of that as of other organs.

Several cautions are to be observed in the use of jaborandi. It may produce, and will increase the tendency to, abortion. Ordinarily, small doses are to be preferred, as there is a great tendency to reaction after its use, mental as well as great physical depression, and lack of secretion. The jaborine content should be avoided as far as possible. Since this is insoluble in water, but soluble in alcohol, while pilocarpine is soluble in both, a weak alcoholic menstruum is to be preferred, and commonly the use of the alkaloid, carefully prepared, is even better. The Pharmacopœia provides a fluid extract, made with diluted alcohol, the dose of which is ♏x.–lx (0.6–4.0). The dose of pilocarpine is gr. $\frac{1}{6}$–$\frac{1}{3}$ (0.01–0.02). For ocular instillation, a one-per-cent. solution is to

be preferred, and one or two minims will be found sufficient.

Poisoning.—This is quite liable to occur, if we include in the term the succeeding prostration from overdoses. In acute poisoning there is great contraction of the pupil, with the cutaneous and salivary symptoms already described. Diarrhea and cramps, as well as nausea, occur. Dyspnea, with excessive bronchial secretion or transudation, or both, occur, death being due to pulmonary edema. Paralysis of the lower limbs is frequent. Atropine is the natural antidote. All forms of respiratory aid are indicated.

Henry H. Rusby.

Pilulæ.—The pill (*pilula*) is a favorite form for the administration of medicines, since in such form are combined the advantages of permanence, portability, exactness of dosage, convenience of administration, and concealment of bad taste. The only drawbacks of the pill are comparative slowness of action, and the fact that some persons (all little children and some adults) cannot swallow pills. The pill form is appropriate for any solid medicine which is not corrosive or deliquescent, and whose dose is within the weight of a few grains; and may even be employed in the case of certain fluids of small dosage such as croton oil. In order to be within bounds in the matter of size, pills, if composed of light substances, such as vegetable powders, should never exceed, individually, the weight of five grains nor, if made up of heavy matters, such as metallic powders, the individual weight of from six to seven grains. And pills are of most convenient size which do not weigh more than half such stated quantities. The proper *excipients* for pills will vary according to the nature of the basis ingredient of the pill. *Sticky vegetable extracts* need no excipient; such substances, indeed, constitute themselves excellent excipients for heavy powders. *Soft gum resins* also require no excipient, although in making such material into pills the addition of a few drops of alcohol may be necessary to reduce hardness. *Substances, fluid or semifluid,* acquire the proper consistency by admixture with some indifferent dry powder, such as pulverized starch or gum arabic. *Powders,* if heavy, are best treated by incorporation in some indifferent sticky vegetable extract, or in confection of rose; or, if light, by admixture of some viscid fluid, such as glycerin, syrup, or honey. Mucilage is unsuitable for such purpose because of its tendency to make the pill mass unduly hard when dry. For *resinous and fatty* bodies, *soap* makes a convenient excipient. In the prescription of extemporaneous pills it is commonly not necessary for the physician to specify the excipient—the selection of the appropriate substance being regarded as the function of the pharmacist. After being made, pills are variously *coated.* Shaking with an indifferent dry powder, such as lycopodium or liquorice powder, is the simplest procedure in such line, and suffices to prevent the pills from cohering, but does not conceal taste. For the latter purpose, if the pills have been freshly made, a convenient operation is the shaking of the pills in a box with silver or gold foil. By this manipulation the pills become covered with bits of foil which adhere fast enough to conceal taste during the act of swallowing, but which break away readily thereafter and so do not interfere with the solution of the pill in the stomach. By special processes, also, pills made by the wholesale are given coatings of gelatin, sugar, or other analogous material. Such coatings necessarily delay the solution of the pill substance by the time required for their own solution. A special make of pill is what is called the *compressed* pill, wherein a light vegetable powder is made into pill form by mechanical pressure, without the use of any excipient. Such pills may be so hard as to be soluble with difficulty.

	Composition.	Dose.
Pilulæ Aloes (pills of aloes).	Purified aloes, 13 gm.; soap, 13 gm.; water, q.s. To make 100 pills.	2 pills.
Pilulæ Aloes et Ferri (pills of aloes and iron).	Purified aloes, 7 gm.; exsiccated ferrous sulphate, 7 gm.; aromatic powder 7 gm.; confection of rose, q.s. To make 100.	2 pills.
Pilulæ Aloes et Mastiches (pills of aloes and mastic).	Purified aloes, 13 gm.; mastic, 4 gm.; red rose, 3 gm.; diluted alcohol, q.s. To make 100.	2 pills.
Pilulæ Aloes et Myrrhæ (pills of aloes and myrrh)	Purified aloes, 13 gm.; myrrh, 6 gm.; aromatic powder, 4 gm.; syrup, q.s. To make 100.	2 pills.
Pilulæ Asafœtidæ (pills of asafetida).	Asafetida, 20 gm.; soap, 6 gm.; water, q.s. To make 100.	2 pills.
Pilulæ Catharticæ Compositæ (compound cathartic pills).	Compound extract of colocynth, 80 gm.; mild mercurous chloride, 60 gm.; resin of jalap, 20 gm.; gamboge, 15 gm.; diluted alcohol, q.s. To make 1,000.	2 pills.
Pilulæ Catharticæ Vegetabiles (vegetable cathartic pills).	Compound extract of colocynth, 60 gm.; extract of hyoscyamus, 30 gm.; resin of jalap, 20 gm.; extract of leptandra, 15 gm.; resin of podophyllum, 15 gm.; oil of peppermint, 8 c.c.; diluted alcohol, q.s. To make 1,000.	2 pills.
Pilulæ Ferri Carbonatis (pills of ferrous carbonate)	Granulated ferrous sulphate, 16 gm.; potassium carbonate, 8 gm.; sugar, 4 gm.; tragacanth, 1 gm.; althæa, 1 gm.; glycerin, water, each, q.s. To make 100.	2 pills.
Pilulæ Ferri Iodidi (pills of ferrous iodide).	Reduced iron, 4 gm.; iodine 5 gm.; glycyrrhiza, 4 gm.; sugar, 4 gm.; extract of glycyrrhiza, 1 gm.; acacia, 1 gm.; water, balsam of Tolu, ether, each, q.s. To make 100.	2 pills.
Pilulæ Laxativæ Compositæ (compound laxative pills).	Aloin, 1.30 gm.; strychnine, 0.05 gm.; extract of belladonna leaves, 0.80 gm.; ipecac, 0.40 gm.; glycyrrhiza, 4.60 gm.; syrup, q.s. To make 100.	2 pills.
Pilulæ Opii (pills of opium).	Powdered opium, 6.5 gm.; soap, 2.0 gm.; water, q.s. To make 100.	1 pill.
Pilulæ Phosphori (pills of phosphorus).	Phosphorus, 0.06 gm.; althæa, 6.00 gm.; acacia, 3.00 gm.; chloroform, glycerin, water, balsam of Tolu, ether, q.s. To make 100.	1 pill.
Pilulæ Podophylli, Belladonnæ et Capsici (pills of podophyllum, belladonna and capsicum).	Resin of podophyllum, 1.6 gm.; extract of belladonna leaves, 0.8 gm.; capsicum, 3.2 gm.; sugar of milk, 6.5 gm.; acacia, 1.6 gm.; glycerin, syrup, each, q.s. To make 100.	1 pill.
Pilulæ Rhei Compositæ (compound pills of rhubarb).	Rhubarb, 13.0 gm.; purified aloes, 10.0 gm.; myrrh, 6.0 gm.; oil of peppermint, 0.5 c.c.; water, q.s. To, make 100.	2 pills.

Quinine pills of this make have been known to be vomited, almost intact, several hours after swallowing; and others to have passed through the intestinal canal unchanged. For the *administration* of pills, it suffices, with the majority of persons old enough to take pills at all, to put the pill, naked, upon the back of

the tongue, and thereupon take a gulp of water. If, however, there be difficulty in swallowing under such conditions, the pill may be put in the middle of a pulpy mass, such as preserves or apple scrapings, and so offered for deglutition.

Fourteen pills of special composition are official in the United States Pharmacopœia. In the majority of instances of these preparations, the Pharmacopœia establishes the weight for the individual pills as well as the constitution of the mass. Such official pills are then entitled *Pilulæ*, Pills. In two instances, however, the composition of the pill mass is alone directed, in which case the preparation is entitled *Massa*, Mass (see *Massæ*). R. J. E. Scott.

Pimenta.—Allspice. The nearly ripe fruit of *Pimenta officinalis* Lindley (fam. *Myrtaceæ*). The source of this fruit is a handsome, evergreen, fragrant tree, about ten meters (30 ft.) in height, with opposite, dark-green, shining leaves and small white flowers.

The allspice tree is a native of the West Indies, South and Central America, and Mexico. It is abundant in the island of Jamaica, both wild and cultivated, and has been introduced into Asia and other tropical places.

This spice has been used in Europe for more than two centuries, and is still in great demand, both there and here, as a domestic condiment. It comes almost entirely from Jamaica, where it is obtained in enormous quantities, from both wild and cultivated trees. The fruits—like those of pepper and cubebs—are collected just before they are ripe and dried in the open air. When fully ripe, a portion of the fragrance is lost. The dried fruits are slightly smaller than the fresh; spherical or nearly so, finely wrinkled or tuberculated upon the surface, of a brown or grayish-brown color, and having a strong, agreeable, aromatic, clove-like odor. The limb of the calyx is usually rubbed away, leaving a circular projecting margin, or crown at the apex of the fruit, enclosing a shallow saucer-shaped calyx cup, from the middle of which rises the style, usually broken off at the top. The seeds are brown, flattish, exalbuminous, the embryo spirally coiled. A section of the fruit reveals, just below the surface, numerous large oil cells, some of which, projecting outward, form the small corrugations to be seen upon the outside. These cells contain most of the oil; in the seeds are fewer and smaller oil cells.

The oil of allspice (*Oleum Pimentæ*, U. S. P.), which is its only valuable constituent, can be obtained to the extent of two to four per cent. With this, occur fixed oil, resin, tannin, and gum. Allspice is little used medicinally, in doses of gr. viij–xxx. (0.5–2.0), as an ordinary aromatic, similar to cloves, but weaker. There is no official preparation, though it enters, as a carminative and flavor, into several official preparations.

The oil of allspice (*Oleum Pimentæ*, U. S. P.) is a colorless, yellow or reddish liquid, with a strong odor and taste of allspice, and decidedly pungent. When assayed by the U. S. P. process, it should yield not less than sixty-five per cent. by volume of *eugenol*, its active constituent. Its specific gravity is 1.033 to 1.048 at 25° C. (77° F.). It is miscible in all proportions with ninety per cent. alcohol, and soluble in two volumes of seventy per cent. alcohol. It forms a semi-solid mass with an equal volume of concentrated solution of sodium hydroxide. H. H. Rusby.

Pineal Syndrome.—This is a group of physical and mental signs brought into prominence by Fröhlich and Marburg. It is due to disease of the pineal gland, chiefly tumors of the same, and shows chiefly in two groups of symptoms, which are resultants of (1) the pressure of the tumor, and (2) metabolic changes, pineal proper(?) or hypophyseal through internal hydrocephalic pressure.

(1) The tumor after it has become a certain size (one-half to one inch in diameter) usually causes neurological signs. These are those usually present when there is increased intracranial pressure from the prevalent hydrocephalus. Hence there is headache, sometimes with nausea and vomiting, and giddiness, failing eyesight with papillary edema, abnormal tiredness or sleepiness, and motor signs such as increased muscular tonus, weakness of the muscles, increased tendon reflexes. Frequently there is pressure upon the corpora quadrigemina, which occasions ocular palsies, which may be for upward or downward movements or even show skew deviations. The pupils are usually widely dilated and often are sluggish to light and to accommodation. Facial palsies may be present. Buzzing or other auditory symptoms and giddiness, staggering and cerebellar signs may be noted when the tumor presses upon the cerebellar peduncles. In a few patients increased thirst and glycosuria are found. (2) Metabolic symptoms usually consist of adiposis with manifestations of altered development of the primary and secondary sexual characters. The lipomatosis is that similar to the adiposis seen in changes in the pituitary glands, particularly from hypopituitarism. There is a lack of development of the sexual organs, as a rule, although at times there is an increased growth of the primary and secondary characters, such as seen in the increased hairiness, infantile or deep voice, enlarged penis, etc. In many patients there is a pronounced cachexia. The only known mode of treatment would be possibly surgical. Smith Ely Jelliffe.

Bailey and Jelliffe: Tumors of the Pineal Body. Archives of Internal Medicine, Dec., 1911.

Kidd: Rev. of Neur. and Psychiatry. Pineal Body, 1913.

Pinehurst and Southern Pines, N. C.—Pinehurst, six hundred and thirty feet above sea-level, is situated in the "Pine Belt" of North Carolina, not far from the center of the State, about seventy-five miles southwest of Raleigh. It is a comparatively recent creation, an attempt by one person to establish a model health resort in a favorable climate.

It embraces about five thousand acres, privately owned, and under the absolute control of the owner. Much labor and expense have been bestowed upon this enterprise; the grounds have been carefully laid out by landscape architects, and every attention has been paid to the sanitary conditions, sewerage, water supply, plumbing, etc., so that one is assured of finding here most wholesome hygienic surroundings and excellent accommodations. Consumptives, however, are not received, the desire evidently being to provide a winter resort for the large number of persons who, though not ill, desire to spend the winter in a comparatively mild and equable climate where they can remain for the greater part of the time out of doors.

Invalids are also received here, according to the writer's understanding, suffering from diseases other than tuberculosis. The soil of all this upland region is sandy, quite resembling the dry sand on the edge of the seashore, in which soil the long-leafed pine flourishes. Pines and sand comprise the scenery, but this lack of variety has its compensation in the abundant sunshine and bracing air. Moreover, the peacefulness of such surroundings must be restful to tired nerves.

The average winter temperature ranges from about 44° to 65° or 70° F., said to be about that of southern France. In January, 1902, the maximum temperature was 72° and the minimum 20°, while in Philadelphia it was 54° and 15° respectively, and in Boston 54° and 4° F.

There is a large amount of sunshine, and one can

generally spend most of the time out of doors. In the Piedmont Plateau which embraces this region, the annual average rainfall is 49.85 inches, and for the winter 12.28 inches. Snow is said to appear about once in two years, but remains only for a few hours. January is the coldest month; there may then be frosts at night and thin ice may coat the ponds. Spring begins by the middle of February. Protection is afforded from the cold northwest winds by the Appalachian range and by the pine forests. Naturally there is little to attract the visitor in this monotony of sand and silent, dark pines, but art has done much to make life attractive here. There are extensive golf links and a club house; shooting preserves for quail; horseback riding, tennis, croquet, etc. There are several hotels of varying prices, and furnished cottages for rent. The water is obtained from artesian wells and is pure and good. All the conditions of modern living are found here, and every attention seems to have been given to the maintenance of a high standard of sanitary excellence. Pinehurst has electric railroad connection with Southern Pines, six miles distant, which is on the Seaboard Air Line Railroad. It is a journey of eighteen hours from New York to Pinehurst.

Southern Pines, about six hundred feet above sea-level, is six miles distant from Pinehurst, and possesses similar conditions of climate, soil, and vegetation. It is situated upon a large sand bank, and is surrounded by the characteristic pine.

It is a comparatively new town, and is essentially a winter health resort largely made up of Northern inhabitants or visitors. It has more of the features of a town than Pinehurst, there being several churches, shops, a graded school, library, electric lights, a trolley line, good water supply, and a sewerage system. There are several hotels of varying accommodations and prices, furnished cottages, apartments, and boarding-houses. Tuberculous patients are generally received here, although at the largest and most pretentious hotel, the "Piney Woods Inn," the statement is made that "confirmed consumptives will not be cared for."

Opportunities are afforded for various outdoor diversions, such as golf, tennis, driving, and small-game shooting.

It is said that several thousand visitors frequent this resort during the winter season, and it can be recommended, especially for those of moderate means and requirements who desire to live with their families in one of the many small cottages which can be obtained at a moderate rental.

Several miles south of Southern Pines is Pinebluff, which is being developed as a health resort.

The air in all this pine-belt region is pure and dry, and impregnated with the balsamic emanations of the pines. It affords favorable conditions for many cases of tuberculosis and bronchitis, for convalescents from acute diseases, and for those suffering from chronic nephritis. This region is also a convenient halting place for those going to or returning from the lower South.

The season is from November to April.

Edward O. Otis.

Pinel, Philippe.—Born at Saint-Paul, in the Department of the Tarn, France, on April 11, 1755. He studied medicine first at Toulouse and then at Montpelier, from which latter university he received his doctor's degree. Possessing very scanty financial means, and preferring a life of retirement, he devoted himself at first to the work of translating from the English. Cullen's Nosology, for example, is one of the treatises which he rendered into French (Paris, 1781, 2 vols.). In 1792 he accepted the position of Chief Physician of Bicêtre, one of the principal lunatic asylums of Paris; and it was the experience which he gained in this institution that enabled him to do two things of great importance—to write a most valuable treatise on the subject of insanity, and to substitute, in the treatment of this class of patients, kindness, gentleness, firmness, and justice, tempered with patience, for the absurd and barbarous methods commonly employed at that time—methods which made it necessary (so it was claimed) to put many of these unfortunate human beings in chains. But these were not the only ways in which Pinel rendered valuable services to the science of medicine. The publication by him, toward the end of the eighteenth century, of his admirable work on philosophical nosography at once placed him in the front rank of the most celebrated physicians of Europe. This treatise exerted a very strong influence over the epoch in which he lived. As time went on, Pinel was honored by his contemporaries in a great variety of ways. He was made Physician-in-Chief of La Salpêtrière; Professor at the École de Médecine of Paris—first, of medical physics, and afterward of internal pathology; member of the Institute, as Cuvier's successor; and, finally, Secretary general of this society. He died Oct. 26, 1826, at the age of eighty-one.

Of his published writings the following deserve special mention: "Nosographie philosophique, ou la Méthode de l'analyse appliquée à la médecine," Paris, 1798 (sixth edition, 3 vols., Paris, 1818); "Traité médico-philosophique sur l'aliénation mentale, ou la Manie, avec figures representant des formes de crânes, ou des portraits d'aliénés," Paris, 1801; and "La médecine clinique rendue plus précise et plus exacte par l'application de l'analyse, ou Recueil et résultat d'observations sur les maladies aiguës à la Salpêtrière," Paris, 1802 (third edition, 1815). A. H. B.

Pinkroot.—See *Spigelia*.

Pinta.—Pinta, or caraate, is a contagious epidermidomycotic affection limited to tropical countries, where it is extremely common. It consists of different sized and shaped scaly lesions most frequently located upon the exposed surfaces of the body. The color of the lesions varies according to the color of the individual's skin. In the dark races the spots are of a reddish or grayish color, occasionally shading into a bluish black. In the whites, reddish or yellowish colors prevail.

The disease begins as an erythema, which is soon covered with fine brany scales. The lesions extend peripherally, new spots appearing in their immediate vicinity. As the disease progresses, the scaling becomes more marked. A considerable degree of pruritus is invariably present. There are several forms of the affection, each probably due to different varieties of the aspergillus fungus. The disease is essentially chronic, its course running on for months or years. As it retrogresses, it leaves depigmented areas which are permanently indelible. These are apparently caused by the invasion of the rete by the fungus, with subsequent disappearance of the pigment. The vitiliginous spots, however, differ somewhat from true leucoderma. According to Wise, who has seen a large number of cases, there are numerous islands of normal pigmented skin; the areas are not as large, nor are there borders as well defined as in true leucoderma. The disease extends by autoinoculation from scratching. It is much more prevalent in people of unclean habits. Filth and disinclination for soap and water are important predisposing factors. Caraate is caused by various fungi of the aspergillus class. Montoya has found similar organisms in plants, stagnant waters, etc. The disease may therefore be transmitted by direct contact, or intermediate agency, such as insect bites. The mycelia are highly refractive, their filaments are short and non-branching. The spores are pigmented and round or oval in shape. The disease may be very extensive, even

at times invading the buccal or vulvar mucous membrane, it does not however affect the general health.

The treatment is that employed for other epidermidomycotic dermatoses. In recent patches tincture of iodine or sodium hyposulphite is very useful, the latter in about a twelve per cent. dilution. Ammoniated mercury should prove of benefit. In older patches chrysarobin seems to be the favorite therapeutic agent. PAUL E. BECHET.

Piophila.—A genus of flies. The larva of one species, *P. casei*, is the cheese skipper and causes intestinal, and rarely nasal, myiasis. A. S. P.

Piorry, Pierre Adolphe.—Born at Poitiers, France, on Dec. 31, 1794. He received his doctor's degree from the University of Paris in 1816, his graduation thesis bearing the title: "Sur le danger de la lecture des livres de médecine pour les gens du monde." In 1826 he was made an Agrégé, and in 1827 a Médecin des hôpitaux. Very soon after Laënnec had published his treatise on auscultation, Piorry announced the invention of his plessimeter; and in 1828 he wrote an essay on the subject ("Traité sur la percussion médiate"), and was awarded, for this work, one of the Monthyon Prizes. In 1840 he was made Professor of Internal Pathology in the Faculté de Médecine. From 1864 to the tme of his retirement he held the position of Professor of the Medical Clinic at Hôtel-Dieu, as Trousseau's successor. He died in 1879.
A. H. B.

Piper.—PEPPER, *Black Pepper. Piper Nigrum.*—The dried, nearly ripe fruit of *Piper nigrum* L. (fam. *Piperaceæ*) U. S. P.

The pepper plant is a native of India, but commercial pepper is wholly the product of cultivated plants, and comes chiefly from the East Indies, that of Penang being preferred. The plant is a woody climber, and is trained chiefly to the betel tree. The fruits are produced in aments, somewhat resembling strings of currants. Upon ripening they turn first red, then yellow. After the latter change their properties are largely lost. They are therefore gathered and dried when they begin to change color.

DESCRIPTION.—About four millimeters ($\frac{1}{16}$ in.) in diameter, nearly globular, blackish, very strongly reticulate-wrinkled, bearing a low style base at the summit and consisting of a thin fleshy pericarp and a crustaceous, whitish putamen containing a more or less undeveloped seed; odor characteristic, strong; taste strongly aromatic and pungent.

A transverse section of pepper shows a layer of large resin cells near the surface, and beneath this a soft parenchyma (shriveled in the dry state) containing starch and oil drops. The inner portion of the pericarp contains large oil cells and the seed shows brownish masses of amorphous piperin.

Piper Album, or *White Pepper*, is pepper with most or all of the fleshy portion removed, either before drying ("natural") or by subsequent grinding ("machine"). One variety ("Singapore") consists of the very young fruit dried entire. Its pungency varies accordingly. If nearly ripe when gathered, it is less pungent than it is when the innermost layers of the sarcocarp have been rubbed or ground away, since these are rich in the active constituent.

COMPOSITION.—The pungency of pepper is due to the presence of ten or twelve per cent. of soft, very sharp-tasting *resin*, which is contained, as indicated above, mostly in the cells just beneath the surface. An *essential oil* of clear white color, having the full fragrance of the spice without its biting taste, exists to the extent of one or more per cent. The third and most peculiar ingredient is the neutral, crystalline, and inodorous substance *piperin*, which exists to the extent of from two to eight per cent. It was discovered by Oerstedt in 1819. On decomposition it yields *piperidine*. Piperin (*Piperina*, U. S. P.) is scarcely soluble in water, but dissolves moderately well in chloroform, ether, and alcohol; at 212° F. it melts to a yellow, oily liquid. Although it is at first tasteless, it develops a strong pungency if kept in the mouth for some time. Besides these, starch, mucilage, and albuminous matters are found, as in other vegetable tissues.

ACTION AND USE.—Applied to the skin, pepper is rubefacient, and finally painfully irritant. It is occasionally sprinkled over the surface of other applications for this effect. In water it is a popular but painful gargle for "sore throat." Taken internally, it is in small doses a stimulant, in large ones an irritant to the stomach—that is, it acts like most other spices. It has been given as a specific in the treatment of hemorrhoids, but is out of use for this purpose. As an antiperiodic it is also obsolete, although piperin is occasionally mentioned in this connection. Whole peppers were formerly swallowed for the cure of some cases of dyspepsia. Dangerous symptoms—"rigors, convulsions, and delirium"—have been said to follow the immoderate use of pepper (Phillips). Although a typical spice, pepper is much less employed in medicine than ginger, cardamom, and cinnamon.

ADMINISTRATION.—For dyspeptics or others needing spices, there is no better way than to eat it on the food, or if a larger quantity is indicated than is agreeable to the taste, gr. vij. (0.5) or less may be given in pills or in a bolus, with honey, two or three times a day; or four or five drops of the *oleoresin* (*Oleoresina Piperis*, U. S. P., strength about $\frac{2}{1}$) may be taken if a more compact and stronger dose is needed. Dose of piperin, gr. vij. (0.5) or less. Commercial ground pepper has been subject to enormous adulteration, now largely restricted by the pure food and drug laws. Olive stones, shells of nuts and similar substances have been ground with it. A favorite method has been to add the outer pericarp, "pepper shells," removed in preparing machine white pepper. This increases the percentage of ash and reduces that of starch, which enables it to be detected. The best method of detecting impurities is by the use of the microscope.

ALLIED PLANTS.—The genus is a very large one, of 600 species, of exclusively tropical plants, mostly shrubs, and frequently, like the present one, climbers. Many of them have pungent fruits. *P. officinarum* Cas. D. C., and *P. longum* Linn., are the sources of "long pepper," which comes in compact spikes one or two inches (2–5 cm.) long, and about a sixth (0.5 cm.) in diameter. Its constituents are identical with those of the above, but its flavor and strength are inferior. Long pepper is never sold at retail in this country, yet it is a common article in wholesale houses; it is probably used as an adulterant of black pepper. *P. betle* Linn. is an East Indian vine whose leaves are chewed with areca nuts as a masticatory (or a habit) by many aboriginal tribes of the great Polynesian Islands. H. H. RUSBY.

Piperazin.—*Diethylene-diamine* $(C_2H_2NH)_2$. A synthetical compound primarily intended to replace spermin, but found to be a different body, both in chemical and in physiological characters. It is now utilized only as a solvent for uric acid in the place of lithia salts.

When prepared by a patented process it is supplied to the profession under the name of piperazin. It forms in bright, lustrous tablets which are extremely hygroscopic.

Laboratory experiments showed that it possessed unusual solvent properties upon uric acid and vesical calculi. It was stated to be twelve times as active as lithium salts. From this it was recommended as a valuable remedy in the treatment of gout and allied conditions, to promote the excretion of uric acid and dissolve vesical and renal calculi. It has been found to possess a diuretic action and to be of benefit in the treatment of rheumatic conditions and in conditions where there is an excess of uric acid, but it has not proved to be of any value in reducing or removing calculi when they are present. It is a harmless remedy when given in doses of fifteen to thirty grains a day, well diluted. On account of its unstable property, it should be given in freshly prepared solutions.

BEAUMONT SMALL.

Piperonal—heliotropin, methylene ether, protocatechuic aldehyde, $C_6H_3.COOH.O.CH_2$—occurs in small white crystals with a strong odor of heliotrope, and is soluble in alcohol and ether and insoluble in water. It is derived from safrol by oxidation with chromic acid. In dose of gr. viij.–xv. (0.5–1.0) it is antiseptic and antipyretic. It is also used in perfumery.

W. A. BASTEDO.
R. J. E. SCOTT.

Pipsissewa.—See *Chimaphila.*

Piqûre.—When the floor of the fourth ventricle of animals is punctured a transient glycosuria results which is designated *piqûre* glycosuria, the term first being applied by Claude Bernard who discovered this relation between injury to the nervous system and carbohydrate metabolism.

F. P. U.

Pirogoff, Nikolai Ivanovich.—Born at Moscow, Russia, Nov. 25, 1810. He entered the University of Moscow in 1825, and received the degree of Doctor of Medicine from that institution in 1828. Immediately after graduation he visited the University of Dorpat, for the purpose of continuing his medical studies, particularly in the departments of anatomy and surgery, for which he already at that time showed a decided preference. Then, in 1832, not yet being satisfied with the knowledge which he had acquired, he left Dorpat and visited in turn the universities of Berlin and Goettingen. Finally, in 1836, he received a call to fill the Chair of Surgery in the University of Dorpat, and continued to hold this position up to the year 1840. It was during this period that Pirogoff published those essays on the arteries and the fasciæ which gave him considerable celebrity throughout Europe; this statement applying more particularly to his large Atlas of the Surgical Anatomy of the Main Arteries and the Principal Fasciæ of the Human Body. In 1840 he accepted a call to fill the Chair of Hospital Surgery in the Medico-Military Academy of St. Petersburg. In 1847 he introduced the practice of etherization into Russia. In 1848 he began his studies in relation to Asiatic cholera, and performed, during the progress of this work, over 800 autopsies. During the years 1854–1858 he was kept actively at work in the army hospitals at Sebastopol, in the Crimea. During the latter years of his life he lived very quietly on his estate, rarely taking part in any public function. He died Dec. 5, 1881.

The perpetuation of Pirogoff's name in the history of medicine is assured by the operation which he devised for amputating the foot—"Pirogoff's amputation." The treatise which he published on this operation bears the following title: "Osteoplastische Verlängerung der Unterschenkelknochen bei der Exarticulation des Fusses," Leipzig, 1854.

A. H. B.

Piroplasma.—A generic name which was used for *Leishmania* by Laveran and Mesnil, and for *Babesia* by Smith and Kilbourne. See *Protozoa.*

A. S. P.

Piscidia.—JAMAICA DOGWOOD.—The bark, preferably of the root, of *Ichthyomethia piscipula* (L.) Kuntze (*Erythrina piscipula* L.; *Piscidia erythrina* Jacq.) (fam. *Leguminosæ*), a large West Indian tree yielding a valuable wood. Its use as a fish poison is ancient. It is crushed and prepared, then dragged through the water in baskets, the fish being quickly narcotized and then easily caught. It has also had for a long time a local reputation for relieving pain, especially toothache, which was treated by applying it, or some preparation of it, locally, in the carious cavity. In this country it has been used for various conditions, generally including pain of so-called nervous character, with uncertain, but on the whole favorable, results. Judging from the published reports, it has been more used in the Western and Southern States than in the East.

The drug occurs for the most part in strips, from six inches to two feet long and up to six inches in breadth. These strips are usually more or less curved, the smaller ones sometimes quilled, the larger sometimes flat, but warped. The thickness of the bark varies from one-twelfth to one-fourth inch. The bark of the root is in shorter and smaller pieces, more irregularly curved, and less fibrous and tough. It is grayish or yellowish brown and often mottled externally, dark brown and fibrous next the wood, frequently with large patches looking as though stained of a bluish green. Upon fracture, the central tissue is seen to be dark green. Odor narcotic; taste disagreeable, acrid.

It contains resin, the crystalline amaroid *piscidin* ($C_{29}H_{24}O_8$), soluble in hot alcohol, and a water-soluble glucoside which is apparently the fish-stupefying agent. The "piscidin" of the market is not a chemical body but merely a resinous extract.

Jamaica dogwood appears to have decided narcotic powers over most animals, it certainly does in a marked degree upon fish, as its original use shows, and in case of frogs and several kinds of higher animals it exhibits the same qualities. The following summary is from experiments by A. C. Nagle: "It is a narcotic to higher as well as lower animals. It dilates the pupil, it causes an increase in the respiration, followed by a sudden decrease; produces salivation and profound diaphoresis; reduces the action of the heart, producing general paralysis and death by asphyxia. It has little effect upon the temperature." In therapeutics it has been tried with good results in neuralgia, headache, hysteria, "phantom tumor," "nervousness," melancholia, prodromic labor pains, neurasthenic pains of various places, etc., as well as for some inflammatory pains, such as those of iritis. It also serves a good purpose as a hypnotic in restlessness, alcoholic wakefulness, etc. For certainty and uniformity of action it is not to be compared with opium or chloral, and disagreeable feelings sometimes follow its administration, as well as that of these more powerful drugs. The fluid extract is usually given in doses of fl. ʒss.–i. (2.0–4.0).

HENRY H. RUSBY.

Piso, Willem.—A Dutch physician who was distinguished for having been the first to introduce ipecac into Europe, for having described fully the virtues of this drug, and for having brought about its adoption as a valuable remedial agent. He flourished in the early part of the seventeenth century, practising first at Leyden and afterward at Amsterdam. He accompanied Prince Maurice of Nassau on his voyage to Brazil, and subsequently published a treatise which bears the following title: "De medicina Brasiliensi

libri quatuor," 1648 (illustrated). Ten years later he published a second book, the title of which reads as follows: "De Indiæ utriusque re naturali et medicina libri quatuordecim," Amsterdam, 1658. The date of Piso's death is not known. A. H. B.

Pitcairne, Archibald.—Born at Edinburgh, Scotland, Dec. 25, 1652. After receiving his academic education at the University of Edinburgh, he was sent to France for the benefit of his health, and in 1680 he obtained the degree of M. D. at Rheims. Upon his return to Edinburgh he began the practice of his profession, and soon attained such eminence that the University of Leiden, Holland, gave him in 1692 the position of Professor of Medicine in that institution. As both Boerhaave and Richard Mead, who were his pupils at Leiden, spoke in strongly appreciative terms of the benefit which they had derived from Pitcairne's instruction, the inference is warranted that his career as a teacher at that university, although of only one year's duration, was thoroughly successful. He rose to be the most eminent physician in Scotland, and it was largely through his efforts that the authorities were finally induced to permit the dissection, under proper restrictions, of human corpses—a privilege which soon enabled the Edinburgh School of Medicine to become one of the best in Europe. He died on Oct. 20, 1713.

Of his published writings the volume entitled "Dissertationes medicæ," published in 1701, and a second edition in 1713, is the only one which is of special interest to physicians. A. H. B.

von Pitha, Franz.—Born at Rakom (or Rakomitz), Bohemia, Feb. 8, 1810. He began his medical studies at the University of Prague, and received from that institution the degree of Doctor of Medicine in 1836, and that of Doctor of Surgery in 1837. From 1838 to 1841 he acted as an assistant in the Surgical Clinic of Prof. J. Fritz. Two years after the death of the latter (in 1841), Pitha was chosen his successor. In 1844 he became one of the founders of the *Prager Vierteljahrsschrift für praktische Heilkunde*, and contributed to its pages (1844–1847) a number of important articles on the following topics: "Ueber die Diagnose und Pathologie eingeklemmter Brüche," Nos. VIII, IX and X; "Ueber subcutane Venen-Unterbindungen," No. XII; "Ueber Teleangiektasien," No. XIII; "Ueber Aether-Inhalationen bei chirurgischen Operationen," No. XVII; "Ueber Chloroform," No. XIX; "Ueber Bronchotomie und deren Indicationen," No. LIII; "Ueber Oedem der Glottis," No. LIV; and a few others. In 1854, when the Medico-Chirurgical Josephs-Academy in Vienna was reopened, Pitha accepted a call to fill the Chair of Surgery in this institution, and at the same time to be at the head of its Surgical Clinic. In 1859, after his service during the Italian Campaign, he was made a noble by the Austrian Government; and then again, in 1866, after the War with Prussia, he received the title of Medizinal Hofrat. He died Dec. 29, 1875.

Of von Pitha's published writings (other than those already enumerated) the following deserve to receive special mention: "Krankheiten der männlichen Geschlechtsorgane," 1864 (in R. Virchow's Handbuch der speziellen Pathologie und Therapie, VI); and the "Handbuch der allgemeinen und speziellen Chirurgie," which he edited in association with Prof. Billroth, and in which he wrote the chapters relating to diseases of the upper and lower extremities.

A. H. B.

Pituitary Gland.—See *Hypophysis Cerebri.*

Pityriasis.—Pityriasis is an affection of the skin in which there is slight redness accompanied by a branny desquamation. The term was formerly used to describe many scaly conditions of the skin, but it is gradually passing out of use, as the conditions are now described under other headings.

Pityriasis of the scalp is the dry form of dandruff in which the scales do not adhere, but fall whenever the hair is brushed. Pityriasis of the face and neck is usually found as ill-defined slightly scaly patches with very little redness. This condition is described by most authors under seborrhea. (See *Dermatitis Seborrhoica.*)

Pityriasis rosea, Pityriasis rubra, and Pityriasis rubra pilaris are described under their own titles, and Pityriasis versicolor under *Tineas.*

Pityriasis Rosea.—This is a disease of the skin characterized by the development largely upon the trunk of symmetrically distributed patches, oval or circinate in outline, slightly scaly, and of a faint red color. It is one of the less common dermatoses. The disease has been described under several names. Pityriasis rosea, the name given it by Gibert, is the one nearly universally used now. It was described by Hebra under the name Herpes tonsurans maculosus, and by Bazin under the title Pityriasis maculata et circinata.

Symptomatology.—The eruption usually develops acutely, appearing in two forms, the macular and the circinate. Probably the first lesion in both forms is a very small pinkish macule or papule which rapidly spreads to form the characteristic macule or patch of the disease. In the macular type the lesions are roundish patches, gradually fading into the healthy skin, of a pinkish color and covered with fine branny scales. These patches vary in size from one-sixteenth to three-quarters of an inch in diameter, and are of a reddish to fawn color. Frequently the periphery of the lesions will show the erythematous color while the center will be fading.

The circinate type of the disease differs from the macular in that the tendency of the patches to spread peripherally is more marked. In this form the border spreads while the center fades. The typical lesion of this form, therefore, is an oval or circular patch with a pinkish border and a fawn-colored scaly center. The characteristic arrangement on the trunk is with the long axes in the lines of cleavage of the skin. Adjacent patches of this sort may coalesce and thus form peculiar gyrate figures. These patches do not usually become larger than an inch in diameter. By the time they reach that size the reddish border breaks up and fades out, leaving the characteristic fawn-colored stains of the disease. The lesions are apt to occur in successive crops, so that it is possible to see at one time the minute papules of the beginning of the disease, along with the patches and circinate figures of a later stage of the process. At times the eruption remains papular for the most part throughout its entire course, only a few patches or circinate figures developing.

Brocq called attention to the fact that a single primary patch, usually of large size, and situated upon the abdomen, preceded by ten days or two weeks the general eruption, and this observation has been confirmed by other dermatologists.

The extent of the eruption varies very greatly. In some cases it is confined to one or two regions, but most frequently it is widely distributed. It occurs by preference on the front and sides of the abdomen, over the chest and on the buttocks, and on the front and sides of the neck. It may be universal, but it rarely develops on the face or below the elbows and knees. There is also considerable variation in different cases in the color of the lesions, which at times

show an inflammatory red but more frequently a pinkish or fawn color. The eruption usually disappears in from two or three weeks to two or three months, but cases not infrequently last longer, even for four or six months.

The appearance of the eruption is usually preceded by a slight rise of temperature with general malaise, but these systemic manifestations are usually so slight as to pass almost unnoticed. There may be some enlargement of the lymphatic glands. This may be confined to the submaxillary and postcervical glands. At times also the axillary and inguinal glands show slight painless enlargement. There is slight itching, particularly at night, or when the patient gets overheated, but it is not of severe character and causes little or no annoyance.

Etiology.—The etiology of the disease is unknown. It is most frequent in early adult life, but occurs at all ages and in both sexes. It was thought by Hebra to be a mycotic affection, and this view has many advocates. Vidal has described a parasite "Microsporon dispar," and Du Bois, 1912, from five cases believes he has confirmed Vidal's findings. The fungus has not been cultivated. The symmetrical distribution of the eruption, its color and annular or papular character, and the accompanying slight febrile disturbance suggest that it may be allied to erythema multiforme.

Histopathology.—Microscopically the changes found are those of a slight inflammatory process in the skin. The organism described by Du Bois was demonstrated by special methods.

Diagnosis.—The exceedingly trivial character of the systemic disturbances and the duration of the eruption serve to distinguish it from the exanthemata. From psoriasis and widely distributed forms of seborrheic eczema occurring in small patches, it is distinguished by the extreme superficiality of the patches, the much lower grade of inflammation, and the character of the scales, the fine branny scales of pityriasis rosea presenting little similarity to the coarser scales of psoriasis and seborrheic eczema. From tinea circinata it is distinguished by its much wider distribution, the rapid development of the lesions, and the absence of the ringworm fungus. It is most likely to be confused with the squamous and circinate syphilides, from which it is distinguished by more rapid development, less scaling, lack of induration, absence from the face and hands, and the absence of concomitant symptoms of secondary syphilis.

Treatment.—The disease is self-limited and requires very little treatment. Constitutional treatment should be symptomatic. Certain authorities think they have seen benefit from the use of salicylic-acid compounds. A mild antipruritic dusting powder lotion or salve is all that is necessary in the way of local treatment. Wm. Allen Pusey.

Pityriasis Rubra.—Pityriasis rubra is a dermatitis, usually subacute or chronic in intensity, in all but the most exceptional cases universal, and characterized by abundant dry desquamation. Other names by which the condition is known are dermatitis exfoliativa (Wilson), pityriasis rubra aigu (Devergie), erythrodermie exfoliante (Besnier). It is a rare condition, and is rather a symptom complex than a definite pathological entity.

Symptomatology.—The disease may begin primarily as pityriasis rubra, or it may develop upon other inflammatory dermatoses. When occurring primarily it may begin in either of two ways. In some cases it begins as a diffuse hyperemia, which increases until the skin becomes a bright red, and with the increase in redness there is the development of the characteristic desquamation. In other cases it begins as circumscribed red scaly patches. These spread peripherally and new patches form at the same time, until the entire surface becomes involved in the process. In the early stages of the disease the skin is of a bright, hyperemic red color, which fades on pressure, and the induration is very slight. As the process becomes older the redness becomes of a deeper hue, and in some cases has presented a markedly venous character. There is also at times, even when arsenic has not been used, the development of marked pigmentation in the skin. The true color of the skin is more or less concealed by the abundant grayish scales which cover it. The abundance of this desquamation is one of the most salient characteristics of pityriasis rubra. The scales are dry and grayish in color; at times they are fine, but usually, except on the face, they occur as thin papery flakes. On the palms and soles the horny epidermis exfoliates in large flakes, which may at times amount to masks of the parts. The scales are easily detached and quickly reform. A quart or more of scales may be produced in twenty-four hours, so that they can be collected by the handful from the patient's bed. There is usually very slight induration of the skin, although after the disease has persisted for a long time the skin may become considerably indurated and stiffened as a result of the chronic inflammatory process. Rarely is there any free exudate. Except for perspiration the skin is dry, although a certain amount of weeping and even the formation of bullæ have been described. When we come, however, to cases of this character, accompanied by bullæ and free exudation, the borderline between this disease and pemphigus foliaceus becomes confusing.

There is more or less involvement of the appendages of the skin. The growth of the hair is interfered with and much falling of the hair takes place. At times the accumulation of scales underneath the nails causes them to be raised up and thrown off. Again the nails may become thin and softened and stunted or lost entirely. In some cases the nails become thick and rough and striated. The secretion of sweat is usually much diminished, but there may be an increase on such parts as the axillæ and genito-crural fold. The tongue in most cases is bright red, undoubtedly due to the exfoliation of the epithelium, which is washed away in the saliva.

The subjective symptoms are relatively unimportant. In rare cases the itching is severe, but usually it is of trivial character or absent. The sensation is more apt to be one of tenderness, burning, and stiffness of the skin. Chilliness and extreme sensitiveness to cold are characteristic of the condition, as they are of all universal inflammatory dermatoses. The onset of the disease is usually accompanied by a temporary febrile disturbance, which may recur with each exacerbation of the process. Except for such slight disturbances there may be no positive illness, although there is usually an indefinite lowering of the general physical tone, which becomes more marked as the disease progresses. Later on, the patients become anemic, cachectic, and emaciated, and thus become the ready prey to intercurrent affections. Insanity, and other mental and nervous disturbances have been noted in a number of the cases.

The acute cases are often accompanied by very violent constitutional symptoms, with all the evidences of grave septic or nutritional disturbance. The temperature may range as high as 105° or 106° F. There may be great depression, diarrhea, rigors, and a typhoid condition, and death may occur in one or two weeks.

Etiology.—The cause of the disease is unknown. It is probable that several conditions, essentially different, present this complex of symptoms. It is rare in children and occurs most frequently after middle life. It is more frequently observed in men than in

women. Crocker thinks there is a close relationship between acute rheumatism and gout and pityriasis rubra, eleven out of eighteen cases which he analyzed having shown this relationship. Jadassohn and more recently Sachs have pointed out the frequency of the association of tuberculosis in some form with pityriasis rubra. In recent years many of the cases have been found in association with generalized adenopathy and there are good grounds for the belief that in these cases the skin symptoms are a manifestation of intoxication caused by the elaboration of toxins in diseased lymph nodes. The condition is a rare complication of leucemia, pseudo-leucemia and tuberculous adenitis. It is recognized that pityriasis rubra may supervene upon psoriasis, eczema, and other inflammatory affections. Brocq has seen a severe acute attack brought on by the vigorous application of chrysarobin, and Crocker has seen it follow vigorous inunctions with mercurial ointment and the external use of arsenic. Stelwagon has seen it develop on the extremities after the use of quinine by patients who had an idiosyncrasy as regards that drug. Since the introduction of salvarsan many cases have resulted from the administration of that drug. It has also been seen rarely from the administration of other forms of arsenic and of mercury. These forms from the internal administration of drugs or local use of drugs usually run an acute course with recovery in a relatively short time. As an exciting cause, sudden chilling of the body has in some cases seemed to have a direct relationship to the development of the disease, and in other cases it has been excited by alcoholic debauches.

Pathology.—Microscopically the disease shows nothing to differentiate it from other simple inflammatory processes in the skin. There are the usual changes of a superficial dermatitis, and when the disease has persisted for a long time there are the connective-tissue changes characteristic of chronic inflammation of the skin. Several efforts have been made to discover central or peripheral nerve changes in connection with the disease, but without definite findings.

Diagnosis.—The involvement of the entire skin, which occurs in all but the rarest cases, the profuse dry desquamation, the slight induration, together with the rapid development, are the prominent characteristics of the disease.

If it is admitted that psoriasis or a squamous eczema could become absolutely universal and of uniform type of eruption throughout, it is possible that they might be confused with pityriasis rubra. It is hardly likely, however, that this ever occurs. A universal psoriasis could be differentiated by the gradual development, the greater induration of the skin, and the thick, silvery white, closely adherent scales of that disease, and the hemorrhagic puncta following the forcible removal of the scales. It is hardly conceivable that an eczema could show a uniform type of eruption over the entire body, such as is seen in pityriasis rubra. Additional points of distinction from eczema would be the yellowish crusts of eczema, the presence of more or less free exudate, less rapid onset, greater induration of skin, more itching, and less evidence of constitutional disturbance.

The two conditions with which pityriasis rubra is likely to be confused are pemphigus foliaceus and pityriasis rubra pilaris. In pemphigus foliaceus there is the occurrence of flaccid bullæ, which, if not seen themselves, at least leave traces of their existence in undermined borders of epidermis and in the excretion of serum and pus, which dries in crusts upon the surface and gives rise to the sickening characteristic odor of pemphigus foliaceus. Pityriasis rubra pilaris does not develop so rapidly as pityriasis rubra, is not so likely to be universal, is accompanied by much greater induration of the skin, and shows the characteristic papules, which are entirely absent in pityriasis rubra. These rough, dry, horny papules, capping the hair follicles and giving the skin the nutmeg-grater appearance, that are seen on the back of the fingers and hands in pityriasis rubra pilaris, are entirely absent in pityriasis rubra.

Treatment.—The patients are made much more comfortable by emollient local applications. The essential thing is to keep the skin thoroughly lubricated. This may be done with vaseline, rose ointment, olive oil, lanolin, or mixtures of these in the form of liniments. C. J. White strongly recommends a powder treatment of these cases. The treatment consists essentially in keeping the patient enveloped in a bland, dry dusting powder. For this purpose nothing is better than talcum. The powder should be used by the gallon, and the patient kept continuously covered by it. For the first day or two the treatment is distressing because of the dryness of the skin that it produces, but the ultimate result in many cases is surprisingly good. Presumably the action is due to the drying effect of the powder. In severe cases much benefit may be obtained by keeping the patient immersed in a continuous bath. The internal treatment is symptomatic, and is directed toward building up the patient's general health. Arsenic and quinine have both been advised empirically without very strong evidence of their having any specific effect. Mook has found intravenous injections of quinine useful in the cases. The patients should be carefully protected against chilling, and they do best when they stay in bed. There is little evidence that treatment has any effect except in relieving symptoms.

Wm. Allen Pusey.

Pityriasis Rubra Pilaris.—This is a chronic inflammatory disease of the skin, characterized by the development at the mouth of the hair follicles of firm acuminate papules consisting essentially of epidermal plugs usually pierced by broken hairs. A confluence of these elementary lesions produces the large inflammatory, slightly scaly areas of the disease. In most cases the eruption becomes practically universal. Occasionally it is limited to extensive patches, often of polycyclic outline.

The disease was first described under the above title by Devergie. There has been much discussion over the attempts to identify it with lichen ruber of Hebra and lichen ruber acuminatus of Kaposi. It is now generally accepted that these three terms describe the same condition, and Devergie's name, Pityriasis rubra pilaris is generally used. The most important contributors to our knowledge of the disease since Devergie are Besnier and Brocq.

Symptomatology.—The disease may begin insidiously in fine branny scaling of the scalp, face, palms, or soles, but as a rule when first seen the process shows red, thickened, rough patches about the borders of which the characteristic horny papules may be found. The most typical lesions of the disease are the papules in the skin on the posterior surface of the fingers between the joints. Here they occur as discreet, horny, black-tipped papules which produce a peculiar nutmeg grater appearance. These lesions on the fingers are usually seen early, and are present in nearly all the cases. The patches of the disease are produced by the confluence of individual papules which do not themselves enlarge. The extensive patches of the disease show the skin thickened and red with a moderate amount of desquamation. The disease may remain in patches or it may become practically universal. In the extensive cases the hair and nails show the effects of the disease. The nails become thin and fragile. The hair is likely to be lusterless, sparse, and short.

Subjectively, there is considerable discomfort from fissuring of the skin, particularly on the hands, and from hypersensitiveness to external irritants due to

the defective horny layer. The general health of the patient may be apparently unaffected, but in the universal cases after several years the patients become reduced in strength and they are usually carried off by some intercurrent malady.

Etiology and Pathology.—The etiology of the disease is unknown. The onset is usually during adolescence and early adult life, but a case has been reported as early as two and a half years. A number of observers have called attention to the coincidence of tuberculosis in patients suffering from pityriasis rubra pilaris as well as in other types of exfoliative dermatitis, and have suggested a possible etiological relation between the two. The pathology is briefly that of an inflammation of the corium with secondary changes in the epidermis, the most conspicuous of which are the formation of hyperkeratotic plugs pierced by hairs and deeply set in the mouths of the hair follicles.

Diagnosis.—Recognition of the elementary lesions, the acuminate, horny, follicular papules is the first essential to a diagnosis. Characteristic lesions can often be found on the edges of confluent patches, or most frequently on the backs of the hands and fingers, where the minute blackish horny plugs, each pierced by a hair, are almost pathognomonic.

The disease must be differentiated from keratosis pilaris, from lichen planus, from ichthyosis, from psoriasis, and from pityriasis rubra of Hebra. From keratosis pilaris it may be distinguished by the fact that keratosis pilaris is usually more limited, and effects the extensor surfaces of the extremities chiefly, and is very slightly, if at all, inflammatory. The livid violaceous color of lichen planus is usually distinctive. Ichthyosis is congenital and lacks the inflammatory features of pityriasis rubra pilaris. The characteristic elementary lesion of psoriasis, the silver-scaled papule, larger than the follicular lesion of pityriasis rubra pilaris, and the capillary bleeding points found on lightly scraping the psoriatic lesion, suffice for a diagnosis. Pityriasis rubra of Hebra lacks the distinct papules and the infiltration of the patches which occur in pityriasis rubra pilaris, and atrophy of the skin is also distinctive in the former condition.

Treatment.—The condition is resistent to treatment, and thus far palliation alone has been possible. The use of a bland ointment is desirable in order to protect the skin, and soften it, and to overcome scaliness. For this purpose vaseline is as good as anything, or an oil, such as olive oil, may be used. The addition of a small quantity of salicylic acid, one or two per cent. to such an application may act as an antipruritic, or other antipruritics such as camphor-choral in the proportion of one or two per cent. may be added. Internally arsenic and protiodide of mercury are recommended on empirical grounds. Cod-liver oil also is recommended. The administration of thyroid gland has been disappointing. There is no evidence that any drug is of specific value in the disease. In general the patient should be sustained in every way possible and made comfortable. There is no evidence that anything more than rational measures in the way of treatment are of any value.

Wm. Allen Pusey.

Pix Burgundica.—Burgundy Pitch. This opaque resin is nominally, and properly, obtained in Europe from the Norway spruce, *Abies abies* (L.) Rusby (*Pinus* A., L.; *P. picea* Du Roi—fam. *Pinaceæ*), a magnificent evergreen with a pyramidal head reaching forty meters or more in height, and having branches even down to the very ground. Its cones are large and pendant, its foliage is close, and of a brilliant green color. It is an abundant forest tree of Northern Europe and Asia, and a freqent ornamental one here.

Burgundy pitch is not an empyreumatic product like common black pitch, but a turpentine which has been exposed to hot water or steam, and has in consequence taken up enough of it to become opaque. It is collected by making rather deep incisions in the trunks of the trees, scraping off the resinous sap that flows out, boiling it in water, and straining it through cloths. The collection is carried on in Austria and Switzerland, but not to a very great extent, and is diminishing. In the place of this genuine article, the turpentine of other European Pinaceæ, prepared in the same way, is frequently substituted, and is sanctioned in most countries; and besides this, an entirely spurious preparation of common American rosin, mixed with oil or fat and water, is the common (false) Burgundy pitch of the market. That sold in this country is said to be almost never genuine. The following is the official description:

Hard, yet gradually taking the form of the vessel in which it is kept: brittle, with a shining, conchoidal fracture, opaque or translucent, reddish brown or yellowish brown; odor agreeably terebinthinate; taste aromatic, sweetish, not bitter.

It is almost entirely soluble in glacial acetic acid, or in boiling alcohol, and partly soluble in cold alcohol.

The principal portion of this substance—eighty per cent. or more—is *resin*, amorphous and opaque until the water is evaporated off, then clear; from three to five per cent. of *essential oils* is also present.

It is a mildly stimulating substance when applied to the skin; taken internally it has the properties of common rosin, or, in a mild degree, those of turpentine; stimulating in small doses, irritating in large ones; but it is milder in its taste and action than common turpentine. Its medicinal use is almost entirely confined to its presence in a few plasters. Burgundy pitch plaster (*Emplastrum Picis Burgundicæ*). Burgundy pitch, 80 parts; yellow wax, 15 parts; olive oil, 5 parts, melted together. It may be used as it is, or as the basis for other more active medicaments. The pitch plaster with cantharides is more stimulating; it consists of Burgundy pitch, 92 parts; cerate of cantharides (thirty-two per cent.), 8 parts, melted together after straining the cantharidal cerate through a very fine strainer.

H. H. Rusby.

Pix Canadensis.—Canada or Hemlock Pitch. This is a product of the *Hemlock Spruce, Tsuga canadensis* (L.) Carr. (*Pinus* C. L.; *Abies C.* Mx.—fam. *Pinaceæ*), collected and prepared in much the same way as the preceding. It appears often to have been boiled for a greater length of time, and is frequently very dark, almost black in consequence. It is described as follows: "Hard, yet gradually taking the form of the vessel in which it is kept; brittle, with a shining conchoidal fracture, opaque or translucent; dark reddish brown; having a weak, somewhat terebinthinate odor." Canada pitch has essentially the same composition and properties as the preceding, and is used for the same purposes. A plaster is made of it in exactly the same way as the Burgundy pitch plaster (see above).

W. P. Bolles.

Pix Liquida, U. S.—Tar, *Pine Tar.* An empyreumatic oleoresin obtained by the destructive distillation of the wood of *Pinus palustris* Miller, and of other species of *Pinus* (fam. *Pinaceæ* or *Coniferæ*).

The essential features of tar distillation are the partial burning of a wood rich in turpentine, the heat thus produced serving to expel from the wood near it the volatile and liquid products present, or which form during the process, the volatile ones ascending into the flame and being destroyed, the heavier ones settling downward and being collected as tar. It is

almost altogether performed in rude stills constructed in the forest where the wood is gathered. The still is formed by stacking the wood upon a level and hardened spot of ground, surrounding it with a trench leading into a pit and surrounding the stack with a circle of earth and sods, thus preventing the free access of air. The stack is then ignited at the top and slowly burns downward, the expelled tar gradually trickling to the bottom and flowing into the pit, from which it is removed and stored in barrels, in which it hardens and is marketed. The wood used consists chiefly of dead branches and trunks and stumps of the trees which have been killed by tapping for turpentine.

Tar is thus described by the Pharmacopœia: Semiliquid, viscid, blackish-brown, non-crystalline, translucent in thin layers, becoming granular and opaque with age; odor empyreumatic, terebinthinate; taste sharp and empyreumatic.

Tar is soluble in alcohol, fixed or volatile oils, or solutions of potassium or sodium hydroxide; it is heavier than water and is slightly soluble in it, the solution being of a pale yellowish-brown color and having an acid reaction.

The composition of tar is highly complex. Its constituents are, as might be expected, closely similar to those of coal tar, the sources of the two differing more in the length of time consumed in the production than in the essentials of the process. A large number of these constituents and their products are considered under separate titles in this work. The more important constituents are contained in the oil, considered below, and in the pyroligneous acid, which, when distilled off, leave *common pitch* or *naval pitch* (*Pix navalis*). In the distillate the acid and the oil separate, either on account of their different distilling points or on account of their different specific gravities. The acid is a source of acetic acid and numerous other substances. The relative percentages of the different portions, as also of the constituents of the latter, differ widely in different tars, depending upon the kind of wood employed, its condition and character, the details of the distillation, etc., so that both tar and tar oil are exceedingly irregular in character. The properties of tar are considered below, under Oil of Tar. Tar is itself employed externally, chiefly in the form of the *ointment* (*Unguentum picis liquidæ*, U. S. P., consisting of 50 parts of tar, 12½ parts of yellow wax, and 37½ parts of lard), and internally chiefly in the form of the *syrup* (*Syrupus picis liquidæ*, U. S. P., containing 7½ parts of tar, 10 of glycerin, and 80 of sugar, with water to make 100). The dose of tar is gr. xv. to lx. (1.0–4.0); of the syrup, about four times as much. Tar is often given in the form of the water, made by thoroughly stirring four ounces of tar in a pint of water, allowing to settle, and decanting. Of this, half a tumblerful may be taken three or four times daily, and it is an excellent antiseptic diuretic.

Oil of tar (*Oleum picis liquidæ*, U. S. P.) is thus described in the Pharmacopœia: "An almost colorless liquid when freshly distilled, but soon acquiring a dark reddish-brown color, and having a strong, tarry odor and taste. Specific gravity about 0.970 at 15° C. (59° F.). It is readily soluble in alcohol, the solution being acid to litmus paper." It contains, as its principal part, creosote, which in turn consists of *guaiacol*, cresol, creosols, and phlorol, and which has been elsewhere considered; carbolic acid in small amount, toluene, xylene, paraffin, naphtalene, pyrocatechin, etc.

Oil of tar possesses, in lesser degree, the antiseptic and poisonous properties of the substances which it contains, as above stated. It has at the same time the diuretic and diaphoretic, as well as the irritant properties of the closely related substance oil of turpentine, though in milder degree, but is more distinctly expectorant than that substance. Its uses, both professional and domestic, depend directly upon these properties. As a counterirritant, its action is very mild, and it is an excellent chest application for young children. Its antiseptic action is often secured as a constituent of mixtures destined for inhalation purpose. Internally, its chief use is in bronchitis, especially the chronic form, and its internal administration is commonly combined with its use as an application to the chest. Oil of tar is less frequently administered than the syrup, but may be given in doses of ♏ i. to v. or even ♏ x. There is no official preparation. HENRY H. RUSBY.

Placenta, Pathology of the.—The chief part of the pathology of the placenta has been discussed under the heads of *Chorion, Pathology of the*, and *Decidua, Pathology of the*. This article will treat only of the general pathological conditions of the organ considered as a whole; namely, anomalies of development, size, and location, general disturbances of circulation, inflammation, etc.

ANOMALIES OF DEVELOPMENT.—These are of not infrequent occurrence. Instead of the usual round or oval form, the placenta may exhibit the greatest diversity of shape, such as crescentic, horseshoe, elliptical, etc. (*placenta biloba, triloba, multiloba, duplex, triplex, arcuata, reniformis, fenestrata, pandureformis, etc.*). Besides the main organ there may be found completely separated cotyledons appearing as smaller accessory placentas (*placentæ succenturiatæ*). The smaller accessory placentas owe their origin to a localized failure of placental development in certain areas corresponding to an endometritic thickening of the decidua with fibrin formation, leading to an obliteration of the intervillous sinuses at the point of separation between the main mass and the accessory cotyledons. Following the obliteration of the intervillous spaces the villi of the intervening areas undergo atrophy or fibroid change. Not infrequently the accessory placentas may suffer a similar change from obliteration of the intervillous spaces and appear in the mature placenta as thickened, bloodless areas separated from the main organ (*placenta spuria*). If the placenta becomes divided in similar manner by atrophy or non-development of a portion of the chorion, into two portions of approximately equal size, the phenomenon of an apparently double placenta with one child is presented (*placenta duplex, dimidiata, bipartita*). Smaller accessory placentas may also be associated with this condition. The cord may be inserted marginally upon one-half, or there may be a velamentous insertion between the two halves. It is also possible that a double placenta may be formed by the changes that occur in the placenta following the original implantation of the ovum in one of the uterine horns. Under such conditions the placenta finds proper nourishment for its development upon the anterior and posterior walls of the uterus, but not in the horn itself where the decidua is developed but slightly. As the result of the non-development of the chorion over the poorly developed decidua of the horn the portions of placenta developing on the anterior and posterior walls become separated from each other and appear as a double organ. According to some writers a double placenta may be formed through a secondary implantation of a placenta reflexa upon the opposite uterine wall; but by the majority of authorities this is considered doubtful. The peculiarities in development of the placenta mentioned above have been regarded as examples of an atavistic reversion to the placental type of some of the lower animals; but it is very likely that they represent the sequelæ of inflammatory conditions of the endometrium, or are secondary to a localized obliteration of the intervillous spaces and atrophy of the chorion analogous to infarct formation. Such atrophy may be due to the fact that the affected portions of the

chorion do not find a favorable location for development. If the vera is very slightly developed and possesses no spongiosa the membranes may be very firmly adherent (*Placenta accreta*). The various anomalies of development may have a practical importance, in that portions of the placenta may be retained after delivery; this is particularly likely to occur in the case of double placenta or when accessory placentas are present.

Placenta marginata is the term applied to the placenta when the chorion leve is given off, not from the edge of the placenta, but from its surface, so that there is produced beyond the attachment of the fetal membranes an edge or margin which does not stand in direct connection with the main mass of the chorion. From this margin the membranes are easily stripped; its surface is covered with a thick, firm, yellowish fibrin layer which is elevated one to two centimeters above the general surface of the chorion. On microscopical examination the fibrin ring or margin is found to consist of atrophic and necrotic villi with obliterated blood spaces. Its structure is therefore the same as that of the placental infarct. If, on the inner side of the fibrin ring, there is developed a ring-formed elevation of the chorion, the variety known as the *placenta circumvallata* is produced. Both of these anomalies develop as the result of an abnormal proliferation of the *reflexa* with a subsequent infarction of the same and of the enclosed villi. In this way there is formed on the surface of the placenta a stiff and inelastic ring of fibrin at a time when the placenta has not yet attained its full size. The fibrin ring hinders the peripheral growth of the villi, but these are able to penetrate the decidua outside of the ring, where they give rise to masses of villi lying outside of the firm attachment of the membranes to the placenta. As the result of the formation of the placenta marginata, portions of the membranes are likely to be retained after delivery; and in those cases in which the condition develops very early the growth of the placenta may be so limited that the fetus will probably be insufficiently nourished and abortion may occur.

The *placenta membranacea* is a rare form in which the organ is thin and flat, and extends over a large surface, either the whole or a large part of the chorion bearing permanent villi. It has been variously explained, but the most plausible theory is that the persistence of the villi over such a large part of the chorion is due to the fact that the villi penetrating the original serotina did not obtain sufficient nourishment. The *placenta membranacea* may give rise to clinical symptoms of *placenta previa*, hemorrhages, retention, etc. Separation in the case of this form of placenta is much more serious than that of the normal form of organ.

Abnormalities of Site.—*Placenta previa* (*q.v.*) is the most important form of abnormal location of the placenta.

Anomalies in the insertion of the cord are not infrequent; the usual attachment is the center of the organ; not rarely it is eccentric, or even at the margin (*battledore placenta*). When the cord is inserted into the membranes some distance outside of the placental margin the condition is known as *velamentous insertion*. The vessels bifurcate at the point of insertion, their divisions running between the amnion and chorion to the placenta.

Circulatory Changes.—Edema of the placenta occurs rarely. It is usually associated with general edema of the fetus; more rarely with maternal dropsy. Disturbances of fetal circulation, thrombosis of umbilical or hypogastric arteries, antenatal closure of the foramen ovale, congenital syphilis, etc., have been regarded as the exciting causes. The placenta of acardiac monsters is usually edematous. The number of leucocytes in the blood of the fetus may show a great increase in these cases. The edematous placenta is larger and heavier than normal, pale, friable, and soft. Microscopically the villi are found to be greatly enlarged and closely packed together; the intervillous spaces are reduced in size and contain but little blood. The stroma of the villi is separated by fluid, the cells being pushed far apart. The fetus usually dies *in utero* as the result of the conditions causing the edema.

Hemorrhage.—True apoplexies of the placenta are rare. They may occur either in the maternal or in the fetal portion, and are usually the result of inflammatory changes. In the fetal portion the mass of blood becomes encapsulated by a dense layer of fibrin. The neighboring villi are compressed and become atrophic or necrotic. The nutrition of the fetus may be impaired and abortion result. Very rarely the hemorrhage may occur upon the surface beneath the amnion or chorial covering (subchorial hematoma), or the blood may burst through the serotina and escape externally. In such cases the fetus is usually born dead. In some of the reported cases the hemorrhage was regarded as due to a rupture of a branch of the umbilical vein or artery following thrombosis, twisting, or laceration. The causes of these hemorrhages are unknown and their pathology is doubtful. It is probable that some of the cases described were not true placental apoplexies. The small dark red areas frequently seen throughout the placenta, and regarded by many as interstitial hemorrhages, are not true hemorrhages, but represent local congestions of the intervillous spaces. Inasmuch as the blood is contained within the normal blood spaces the condition cannot be considered to be hemorrhage.

Hemorrhages into or from the placenta as the result of trauma or of attempts at abortion are of frequent occurrence. Hemorrhage from partial separation of the organ occurs in placenta previa. In inflammatory conditions of the maternal portion of the placenta, degenerative changes in the serotina, etc., partial separations of the fetal placenta may occur. Such hemorrhages are of frequent occurrence in the acute infections, syphilis, nephritis, Basedow's disease, chronic endometritis of gonorrheal origin, etc. In all these cases the hemorrhage is from the maternal vessels and not from the fetal. They represent decidual changes rather than placental. The escaped blood fills up the cavity caused by the separation of the chorion or outer layer of the decidua, or may break through the fetal membranes or escape externally. The serotina may be completely destroyed and a large cavity formed between the muscle of the uterine wall and the placenta. The chorionic villi and fetus may be compressed; the latter suffering from disturbances of nutrition may die, or may present abnormalities of development.

Retrograde Changes.—As has been mentioned in the articles treating of the pathology of the chorion and decidua, the retrograde changes which are constantly found in the mature placenta must be regarded as the expression of a physiological decay of the organ. The great majority of the older observations on inflammation, fatty degeneration, amyloid change, etc., were most probably nothing more at foundation than the various appearances produced by the physiological processes of infarction found constantly in the ripe placenta.

Atrophy of the placenta may follow extensive hemorrhages, or inflammation, or atrophy of the decidua.

Necrosis.—Simple necrosis of the chorionic villi occurs in placental infarction. An abnormal degree of this change may be caused by nephritis of the mother, by syphilis, tuberculosis, etc.

Placental Infarction (see *Chorion, Pathology of*).

Fatty Degeneration.—The cases described in the literature by Barnes and others were unboudtedly placental infarcts. Fatty degeneration of the chorionic villi is extremely rare except as a sequela of other changes, retained placenta, placental infarction, etc. A small amount of fat is almost constantly present in the normal ripe placenta, and is to be regarded as physiological.

Calcification within certain limits is almost constantly found in the mature placenta, and is to be regarded as physiological. Only in marked degree is it of pathological significance. In the latter case it follows excessive infarction, fatty degeneration, etc., in nephritis, syphilis, acute infections, malaria, etc.

Amyloid has been described as occurring in the placenta; but the appearances taken for amyloid were probably those of infarcted areas.

Myxomatous degeneration of the stroma of the chorionic villi occurs in retained placentas and in hydatid moles.

Pigmentation.—Deposits of blood pigment may be found in both the normal and the diseased placenta, resulting from the disintegration of red blood cells contained in the clots found between the villi. Rarely this pigment may be taken up by the villi and be found deposited in the stroma of the latter.

Hyaline degeneration of the villi occurs to a certain extent in the ripe placenta as an evidence of physiological atrophy. When it occurs prematurely, or to a marked degree, it is to be regarded as of pathological significance. It may follow the changes produced in the villi by the acute infections and certain intoxications, but is most often due to syphilis.

Hypertrophy.—An enlargement of the placenta may be due to edema or degenerative conditions of the villi. Fibrous hyperplasia occurs in syphilis, nephritis, etc. A true hypertrophy—that is, an enlargement of the organ with preservation of normal structure—is of rare occurrence in association with abnormal development of the fetus.

Inflammation (see *Chorion, Pathology of*).

Tuberculosis of the placenta has been frequently reported (Lehmann, Schmorl, and Kockel, Auché and Chambrelente, Warthin, Weller, *et al.*). It is not improbable that the disease is of more frequent occurrence than the published reports would indicate. Inasmuch as there are no gross changes in the placenta by which the condition can be recognized without microscopical examination, it is probable that cases escape diagnosis. In all cases of maternal tuberculosis of advanced degree, in miliary tuberculosis, and in all cases of maternal tuberculosis in which the tubercle bacilli gain entrance to the blood, the bacilli will undoubtedly be found in the blood contained within the intervillous spaces. The conditions would therefore favor the development of tubercles in this location. On the other hand, it may be argued that the syncytium and fetal tissues possess a certain degree of immunity toward the tubercle bacillus. This view is supported by the fact that in placental tuberculosis large masses of fibrin containing great numbers of tubercle bacilli may be found resting upon an apparently normal syncytium; and in a case seen by the writer the syncytium had even grown around and enclosed such a fibrin mass containing tubercle bacilli. From Warthin's laboratory an instance has been reported by Weller of a pulmonary lesion in the mother having been discovered first through the finding of miliary tubercles in the placenta.

Syphilis may affect either the fetal or the maternal portion of the placenta. In both cases the changes are those of inflammation and premature degeneration. Gummatous proliferations have been reported as occurring in the serotina; but it is not improbable that some of the changes described as such were in reality fibrin masses and not gummata. The most characteristic and constant change in the placenta due to syphilis is that which occurs when the infection takes place at the time of conception or during the early stages of pregnancy. In such cases the chorionic villi not infrequently show a fibroblastic proliferation (interstitial placentitis) of the stroma with resulting obliteration of the chorionic vessels. Spirochetes have been demonstrated in the hyperplastic villi. If the fetus survives, the affected villi undergo a fibroid change. In the great majority of cases, however, the condition results in abortion. Infection during the later months may produce little change in the placenta; or the physiological phenomena of obliteration of the chorionic vessels and infarction may be much more extensive than normally. The interstitial placentitis occurring in the early months of pregnancy is characteristic of syphilitic infection only in the involvement of large areas. A similar change is also found in the neighborhood of placental tubercles.

Gonorrheal placentitis has been regarded clinically as a cause of abortion. Cases have been reported in which the gonococcus was found. The etiological rôle of the gonococcus has been clearly shown in cases of interstitial decidual endometritis.

Placental adhesions with the uterine wall are of much more rare occurrence than is usually believed. In rare cases the serotina may fail of development and the chorionic villi penetrate directly into the uterine wall. In cases of decidual endometritis fibrous connective tissue may develop in the serotina and give rise to firm connections between uterus and placenta. The majority of placental adhesions are due to firm blood clots extending from the intervillous spaces into the maternal sinuses. As a result of such adhesions portions of the placenta may be retained, and this may lead to severe hemorrhages or to secondary infection. Putrefactive processes may take place in such retained placental tissue, as well as in that retained after abortion.

Detachment of the margin of the placenta of slight degree is relatively frequent, and possesses no significance. Its occurrence is revealed by masses of fibrin or blood clot lying between the decidua vera and the reflexa. More extensive detachments may endanger the life of both mother and fetus. Such detachments are usually associated with hemorrhage; the blood may collect in the space formed by separation of the placenta from the serotina or burrow between the layers of decidua and escape externally. In rare cases the blood may rupture into the amniotic cavity. Only exceptionally, when the detachment occurs in the central part of the placenta while the edges remain attached, is the hemorrhage unimportant. In such cases death of the fetus occurs, however, as the result of disturbed nutrition. The detachment of the placenta during birth is of rare occurrence. Such premature loosening of the organ is due to sudden diminution in the volume of the uterus following the loss of large amounts of amniotic fluid. The weight of the placenta causes it to descend into the lower segment of the uterus, where it may present before the fetus, and may be expelled first. In such cases the child is usually lost.

Changes in the Placenta after Intrauterine Death of the Fetus or Abortion.—After death of the fetus in the early weeks of pregnancy the retained chorion may continue to grow. Hemorrhages occur repeatedly, forming thick layers of blood clot, which gradually loosen the placental remains. These together with the blood clot are discharged as a *fibrin* or *fleshy mole.* A deposit of calcium salts in the fibrin mass gives rise to a *stone mole;* myxomatous or hydropic degeneration of the stroma of the villi to a *hydatid* or *grape mole* (see *Chorion, Pathology of*). Through continued growth of the villi with successive deposits of fibrin, polypoid tumors (*placental polyps*)

may be formed. These may be discharged spontaneously or may become gangrenous or purulent as the result of infection. A penetration of the uterine wall by proliferating villi gives rise to the condition known as *malignant* or *destructive placental polyp* (see *Syncytioma*).

Placental Cysts.—Cystic formations have been frequently described as occurring in the placenta. The majority of these have undoubtedly been degeneration cysts, arising either from a myxomatous or hydropic degeneration of the stroma of portions of the chorion, or from the liquefaction of areas of infarction. Small cysts may arise in the placenta as the result of the liquefaction of small encapsulated hemorrhages. The cysts arising from the degeneration of infarcted areas may reach a very large size, and in rare cases may be mistaken for a second amniotic sac. They are found usually on the fetal side, beneath the connective tissue of the chorion. Their walls are lined by large epitheloid cells, in part syncytial and in part decidual. Small cysts lined with epithelial cells (so-called dermoids) have been observed in the placenta. These have been interpreted as representing remains of the allantois.

Tumors.—New growths of the placenta belonging to the connective-tissue group are extremely rare. Alin collected twenty-three cases from the literature, and twenty additional cases have been reported up to 1902. The diagnoses given were myxofibroma, fibroma, angioma, fibromyoma, and sarcoma. The majority of these cases are very doubtful. The so-called myxoma fibrosum is the most common form; it is found usually on the fetal surface, and is rarely embedded in the placental mass; and still more rarely it reaches the maternal side. These growths present a varied appearance, but are usually encapsulated, firm, and homogeneous on section. Microscopically they show an alveolar structure, the tissue resembling that of the umbilical cord, sometimes very rich in cells, at other times containing but few. It is very doubtful indeed if these formations are to be regarded as true neoplasms.

Of much more frequent occurrence are the growths arising from the syncytium, the *benign chorio-epithelioma* or *hydatid mole*, and the malignant chorio-epithelioma (*syncytioma malignum*). Such growths arise from retained chorion after abortion or delivery, usually after the former during the early weeks of pregnancy. From the decidual cells a sarcoma may arise (*sarcoma deciduocellulare*). Confusion, however, exists with regard to this variety: in many cases syncytioma has undoubtedly been regarded as a sarcoma of decidual origin.

ALDRED SCOTT WARTHIN.

Placenta Previa.—The term placenta previa refers to the attachment of that organ to a portion of the uterus which becomes dilated during the process of labor. The uterine sinuses are consequently held open as the placenta is separated and a greater or less degree of hemorrhage results, depending on the relative position of the mass of the placenta and the cervical os. Placenta previa has been described as lateral (attachment in lower segment without impinging on os), marginal (lower edge coming down to the internal os), partial (a portion covering the os), and central (when the internal os is completely covered). A more practical classification would include only two varieties, the partial or incomplete, and the central or complete. A placenta previa which is diagnosed as apparently complete at the beginning of dilatation may turn out to be only partial when the process is completed.

It is difficult to determine the *frequency* of the occurrence of placenta previa from cases in general practice as many fail to be reported. Hospital statistics on the other hand are likely to exaggerate the frequency, as they include a large number referred from other sources. The older statistics state that placenta previa occurs once in 1,500 cases in general practice, while in the more recent statistics a proportion of 1 to 700 is claimed. Among the obstetrical clinics we find that at Budapest in 11,770 labors which occurred in a period of ten years, fifty-six cases of placenta previa, or one in 210 were reported (Frigyesi). In a series of 60,000 cases at the Lying-In Hospital, New York, Markoe records 311 instances of placenta previa, or one in about 193 cases. Other series of hospital statistics based on a large number of cases afford similar results. As the condition is associated usually with the existence of a previous pregnancy or its consequences, or an endometrial disturbance, placenta previa is consequently more frequent in multiparæ than in primiparæ—thus Frigyesi (Budapest), in a series of over 11,000 cases found ten per cent. occurring in primiparæ and ninety per cent. in multiparæ; in Chrobak's series of about 31,000 labors, placenta previa was noted in 0.17, 0.48, 1.37, 1.28, and 3.39 per cent. of the patients according as they had given birth to one, two, three, four, five, or six children respectively; and if the number of children varied between seven and ten, the percentage was 5.51. Moreover in primiparæ the partial varieties of placenta previa have been noted as occurring more commonly than the complete.

No definite knowledge is at hand as to the *etiology* of this complication of pregnancy. As already noted, however, there are two factors which seem to play an important rôle, namely, multiparity and endometrial disease. It has also been pointed out by Strassmann that the effect of inflammatory or atrophic changes on the decidua resulting from frequent pregnancies is an important factor by limiting the amount of blood going to the placenta, so that it is necessary for the organ to be spread out over a greater area of attachment, approaching in this way the lower uterine segment. The low implantation has also been ascribed to anomalies in the form of the uterus. It is now generally accepted that placenta previa results either from the primary implantation of the ovum in the lower portion of the uterus associated with an excessive cleavage of the decidua vera, by which the extension of the placenta to the region of the internal os is facilitated, or to its partial development over the decidua reflexa.

Among the *complications* attendant upon placenta previa are anomalies in the position of the fetus. It has been estimated that in about thirty per cent. of the cases abnormal presentations occur, due to the fact that multiparæ with relaxed uteri and abdominal walls are most frequently affected, and also that in over five per cent. of the cases the labor does not begin at the end of pregnancy but at an earlier period when the position of the fetus is not finally determined. The presence of the placenta in the lower uterine segment also undoubtedly interferes with the proper engagement of the head. In a series of 342 cases reported by Bürger and Graf there were sixty-nine per cent. of vertex, nine per cent. of breech, and twenty-one per cent. of transverse presentations; in Frigyesi's series of 110 cases there were seventy-three per cent. of vertex, eleven per cent. of breech and fifteen per cent. of transverse presentations. Premature labors have been noted in about sixty per cent. of all placenta previa cases, so that the interests of the child are less to be considered than those of the mother. (This subject will be referred to again in discussing the treatment.)

SYMPTOMS.—The prevalent symptom associated with placenta previa is naturally hemorrhage and in most cases the condition is not recognized until this occurs. Hemorrhage from placenta previa rarely comes on before the seventh month of pregnancy and may be very slight at first, depending on the soften-

ing process in the cervix. It is generally assumed that the greater the volume of the placenta which occupies the lower segment the earlier and the more severe the hemorrhage. Bleeding may be intermittent and scant in amount or sudden and severe. It has been shown that pregnancy is terminated earlier in the cases with a complete placenta previa than in those in which the incomplete variety is present. In every instance in which a hemorrhage comes on without warning during the latter months of pregnancy, a vaginal examination should immediately be made under careful asepsis. If the placenta is situated over the os it can be felt as a spongy mass on pushing the finger through the canal. This finding may also be simulated by a firm clot, by a thick vernix in matted hair, by a monstrosity with exposed viscera or anencephalus, and even by thickened vascular membranes. In isolated cases a separation of the decidua can occur, particularly in primiparæ, where constant pressure from rigid abdominal muscles serves to keep the presenting part firmly impressed in the lower uterine segment and thus leads to an early softening of this portion of the uterus. The resulting hemorrhage may be well marked and closely simulate that from a placental separation, the diagnosis depending on the absence of the placenta on palpating the head through the vaginal fornices. The cervix in placenta previa cases is usually more boggy and more vascular than under ordinary circumstances. Where the placenta is of the incomplete variety it may not be possible to make a definite diagnosis. In most cases of placenta previa anomalies in the position of the fetus will be present as already stated and the presenting part cannot therefore be felt on bimanual examination. Especially when the head is below, this cannot be impressed into the pelvic brim. In a certain proportion of cases of incomplete placenta previa the bleeding may not begin until labor comes on and the os is sufficiently dilated to involve the placental attachment. In such cases the differential diagnosis between placenta previa and the separation of the normally situated placenta must be taken into consideration, although in the latter, pain usually accompanies the discharge of blood but not necessarily so. If bleeding therefore occurs and the placenta cannot be felt it may become necessary to terminate labor if the hemorrhage does not abate and the constitutional effects of the same appear. The more or less constant trickling of blood in certain cases will gradually bring about a marked degree of anemia in the patient and demand intervention. Where the cervix is not sufficiently dilated to permit the introduction of the finger, this may be done under light anesthesia in order that the necessary information may be obtained. Inconstant subjective symptoms of placenta previa are sensations of pain and pressure in the lower abdomen, frequent urination and leucorrhea.

Prognosis.—The prognosis in placenta previa depends on how completely the internal os is covered, and the danger to both mother and child is measured by the time and degree of the hemorrhage. Appropriate treatment in appropriate surroundings is also an important factor in the prognosis. In Markoe's statistics from the New York Lying-In Hospital which include many serious referred cases, the maternal mortality in round numbers was fourteen per cent. for the central variety with a fetal mortality of fifty-eight per cent.; while the combined mortality for the partial varieties was thirteen per cent. for the mothers and fifty-four per cent. for the children. Although the statistics for maternal deaths have improved with the development in treatment of this condition, the fetal mortality has shown little decrease in recent years, thus in various statistics of a large series of cases this mortality is stated as varying from thirty-five to sixty per cent. In a collection of cases from various recent sources made by De Lee and numbering 2,153, the maternal mortality was 7.68 per cent., and 61.44 for the babies. Krönig's collection of 6,569 cases showed mortality percentages of 9.3 and 58.7 for mothers and children respectively.

The mother in the fatal cases usually succumbs to shock from hemorrhage as the direct result of the placental separation, or from the lacerations, or even uterine rupture due to hasty delivery. The condition of the patient, moreover, predisposes to subsequent infection, which is favored by the clots in the sinuses of the lower uterine segment. The children usually die as the result of asphyxia from the interference with the placental circulation, prematurity, or the necessarily rapid or difficult extraction in many cases. It may be said that the mortality in the mother depends on the variety of the placenta previa, the method of delivery, and the condition of the patient when first seen. As vaginal and cervical tamponade was succeeded by combined version the mortality statistics varied with the acquired skill of the operator and more recently the employment of cesarean section has again reduced the mortality in a restricted class of cases, especially as concerns the fetus. A further criticism of these methods will be found under the treatment.

Treatment.—In considering the treatment of placenta previa no single method can be applied to all cases and success depends on the proper differentiation of the patients, the correct diagnosis, the skill of the operator, the condition of the patient and her environment. In cases where the diagnosis is made early, before much bleeding has occurred and the child is just viable, a few weeks of delay may insure the life of the latter, but the mother should be kept in bed in a hospital, recourse to other methods of treatment being had as soon as demanded. There is no safe expectant plan of treatment and in every case the absolute rule is to reduce the amount of blood lost to the minimum. The employment of vaginal packing was used for many years and still serves a useful purpose in cases where no operative facilities or assistance are at hand, but the proper place for the treatment of a case of placenta previa is in a hospital, and where such facilities are to be had only temporizing measures should be made use of. In a case of pregnancy where bleeding is noted at the seventh month the patient should be kept absolutely quiet and as soon as a diagnosis is made means for immediate delivery should be provided, either at home or in a suitable institution. As a rule, labor pains are not present in the early stages of this condition, but if so they must be checked by the administration of a quarter of a grain or more of morphine until means to stop the bleeding have been instituted. Where the cervix is sufficiently dilated and the hemorrhage severe enough to require immediate control, a set of packing instruments and several tubes of plain sterile gauze strips, one or two inches wide, must be provided. The patient's vulvar region should be thoroughly scrubbed and the hair shaved away. The cervix must then be exposed with the aid of a single-blade speculum and the anterior lip seized preferably with a sponge forceps. The gauze strip is then firmly packed into the cervix and around the fornices finally filling up the vagina. A vulva pad is applied, the patient's knees are tied together and where this has been decided upon, she is sent to a hospital. In a certain class of cases, particularly primiparæ, where the hemorrhage begins at a time when the cervix is elongated and not dilated, a cesarean section under proper conditions affords the best chance for the patient and the child. The *pros* and *cons* of this procedure have been widely discussed in recent years and no definite conclusion arrived at, although those expert in the delivery by this means have obtained excellent results. In general the dilatation

of the cervix with the introduction of a dilating bag serves very well to bring about a sufficient enlargement of the birth canal to permit of delivery with forceps, or a complete version. If this method is decided upon the cervix is dilated with the finger sufficient for the introduction of a large size Voorhees' bag, the latter being inserted within the uterus after tearing through the membranes in the lateral variety of placenta previa, or the placenta itself in the complete varieties. Cragin at the Sloane Hospital for Women favors the insertion of the bag between the placenta and the cervix, claiming that satisfactory dilatation is obtained and the hemorrhage likewise checked. When the process of dilatation is complete the membranes can be ruptured and a version done more readily it is claimed than if the bag had been placed within the amniotic sac. The dilating bag may be left in place until its mission is accomplished even if this consumes from four to twelve hours, as long as the hemorrhage is stopped and the patient's condition good. The presence of the bag induces uterine contractions, especially if a slight weight is attached to the end and the bag has been placed within the amniotic sac. The pressure on the placenta from the same may interfere with the fetal circulation and increase the chances of asphyxia but this is unavoidable. In cases of low implantation of the placenta a simple rupture of the membranes at a point opposite to the edge of the placenta may suffice as this allows the presenting part to come well into the brim and thus to act as an internal tampon. In such cases labor pains usually come on after the rupture and the patient may be delivered without assistance. Rapid dilatation of the cervix or accouchement forcé need only be mentioned to be condemned as a method of treatment for placenta previa. The method which has been considerably employed in recent years consists of the Braxton-Hicks version after rupture of the membranes or perforation of the placenta itself. Thus Frye (Washington) reports a series of thirty-eight consecutive cases delivered by this means with only a single death and that due to postpartum hemorrhage resulting from faulty packing. In this procedure the cervix is dilated manually under light ether anesthesia sufficiently to admit two fingers which are then thrust into the amniotic sac and a foot sought for and seized. This is aided by the abdominal hand and as the breech presents very frequently the manipulation usually is a simple one. As soon as the foot is found it is slowly and gradually pulled through the rent and used as a dilating wedge, the anesthetic being preferably stopped at this time. If the cervix manifests a tendency to rigidity the dilatation with the leg of the fetus must be completed deliberately in order to avoid undue lacerations, several hours being frequently needed for the process. If the extremity is kept wrapped up in a warm moist towel it may be possible to avoid reflex respiratory efforts of the fetus and thus asphyxia. After the breech and trunk have been brought through, the extended arms may be extracted as soon as the shoulder blades are born. Considerable difficulty is often experienced in delivering the head and suprapubic pressure may be necessary to complete the same. As soon as the fetus has been born the placenta, especially if of the central variety, had best be immediately extracted, otherwise the succeeding hemorrhage may prove fatal. It is advisable to administer pituitrin (1 c.c.) just as the head is being born, so that immediate contraction of the uterus will result. The frequency of postpartum hemorrhage in placenta previa makes it almost imperative to employ intrauterine packing in every case, although this precaution is not considered necessary by many writers. Where the placenta is of the incomplete variety it may be left in place until delivered by normal processes unless hemorrhage demands its immediate removal. Unless lacerations of an extreme degree are present in the cervix with attendant hemorrhage, their immediate repair had best be omitted and the repair of perineal lacerations should likewise be made as brief as possible. In view of the danger of postpartum sepsis in such cases free drainage must be provided for and too complete suturing of the cervix may interfere with the same and likewise the packing of the uterus. Stimulation is almost always demanded in cases of placenta previa but should not be given until delivery is complete. During the labor, if the patient's condition requires it, the injection of physiological saline or sugar solution either under the skin or into a vein may be carried out with advantage, and after the patient has been delivered sugar solution may be given by rectum in quantities of eight ounces every four hours. In view of the uterine relaxation likely to occur after the birth the regular administration of pituitary extract or ergot is indicated and the administration of the latter may with advantage be kept up for several days to limit the probability of absorption of toxic or infectious material from the uterus. The child is very apt to be lost from asphyxia during the delivery by the Braxton-Hicks method and if it survives may perish a few days later from prematurity and inanition. Occasionally cases of the incomplete variety of placenta previa are seen, particularly in multiparæ in which a dilatation has progressed rapidly to three or four fingers. Here if the head presents, the pressure from the same during uterine contractions will check the bleeding. Pituitary extract has been successfully employed in such instances, but the same precautions must be observed after the birth of the child to guard against postpartum hemorrhage.

As already stated cesarean section has been recommended in cases seen early where but few examinations have been made and the fetal heart is still good. If carried out in the proper environment the results are excellent although many obstetricians absolutely deny the value of the procedure. In a series of nineteen cases by six operators at the New York Lying-In Hospital (1905–13) only one mother died (septicemia, twenty-first day), two children were stillborn (dead at time of operation) and three died subsequently from atelectasis. The patients varied from para-i to para-xiv, and there were nine undoubted cases of the central variety. The indications for cesarean section in placenta previa may be said to include the central variety associated with an undilated and rigid cervical canal. This is said to exist only in about five per cent. of all cases and is almost never met with in multiparæ. The contraindications may be similarly summarized as including excessive loss of blood, a soft and dilatable cervix and an incomplete variety of placenta previa. Here may also be included those cases in which attempts at delivery have been made or bags inserted, as the possibility of infection is thereby increased. In such cases where the environment is satisfactory a Porro operation may give the best results. Vaginal cesarean section has been employed by a limited number of obstetricians but has fallen into disfavor because of the incision through the cervix and lower uterine segment must necessarily be made in a very vascular portion which does not permit of being readily sutured. The hemorrhage in such cases may be very extreme and the procedure is not to be recommended. In summarizing the treatment of this dangerous complication of pregnancy the final decision must rest with the obstetrician and obstetrical methods employed as a routine in preference to those of a purely surgical character. The treatment by the extra- or intraovular insertion of dilating bags combined with version has given such good results in the hands of many operators that at the present day it must be regarded as the procedure of choice in general practice, leaving the more strictly surgical procedures to those specific-

ally qualified to carry out the same and limiting their application to the class of cases already referred to.

Geo. W. Kosmak.

Plague.—*Synonyms:* pestis, pestilentia, black death, oriental plague, bubonic plague, Pali plague, Chinese plague.

Definition.—An acute, febrile, hemorrhagic septicemia of man and certain of the lower animals, accompanied by inflammation of the lymphatic glands and in certain cases by a primary or secondary inflammation of the lungs, either with or without buboes, and caused by the *Bacillus pestis.*

Plague occurs in epidemics, epizootics, pandemics, and panzootics. Whether or not cases shall occur in man or the lower animals sporadically, epidemically, epizootically, or pandemically, and the degree to which the disease shall be disseminated, depends upon the density of the rodent population and the opportunities which it may have for migration and contact with man. It is contracted by the inhalation, ingestion, or inoculation of the specific microorganism. The latter is the usual means of spread of the disease from rodent to rodent, from rodent to man, and from man to man. The vector of the causative organism is usually the flea. Bedbugs and lice may also act as intermediaries. The portal of entry of the bacillus may be the skin or mucous membranes. Most frequently it is the skin, hence the preponderance of bubonic cases.

History.—The earliest records of the human race contain references to plague. It is mentioned in the ancient Sanskrit and Egyptian writings, and the Bible (First Samuel, Chapters 5 and 6) refers to the bubonic and pulmonic forms of the disease and to its relation to rodents. Epidemics are reported as occurring at least 1,500 years before the Christian era and even the earlier reports note the coincidence of an epizootic among rats and plague among men. Papon, in his chronological lists of widespread epidemics, mentions 41 epidemics of plague as occurring in the fifteen centuries before Christ. During the next 1,500 years there were 109 such outbreaks, and from 1500 to 1720 there were 45 pandemics of the disease. Herodotus, Hippocrates, Procopius, and many other early writers give fairly accurate descriptions of the disease; in fact it may be said that at one time or another the black death has appeared in almost every portion of the globe and has been described by writers of all times and in almost every written tongue. The description given by Rufus of Ephesus might serve to-day as a fairly accurate clinical picture of the disease: "The buboes that one calls pestilential," he says, "are very acute and often cause death * * * accompanied by an acute fever, intense pain, perturbation of the whole body, delirium, eruption of large buboes hard and without suppuration, developing not only in the usual places but also in the popliteal space and elbow, although in general such inflammations do not form in these places." Lybia, Egypt, and Syria have frequently been the scene of plague epidemics, on account of the relation which their geographical position bears to commerce, making them the binding links between the East and the West, their caravan routes affording an easy means for the migration of human beings or rodents having plague.

In 542 A.D. plague became pandemic, it being reported as having originated at Pelusium in Egypt, which at that time was an important transshipment point. While it may not have been the source of the epidemic, it might easily have acted as a center from which the disease could have been disseminated. Plague is a disease which travels as rapidly as the average speed of the general transportation of the country in which it is moving. In two years it was carried from Pelusium to Constantinople, in which it lasted for four months, as many as ten deaths being reported in a single day. From Constantinople it was carried to Persia and the countries of the East. In 558 A.D. the disease reappeared in Constantinople, in which, Agathias says, "it had never really ceased from the time when in the fifth year of the reign of Justinian it had first visited our world." In this pandemic the disease spread all over the then known world. Gregory, Bishop of Tours, records an outbreak in Germany in 546, in Arles in 552, in Auvergne and Clermont in 563. Later in the same year the disease spread to Lyons, Bourges, Chalons, and Dijon. The mortality was frightful, deaths occurring with such great rapidity that it was impossible to afford decent burials. Between those who ran away from fear and those who died, cities were almost depopulated. The mortality was particularly heavy among priests and doctors, and others engaged in caring for the sick. In 582 plague appeared in Narbonne, in 584 in Albi, and in 588 Marseilles was invaded. In 509 an almost explosive outbreak occurred in Rome. It is significant that this outbreak followed close upon the inundation of the city by the River Tiber, thus driving the rodent population into human habitations. Toward the end of the sixth century plague appeared in Ireland and in 663 the disease was widespread throughout the island. The following year it appeared in England. During this period plague continued to appear at one place or another in the Mediterranean littoral at irregular intervals. It is not at all improbable that the disease was constantly present and that the only records we have are of the violent outbreaks. With the increase in commercial intercourse the disease became more widespread and in the eleventh century, just previous to the commencement of the Crusades, it was pandemic, spreading out over Persia, Mesopotamia, Asia Minor, and all western Europe. In the twelfth and thirteenth centuries plague was particularly severe in Europe and between 1294 and 1346 there were no less than six severe outbreaks. In the fourteenth century occurred the second great pandemic, probably the greatest outbreak of the disease of which there are historical records. The starting-point of this epidemic has never been determined, but it is not improbable that there were several enzootic foci from which the disease was carried out along the routes of commerce. Within three years the disease passed with rapid and destructive strides over the inhabited portions of Asia, Africa, and Europe, it being estimated that at least twenty-five per cent. of the population perished from the scourge. The descriptions of this frightful pestilence form some of the most dramatic chapters of literature and made an almost indelible impress upon the human mind. A great number of the cases in this pandemic were pneumonic, and on account of the general insanitary conditions under which people lived at that period, the disease was thus able to spread very rapidly and to gain wide diffusion.

Heberden has made a chronological record of plague during the fifteenth, sixteenth, and seventeenth centuries, during which there were frequent outbursts and epidemics in the various portions of the old world. "Dresden was attacked with plague in the years 1504–5, 1511–12, 1521, 1535–36, 1547, 1563–64, 1571–72, 1585–86, 1591–92, 1607, 1627–28, 1632–3–4–5–6–7. In 1502 the disease was at Brussels; 1517 at Verona; 1525 in Germany; 1531 and 1534 in France; 1539 in Switzerland; 1542 at Breslau; 1550 at Basel; between 1550 and 1553 it spread itself successively over almost all the habitable world; 1559 it was in Holland; 1563 it was in Germany, and again in 1566; 1564 in Savoy; 1566 and 1568 at Milan; 1568 at Paris; 1572 at Basel; 1575 at Milan; 1576 at Venice; 1580 at Marseilles; 1593 it was in Holland and the Low Countries; 1596 and 1597 in Germany; 1603 it was again in Holland; also in 1609; and in the latter part of the year in Denmark; 1618 in Bergen; 1619 in

Denmark; 1622 at Amsterdam, where it continued for eight years; 1623 it was at Montpellier; 1625 at Leyden in Denmark, and in Germany; 1628 at Lyons; 1629 and 1630 at Montpellier; 1631 at Dijon; in 1630 it was besides in Denmark and at Christiania in Norway; and at Parma, Verona, and other parts of Italy; from 1633 to 1637 it was in the Netherlands, and in the latter year at Prague; in 1649 more than 200,000 persons are said to have perished by this disease in the southern provinces of Spain; 1649 and 1650 it prevailed at Marseilles; 1650 it was also in Ireland; 1652 at Cracow; 1653 in Poland and Prussia; 1654 at Copenhagan; 1655 at Amsterdam; and in the course of the same year and the three following it was in many places in the south of Europe; 1660 it was in Scotland; 1663 and 1664 at Amsterdam and Hamburg; 1668 in Flanders; 1670 in Italy; 1679 at Vienna; 1680 at Leipsic; 1684 in Norway; 1685 at Leghorn. In 1622 the mortality by the plague at Amsterdam (at that time equal to about one-third of London) was 4,000; in 1628, 4,500. Felix Platerus, physician at Basel, in Switzerland, about 1580, gives an account of seven pestilential fevers which afflicted that country in the space of seventy years. Thomas Bartholin mentions five that raged in Denmark in his time (1660), and Forestus relates that in his time (1570) the plague was frequent at Cologne and Paris; and refers the cause to the multitude of the inhabitants and the nastiness of the streets.

"By another account Paris is said to have been infected eight times between the years 1480 and 1590; in 1607 two hospitals of reserve, St. Louis and St. Anne, were erected on purpose to receive patients in time of plague or other great calamities. They were opened on account of the plague in 1619, 1631, 1638, 1662, and 1668, since which that disease has been unknown there. We are informed that about the same time Paris was paved, the streets were widened and the city began to be kept cleaner."

In the 146 years between 1543 and 1680 plague deaths occurred in ninety-seven of the years in London alone. Six of these years, 1563, 1592–93, 1603, 1625, 1636, and 1665, were characterized by seven outbreaks. The latter was the so-called Great Plague of London in which in the space of a few months 68,596 deaths from plague were recorded. As the total mortality from other causes was about 10,000 over the normal it is not improbable that many of these were unreported plague cases. All of this despite the fact that at least 200,000 people fled the city. One of the interesting happenings of the outbreak was the Lord Mayor's proclamation in the beginning of the infection calling on the citizens to destroy all cats and dogs because they were supposed to carry "the effluvia or infectious steams of bodies infected even in their furs and hair." An officer was appointed for the execution, thus insuring that the natural enemies of the rat, and therefore the natural enemies of plague, were destroyed. It is stated that 40,000 dogs and 200,000 cats perished through this mistaken policy. Later, "all possible endeavors were used to destroy the mice and rats, especially the latter by laying ratsbane and other poisons for them and a prodigious multitude of them were destroyed." Samuel Pepys in his Diary vividly describes the horrors of the plague year, of which he was an eye witness. Defoe who was about five years old at the time of the epidemic wrote "The Journal of the Plague Year" fifty-six years later, 1721, when it was feared that the disease would be reimported from France where it was then raging. A total of 195,849 deaths occurred in these epidemics. The modern history of plague in India began with the opening of commercial relations by England with that country in the early part of the seventeenth century. Prior to that time plague epidemics occurred in India, and in some of the earlier records the death of rats and mice in the open were considered as certain indications of a threatened outbreak of the disease among human beings. It is an interesting fact that all of these early reports which mention rats at all speak of them as staggering about as though they were drunk, an observation which is often made at the present time. Epidemic plague has been practically continuous in some part of India since the establishment of the English trading posts until the present time. During the latter half of the seventeenth century plague ceased to occur in widespread epidemic form in Europe. The change in trade routes and the shifting of the commercial center of the world from the Mediterranean littoral to London and Amsterdam, and above all the substitution of stone for wood in the construction of buildings, docks and wharves, were factors in bringing about this. During the next century the epidemics of Marseilles in 1720, of Messina in 1743, of Cyprus in 1759 and of Moscow in 1771, may be particularly noted with the shifting of trade routes and the changes in national intercourse due to wars and the introduction of steam vessels, plague appeared in the various parts of the Orient, in Asia Minor, and the Mediterranean littoral at various times in the eighteenth and nineteenth centuries.

Present Pandemic.—The present pandemic of plague began in 1894 in the Yunnan Province of China, whence it spread to Canton from which it began a series of ramifications over the entire globe. Appearing in Canton in January, 1894, it quickly reached epidemic proportions and between March and August of that year it is roughly estimated that 120,000 persons died in Canton alone. It spread to the neighboring island of Hongkong and in the following year reached Amoy, Macao, and Foochoo. In 1896, China, India, Japan, Asiatic Turkey, and European Russia reported cases of the disease. The pandemic continued and in 1898 Madagascar and Mauritius suffered from incursions of plague. The disease continued to spread and in 1899, in addition to the countries already mentioned, Arabia, Persia, the Straits Settlements, Austria, Portugal, Mauritius, British South Africa, Egypt, the French Ivory Coast, and Portuguese Africa, were attacked. In South America the disease appeared in Argentina, Brazil, and Paraguay, and even Hawaii and New Caledonia suffered from its incursions. In 1900 the disease appeared in the United States for the first time, where it continued until 1904. In 1904 the disease reappeared in our country and was eradicated from the City of San Francisco in the following year. It still persists in the State of California, however, among ground squirrels. In 1912 plague broke out in San Juan, Porto Rico, and was very promptly eradicated. In 1914 plague was reported as present in New Orleans. It still exists there among rodents. At the present time the disease may be considered as existing in the Azores, Brazil, Ceylon, China, Cuba, Dutch East Indies, Ecuador, Egypt, Greece, India, Indo-China, Japan, Mauritius, Persia, Peru, Siam, the Straits Settlements, Turkey in Asia, the Union of South Africa, the United States and in Zanzibar. Directly or indirectly our country is in commercial communication with all of the places which have been mentioned, and it must be admitted that in view of the fact that plague is a disease of rodents which travel around the world in ships, the United States must consider itself as seriously menaced by bubonic plague. As an index of the spread and mortality from the disease it may be stated that from 1896 to 1905, in India alone, 4,097,764 people died of the disease, or an average annual mortality of 409,776. In 1904, in a population of less than 27,000,000 in the Punjab, 357,000 people died of the disease, while in all India over one million people perished from plague in that year alone.

Symptoms.—The writers on plague have classified it into two general forms, pestis major and pestis

minor. Pestis major is also described as pestis siderans or pestis fulminans. This merely means that the case may be either a mild one or a severe one. It has also been classified as bubonic, pneumonic, and septicemic plague. In other words a case may have buboes, it may have a pneumonia, either with or without buboes, or the degree of infection may be so profound that all of the discoverable symptoms point to a profound septicemia. As a matter of fact practically all cases are septicemic, and the bacteria may be found in the blood in pretty nearly all of them. The case may be frankly pneumonic, or frankly bubonic, or it may be primarily bubonic and secondarily pneumonic. While this classification is more or less artificial, it plays an important part in prophylaxis because, as can readily be seen, in the absence of ectoparasites, the spread of the disease from human being to human being is far more apt to occur in the pneumonic type of the disease. It is very important that the mild form or pestis minor be recognized because it is so frequently the forerunner of severe epidemics.

Incubation Period.—The incubation period of the disease is subject to considerable variation. It may be as short as three days and usually is about five days, but it may be prolonged to ten days.

Prodromes.—While the onset may be sudden and acute, there may be prodromal symptoms. These are chiefly referred to the nervous system and include frontal headache, vertigo, staggering gait, and a condition which at first resembles drunkenness and subsequently passes into a lethargy. The face is pale, the eyes are injected, the patient appears absent-minded, and there is a vacant, stupid expression of countenance. There is intense malaise, far out of proportion to the findings, and there may be backache, pains in the legs, and great weakness. The tongue is heavily coated, with red edges, and later becomes dry and reddish brown in color. The appetite is lost. There may be vomiting. Usually there is constipation. Loin pain is a frequent symptom, but in other cases pain in the axilla or the neck may be noted. This stage of the disease is short, lasting but a few hours or at most a day. It may be rapid and overwhelming or leisurely and mild. The former is the rule.

Onset.—The febrile symptoms now appear. The patient complains of chilliness. The temperature rapidly mounts to 102°, 104°, or even 107° F. The pulse is rapid, small, thread-like, and at times weak. The skin is dry and warm. Constipation continues. The patient, if he has remained up till now, is obliged to go to bed. Nausea and vomiting may occur. In children convulsions are noted, while in adults there may be an active delirium, but more often hebetude and coma are the rule. In the early stages the patient appears worried, but this soon gives place to an absolute apathy. The speech is thickened and ideation is tardy. As a rule, the febrile stage lasts from two to five days but it may continue longer. The temperature generally seeks normal suddenly, if a recovery is to take place, otherwise it usually continues high until the fatal termination. Sometimes there is a secondary rise of temperature. This is particularly apt to occur if suppuration of the bubo is taking place.

The Bubo.—The buboes usually do not appear until after the onset of the fever The patient frequently complains of sharp lancinating pains in them. They are at first small and exquisitely tender to the touch. Their appearance is preceded by intense pain at the site at which they are to occur. The glands are usually affected in groups, the group attacked depending usually on the site of the inoculation. Femoral buboes occur in from 60 to 70 per cent. of all cases having buboes; axillary in from 15 to 20 per cent., and cervical in from 5 to 15 per cent. In a small proportion of bubonic cases, 3 to 5 per cent.. there may be multiple glandular involvement. Some authors state that the mortality is highest in the case with axillary buboes, but it has been my observation that death in the bubonic form is most apt to occur when the buboes are cervical. At first the glands are extremely hard, and as the inflammation continues they become fused together. There is usually an extravasation about them which at this stage gives one the sensation of feeling of a number of large marbles through a feather pillow. The brawny edematous swelling may, however, not take place, the bubo remaining small and hard. In case there is suppuration of the glands they soften. This is usually regarded as a favorable symptom. Most authors consider the rapid disappearance of a bubo at the height of an attack as very ominous. Sometimes the skin covering the bubo sloughs away and a carbuncle is formed. The bubo may terminate in resolution, suppuration or induration. When suppuration occurs, the wound heals after spontaneous or surgical evacuation of its contents. Frequently healing is delayed for a considerable time. In any event the scar is apt to be large.

Hemorrhagic Signs.—During the seventeenth century it was considered that the purpuric eruption was an invariable forerunner of death from plague. These spots were known as "tokens" and are described by most of the old writers. Large purpuric patches may occur about the petechiæ. The eruption may vary from petechiæ the size of a lentil to patches as large as the palm of the hand. It should be borne in mind that nearly all of the symptoms of plague may be accounted for by the fact that it is a hemorrhagic septicemia, and that not only may there be hemorrhages into the skin but into and from the various organs as well. In a general way it may be said that the more severe the hemorrhagic symptoms the more severe the case must be considered. Epistaxis is not uncommon in the grave cases and sometimes pulmonary hemorrhages are seen. Hemorrhage may take place into the stomach and produce a black vomit or it may take place into the bowel and produce black dejecta. These are symptoms of grave import, as are also urinary hemorrhages and genital hemorrhages in women.

Skin Signs.—In about two to two and one-half per cent. of cases, carbuncles are seen. At first they are red patches on the skin, which become indurated and sometimes present vesicles. These patches slough out, leaving an open wound sometimes two or three inches wide. They are particularly apt to occur over the sacrum and elbow. In some of the epidemics, pustular and vesicular eruptions have been seen. At times profuse sweating has been noticed.

Nervous Symptoms.—The symptoms which are referable to the nervous system may be accounted for by the profound toxemia. Many authors described maniacal delirium in certain outbreaks, but as a rule the nervous symptoms are those of apathy and hebetude, which increases as the disease progresses. Paralyses may occur as sequelæ, but infrequently.

Respiratory Symptoms.—The respiratory symptoms may vary from merely a slight quickening of the respiratory rate to symptoms of a profoundly overwhelming pneumonia. There may be hemoptysis, there may be a secondary bronchopneumonia and bronchitis, or there may be a true pneumonic plague, in which the auscultatory signs are those of a lobular pneumonia. The variation in gravity of the respiratory symptoms may be perhaps accounted for by differences in climate. In general it may be said that the colder the climate the greater the liability to profound respiratory involvement.

Pneumonic Plague.—Some writers have called the bronchopneumonia of plague, which is not an infrequent complication, a secondary pneumonia and have preferred to put pneumonic plague in a class by itself. In the latter type of the disease there is primary bubo, and the attack is focused upon the lungs. The initial symptoms are more profound. Patients seen early

appear very anxious. Their speech is almost inarticulate. The respiration is quickened. There is high fever and there may be no other findings until the second or third day of illness. The patient, though, is overwhelmingly sick. Perhaps the next thing that will be noted will be pleuritic pain. Then comes the cough with blood-stained expectoration. The dyspnea increases. The respiratory rate rises rapidly to fifty and I recall one case in which it was over sixty. As the disease progresses there is cyanosis. On percussion areas of dulness are found and the signs elicited with the stethoscope are those of lobular pneumonia. The pulse is small and very weak, and death, which almost always occurs in this form of the disease, is from heart exhaustion about the fifth day. There is a profound septicemia and the blood changes are those of marked leucocytosis with hemolysis.

Cause of Death.—When death occurs from plague it is usually about the fifth day. In the septicemic form, which is an extremely virulent and rapid type of the disease, death may occur on the first, second, or third day. As someone had said, "The patient dies before he has time to become sick." Sometimes patients recover from plague only to die of the suppuration of the buboes. In the septicemic form, buboes may not be discoverable during life. The picture is that of high fever, great prostration, headache, vomiting, drowsiness, hurried panting respiration, small feeble, dicrotic, intermittent pulse, delirium, carphologia, subsultus tendinum, stupor, coma, collapse. Death usually takes place from heart failure. Severe toxemia, edema of the respiratory organs from the pressure of the buboes, and hemorrhage are also causes.

Prognosis.—In a general way the gravity of the prognosis is directly in proportion to the hemorrhagic symptoms. When the buboes suppurate the chances of recovery are much greater. The more profound the picture of toxemia, the more grave is the prognosis. It should be borne in mind, however, that the prognosis in plague is extremely variable, and patients who one day are apparently proceeding rapidly toward recovery may be dead the next. Of all the diseases which occur in widespread epidemic form, plague has by far the highest mortality. Death is almost sure to occur from the pneumonic and septicemic types. In the bubonic type the average mortality rate is in the neighborhood of fifty-five per cent., although the use of large doses of antitoxin has brought this figure down to thirty per cent. of all cases, and to about ten per cent. in cases which receive specific treatment very early.

Diagnosis.—It is extremely desirable that a diagnosis be made in plague cases as early as possible in order that the patient may receive appropriate specific treatment and that the sanitary officers of the community may crush the focus of the disease before it has had an opportunity to spread. It is pretty nearly impossible in a great many instances to make a positive diagnosis without a laboratory examination, but the general picture of a sudden, profound hemorrhagic septicemia, with enlarged lymphatic glands, and overwhelming prostration should immediately arouse suspicion. The mild cases, the so-called pestis ambulans, are very difficult to diagnose at the bedside. The occurrence of buboes which cannot be accounted for in any other way should put the practitioner on his guard. This is particularly true in seaport cities and among sailors and stevedores. Animal inoculation will confirm or exclude a diagnosis of plague. In the more severe cases the character of the glandular involvement, which is not found in any other acute febrile disease; the worried, anxious expression, the drunken appearance, the slow, slurring disconnected speech, and weakness of far greater degree than you would expect from the physical signs, should make you think of bubonic plague. If you will then aspirate some of the gland fluid from the center of the bubo and make smears, cultures, and above all, inoculations into guinea-pigs, you can make an absolute diagnosis. In the case of the pneumonic and septicemic forms, the same procedure may be made with blood and sputum. In time of epidemic, all rapidly fatal pneumonias and unexplained septicemias should be carefully investigated to exclude plague.

Treatment.—Until very recently the treatment of plague has been extremely unsatisfactory. Of course, patients are to be put under as favorable conditions as possible. The symptoms must be met as they arise, and treatment directed toward sustaining the heart action. This, however, is merely making your patient comfortable and trusting in providence. The antiplague serum which Yersin, Calmette, and Borell perfected, if given early and in large doses, greatly increases the chances of recovery. This serum is produced by the immunization of horses with plague cultures. It should be administered intravenously under aseptic precautions. The India Plague Commission, which made a careful study of all available data regarding this method of treatment, came to the conclusion "that the method of serum therapy as applied to plague has not been crowned with a therapeutic success in any way comparable to that obtained by the application of the serum method to the treatment of diphtheria." During the San Francisco epidemic of 1907 the serum seemed to give encouraging results in spite of the fact that it was used in small doses. Creel used it in large amounts during the Porto Rico epidemic of 1912 and obtained even better results. Guiteras employed the serum in Havana in large doses and with marked success. During the epidemic of 1914 in New Orleans still larger doses were used and effected a cure in practically every case in which the serum was administered early. On the other hand, the use of enormous doses in India frequently failed to prevent a fatal issue. The initial dose should be at least 50 c.c., which should be repeated every two hours until the patient reacts. If improvement should occur there will be a fall in the temperature, the nervous symptoms will become less marked, and the patient will be out of danger in a few days.

In former times considerable stress was laid on the local treatment of the buboes. Various antiseptic ointments have been applied and in certain instances the glands have been dissected out in the hope of checking the disease. In view of the painfulness and apparent uselessness of such methods their use should be discouraged. In the early stages it is a good treatment to put on ice-bags or anodynes or poultices, in an attempt to control the pain. And later, should suppuration take place, the gland should be incised and drained. There is nothing to be gained by precipitate surgical measures.

Quinine once enjoyed considerable reputation in the treatment of plague, but is practically useless. Strychnine, digitalis, and strophanthus may be employed to sustain the heart. The diet should be light but nutritious. The use of alcohol is contraindicated. During the after-treatment itself and at all times during the height of the disease it is of vital importance that the patient should be kept very still in bed. Under no circumstances should he be allowed to sit up or move to any extent about the bed until the temperature has been normal for at least four days. Several authors report fatal terminations because of an infraction of this rule by patients who were apparently on the high road to recovery. Another point which is more in the nature of prophylaxis than treatment is the careful examination of the patient on admission to see to it that he is harboring no ectoparasites. During the New Orleans epidemic, Dr. C. C. Bass, while examining a septice-

mic case, took from her person a bedbug which was proven to be infected. During the San Francisco epidemic a lousy patient spread the disease to two other persons in the room with him. Not only should the patient be examined for all suctorial insects, but his clothing should be also disinfected.

Pathology.—The morbid anatomy of plague, with the exception of the lymphatic swelling, is not very different from that of any of the hemorrhagic septicemias. There is engorgement of practically all of the viscera, and extravasation from the veins affecting practically the entire body. There is congestion of the central nervous system and the brain may be somewhat softened. Similarly the lungs are congested and the posterior parts are edematous, and there are small hemorrhages into the substance and on the surface of the lungs and the pleura. The upper air passages show a catarrhal inflammation and bronchopneumonia is a very frequent complication. This takes the form of a lobular hepatization. There may be embolic abscesses, particularly in the subacute cases. These are scattered irregularly through the lungs as yellowish nodules which feel hard and are surrounded by a congested area. When these are split open they have a central soft portion surrounded by a harder zone of grayish-pink tissue. There is frequently a blood-stained fluid in the pericardium, the right heart is filled with black partially coagulated blood, the heart muscle is pale and sometimes very much softened. The liver is deeply congested and enlarged. It may contain embolic abscesses which on section have the appearance of a nutmeg. The stomach and intestines may contain bloody fluid and sometimes show intense venous congestion. The spleen is greatly enlarged and usually of fairly firm texture. There may be hemorrhages into its capsule. All of the foregoing findings merely mean that the patient has an intense septicemia. The characteristic thing about a plague necropsy is the inflammation and swelling of the lymphatic glands. All of the groups of glands may be affected so as to form continuous chains and they may form agglomerated masses which may weigh over a pound. The bubo itself is characteristic. On section through the overlying skin there is observed an edematous area which may extend for several inches in every direction from the center of the gland. When the incision is made there is an escape of blood-stained serum and not infrequently all of the tissues about the gland are hemorrhagic in appearance. The bubo itself consists of a mass of inflamed glands which are matted together. On section the gland appears reddish or pink and may have a central area which is grayish yellow or mottled brownish red and gray. The individual glands composing the bubo may vary in size from that of a pea to that of a walnut. Of course, the condition of the glands depends largely on the time of death. When this has occurred early in the disease they may be dark purple in color. Later they may be red or violet or brownish red. The glands may be peripherally firm, but this depends upon the stage of the disease at which death occurred. Careful students of the disease have recognized not only the internal buboes which have been spoken of above, but secondary buboes which may develop in all regions of the body quite independently of the seat of the primary bubo. It may be well to sound a note of warning regarding the performance of plague necropsies. Every precaution in technique and asepsis must be taken because there have been several very sad accidents as the result of carelessness in this particular. The plague bacillus can enter the body through the most minute abrasion without producing a reaction at the site of inoculation. In this way several medical men have been infected while performing necropsies and have sacrificed their lives in the pursuit of their scientific duties. The specific microorganism may be found in all of the tissues and fluids of the body. One cannot with safety make a diagnosis of plague on the morphology of the bacteria alone, but one can at least make a provisional diagnosis pending the result of the animal inoculations and cultures. The plague bacilli will usually be extra cellular and about the gland will most often be of the typical shape, *i.e.* short rods with rounded ends which stain deeply with almost any of the aniline dyes leaving a clear space between. Within the bubo itself the involution or degenerative forms are most often seen. The typical forms are seen early in the disease, later the bacteria may take on very bizarre shapes, coccoid, globular, spherical, balloon shaped, sickle shaped, etc. In fact they resemble almost anything which the imagination of the beholder cares to ascribe to them. These odd forms sometimes stain faintly, the dye coloring the periphery and leaving a clear center. Frequently the infection is mixed, pneumococci, streptococci, and staphylococci being seen. The Austrian Plague Commission has drawn attention to the fact that, though the bacillus is frequently not to be found in the suppurating bubo, its vitality is not necessarily destroyed by suppuration.

Bacteriology.—The cause of plague has been attributed to many things, *e.g.* long, dry summers, inundations, the conjunction of the planets, the wickedness of man, the pestiferous emanations from the soil, and noxious vapors and effluvia. Many have thought that it is not improbable that Athanasius Kircher saw the plague bacillus in 1658. In any event he advanced many arguments to prove that the infectious agent was propagated from person to person and described the causative organism as minute worms "so small, so light, so subtile, that they elude any grasp of perception and can only be seen with the most powerful microscope." Modern investigation has proven the correctness of his views in this respect at least. The causative agent of bubonic plague is a polymorphic bacillus discovered independently by Kitasato and Yersin during the Hongkong epidemic of 1894. This organism has been studied by numerous observers in many parts of the world and has been definitely identified as the cause of plague. It belongs to the group of pasteurelloses or hemorrhagic septicemias, *i.e.* diseases in which the causative microorganisms invade the blood stream acutely and are thus distributed to all parts of the body. The plague bacillus has the peculiarity of polymorphism, *i.e.* it exists in more than one form. It is found in the buboes and in the blood in three general shapes, short oval rods, long rods, and involution forms which may be rather large round, pear-shaped or oval forms. As a rule, the organism is a short rod shaped somewhat like a sausage with rounded end. The involution forms which are produced by growth on artificial media are bizarre shapes which may resemble almost anything and even produce branchings and club-like swellings. The production of involution forms is a point to be taken into consideration in determining the bacterium in laboratory diagnosis. It does not form spores. The plague bacillus is readily killed by drying, sunlight, heat and germicides. It is very resistant to cold. In nature it does not have a saprophytic existence and will quickly die in the soil and in other situations outside the human body. When injected into the higher apes and the rodentia it produces the disease. In several instances it has been accidentally inoculated into man and under such circumstances all the symptoms and lesions of the disease have been produced.

Staining.—The plague bacillus in smears is extremely easy to stain with aqueous solutions of methyl blue, gentian violet, fuchsin, or any of the usual basic dyes. It is more difficult to stain in sections. A striking feature of the staining is that it is usually

polar with a clear space between, hence the organism is sometimes called bipolar. It is Gram negative and does not form endospores. It is non-motile. Kitasato and Yersin described it as having a capsule and this may be seen in smears from cultures stained by Romanowsky's method or any of its modifications. Smears from buboes show a few single organisms, the greater number appearing as diplococci or diplobacilli, sometimes they may even form in chains. The bacteria usually crowd the field, but sometimes they are so scarce as to require animal inoculation for their detection.

Cultures.—Under aerobic conditions it is not difficult to grow the plague bacillus on ordinary culture media. The first culture is slower in growth than the subcultures. While blood heat is not the most favorable to the growth of the bacillus, it will grow between wide ranges of temperature, the optimum being about 30° C. It will produce slight growth under anaerobic conditions. When planted on agar plates and maintained at 30° C. for twenty-four hours, the colonies appear under low magnification as minute glistening drops like dew. At the end of forty-eight hours they have a grayish-white appearance, somewhat granular looking with a wide irregular crenated edge. Sometimes the colonies are grayish yellow. When streaked on agar there is developed in twenty to forty-eight hours a slimy whitish-gray mass.

Involution Forms.—The production of involution forms on salt agar is very valuable from a diagnostic standpoint. The media is made by adding two and one-half to three and one-half per cent. of sodium chloride to ordinary agar. When grown on this media there is a very rapid development of the bizarre forms which may resemble spindles, clubs, balloons, pears, sausages, dumb-bells, and a great variety of objects not at all like the typical rod-shaped form. This is not absolutely diagnostic as some of the other pasteurellæ closely related to the plague bacillus may show this phenomenon. The involution forms occur more quickly and with greater certainty in the case of the plague bacillus. Bizarre forms also appear in old dry agar cultures and when the organism is grown on potatoes, also in cases when the infection has been very prolonged. These forms take stains with great divergence. Sometimes very deeply and uniformly, again only very lightly throughout, sometimes peripherally only, sometimes only centrally and again with varnoles which of course take no stain.

Bouillon Cultures.—The organism grows singly, in coccoid forms and in chains on bouillon, appearing as a thin surface film and as sticky flocculent masses on the sides and bottom of the tube. It was formerly taught that the stalactite growth in bouillon on the surface of which were minute droplets of oil was very characteristic. This phenomenon has been observed in other bacteria. The stalactites fall to the bottom of the flask when it is agitated but again reform.

Plague in the Lower Animals.—The most essential factor in the control of plague during recent years has been the realization that it is essentially a rodent epizootic. It is true that the literature of plague contains reports of the disease in monkeys, dogs, cats, horses, asses, cattle, sheep, goats, swine, calves, chickens, pigeons, geese, camels, kangaroos, bats, frogs, geckoes, goldfish, and carp, but many of these reports are not confirmed by convincing experimental evidence.

Hankin noted an epizootic in monkeys in October, 1897, at Kankhal, and a second simian epizootic was observed at a little later date at Jawallapur. A third series of cases was observed at Gadar in the residency of Bombay in December, 1899. In the second and third simian epizootics the diagnosis was confirmed bacteriologically. Calmette and Salimbeni and the German and Russian plague commissions demonstrated the susceptibility of the brown monkey and the gray monkey to plague. From the collected evidence it may be deduced that while monkeys have a great susceptibility to plague infection, they do not seem to play an important rôle in its propagation under natural conditions.

While there are a number of reports on the susceptibility of the dog to plague infection, a study of them does not warrant the belief that the dog is liable to the disease.

There are a large number of reports on epizootic plague among cats, yet these animals probably play a very unimportant part in the continuance and spread of the disease. Hunter concludes that cats are susceptible to plague and that they suffer from an acute or chronic plague septicemia. He was of the opinion that they infected themselves by eating infected rats.

Horses are moderately susceptible to plague infection when pure cultures are injected into their blood streams in relatively large doses. A careful review of the literature does not disclose an instance in which they suffered from the disease in nature.

Schreyer, K. Matsuo, and Wu Lieu Teh, have reported that coolies working in a coal mine and attacked by pneumonic plague infected donkeys with the disease. These are very extraordinary conditions and may be accounted as practically negligible in the course of an ordinary epidemic.

Under natural conditions plague has never been found in bovines. It is true that Simson reported ingestion plague among calves, chickens, pigeons, dogs, geese, sheep, and swine, but Bannerman and Kapadia, the German commission, and Hafkin and Lowson, have reversed his reports. It is, therefore, logical to conclude that these animals do not play a rôle in plague perpetuation or dissemination.

Since 1899, when Dchurkowski described an infectious disease of camels closely resembling plague, there have been several reports of alleged outbreaks of plague in which the camel was the vehicle. The Astrakan commission decided that the camel was susceptible to plague and suggested that these animals might have been the means by which plague has been introduced into countries along the caravan routes. It is doubtful, however, if camels play any great part in the large problem of plague.

The report of the Board of Health of Sydney, 1902, contains a note by Thompson in which he states that in the epidemic of that year seven kangaroos died from plague in the zoological garden at Sydney. This is an isolated instance and without bearing on the general problem.

With regard to bats, the reports are at variance. Gosio experimenting with the Vesperugo noctula believed that he was able to infect them. On the contrary, Toyama reported these animals as insusceptible.

It seems to be fairly clearly demonstrated that birds in general, and particularly birds which run on the ground, are not susceptible to plague

The cold-blooded vertebrates, that is, reptiles and batrachians, have been experimented with by Nuttal, Dweill, Furth, and Fukahara, and do not seem susceptible to plague, either by injection or ingestion.

Mention need not be made of the rôle of insects and Ixodidæ in relation to plague, their part being the transmission of the infection from host to host rather than the function of keeping the disease alive within their own bodies.

The rôle of the rat in the pathogenesis of plague is classical and there is a preponderance of evidence which proves that bubonic plague in man depends entirely on the presence of the disease in rodents. It is true that in the pneumonic form of the disease infection occurs directly from man to man without the intermediation of any ectoparasite, but the great bulk of plague is not pneumonic, but bubonic, and

it is the rodent species which keeps the disease alive and which carries it from country to country and into the home of man. Plague has been found in nature in the *Mus norvegicus*, the *Mus rattus*, the *Mus alexandrinus*, and the *Mus musculus*. The *Nesocia bandicota*, or bandicot rat; the *Arctomys bobac*, or tarbagan; the *Putorius furo*, or ferret; the *Herpestes griseus*, or mongoose, and the *Neotoma fuscipes*, or brush rat, have all been found susceptible to the disease. All of the spermophiles have proved infectible, as have also the *Cynomys ludoviciana*, or prairie dog, and the *Putorius fœtidus*, or skunk. The *Citellus grammurus*, or rock squirrel, and the *Citellus beecheyi*, or ground squirrel, have also proved infectible. The disease has been found in nature in brush rats, skunks, and ground squirrels. The overwhelming fact in plague perpetuation and spread is that it is a rodent disease.

Plague Infection in Rodents.—The clinical manifestations of plague in rodents are of relatively small importance. It is generally said that the plague-infected rat staggers about as though it were drunk, loses the fear of its natural enemies, and comes out into the open where it may be readily captured. Relatively few plague-infected rats are found dead under ordinary conditions. This was especially true during the plague epidemic of 1907 in San Francisco. In Seattle the great bulk of the plague-infected rats, however, have been found dead. In New Orleans it was only during the intensive work incident to the cleaning of plague foci that plague rats were found dead.

Skschivan, Kistner and Schumacher, and many others, have observed and recorded the gross lesions of plague in rats. The Indian Plague Commission which had the opportunity of examining an enormous number of plague rats in Bombay and elsewhere in India crystallized the knowledge of this subject and pointed out its field of usefulness. As to the comparative value of microscopical and macroscopical methods of diagnosis, the Indian Plague Commission states in its report that "the results of tests carried out for the purpose of comparison make it manifest that the naked eye is markedly superior to the microscopical method as an aid in diagnosis and as a result of our experience we are prepared to make a diagnosis of plague on the strength of the macroscopical appearance alone, even though the other results of cutaneous inoculation and culture are negative and the animal shows signs of putrefaction." This conclusion has been verified in many instances, but in the case of chronic or resolving plague of rats it is necessary to resort also to inoculation methods.

Mode of Examination of Rodents in the Laboratory.—The animals to be examined are first immersed in any convenient solution which will kill fleas and other ectoparasites which might be capable of transferring the plague bacillus from the infected animals. The animals are then tacked to shingles and checked as to the location from which they are taken. It may be stated here that in plague eradicative work the trappers are required to carefully tag rats to show where, when and by whom captured. After the rodents have been checked, they are next dissected. An incision is made from the symphysis mentis to the symphysis pubis. The skin is next reflected so as to expose the axillæ and groins. The abdominal cavity is next opened and the condition of the spleen, liver, and other abdominal contents noted. The plastron is next removed and the contents of the thoracic cavity inspected. Careful search for buboes should be made in the region of the various peripheral lymph glands. The entire abdominal and thoracic contents should be subjected to careful scrutiny. Laymen of average intelligence can be readily trained to recognize the gross lesions of rat plague. Every rat should, however, be subjected to careful scrutiny by a pathologist who is responsible for the work. All animals sent to the laboratory including mice, should be subjected to careful examination unless they are so putrid as to make this impracticable.

Gross Lesions of Acute Plague in Rodents.—Subcutaneous injection is the sign which usually first attracts attention. It is seen as an engorgement of the subcutaneous blood-vessels, together with a diffuse red or pinkish color of the subcutaneous muscles. These have a dry, waxy, translucency. While the injection is frequently of a pink color, it should not be confounded with the pinkish injection not infrequently seen in otherwise normal rats. Frequently the injection is dark red, the vessels being distended with blood, and not infrequently subcutaneous edema confined to the vicinity of the bubo will be noted. Cutaneous injection is general, as a rule. Occasionally it may be unilateral and still less frequently confined to the region of the bubo alone. Usually it is intense.

The bubo is the most reliable single sign of plague infection and when present in typical form is enough on which to base a tentative diagnosis. The involved gland is usually surrounded by a more marked injection than is present elsewhere, and an infiltration which may be hemorrhagic. The gland proper is usually caseous. The contents may be shelled out very readily, prior to section the gland feels very firm. The bubo of plague should not be confounded with the indolent enlargement of the lymph glands commonly encountered in non-infected rats. Such glands are tough, elastic and not surrounded by infiltration. In the leprosy-like disease of rats the glands may reach considerable size. Glands of the neck, axillæ, groins, or pelvis may be involved. In America it is usually the glands of the groin which present the buboes.

The liver may either be yellowish in color and studded with a large number of yellowish-white granules about the size of a pin-head, or it may be marked with grayish-white spots giving it the so-called "pepper and salt" appearance. It should be noted in this connection that rats which have been fed on Danyz virus often present lesions in the liver closely resembling those due to plague infection. The granules, however, are larger and more distinct, and the spleen findings are not the same as those observed in plague.

The spleen is markedly enlarged, firm, friable, rather dark in color, and occasionally presents small subcapsular granules. At times the organ appears to be mottled. In certain cases it is slate colored.

It is common to find in plague-infected rats a serous bilateral pleural effusion. The serum is usually clear although it may be blood stained. It is not common to find pleural effusion in rats that are not plague infected.

In making a macroscopic diagnosis of plague it is important to bear in mind that no single sign is pathognomonic; that it is a combination of two or more of the signs that is of moment. In no case should a positive diagnosis of plague be made without having recourse to inoculation of guinea-pigs and other animals.

Chronic Plague.—McCoy reports that no case of natural chronic plague was encountered by him in San Francisco. Similarly the Indian Plague Commission found only a single case in the rats examined in Bombay. However, in the New Orleans 1914–15 epidemic, several rats with the lesions of chronic or resolving plague were found.

In the conduct of eradicative plague measures, it is extremely important, particularly at the time when acute plague is falling off, to discover with as great rapidity as possible all cases of chronic plague. To this end every rodent which is not too badly decomposed should be subjected to careful laboratory examination. The lesions observed in chronic plague are very different from those of acute plague. As a

matter of fact in many instances there is nothing more to attract the eye than perhaps a band of adhesions between the spleen and the diaphragm, or between the lungs and the diaphragm. A careful search should be made for encapsulated foci, and in each instance inoculations should be made into laboratory animals. It will be found that many animals will be used in this way without perhaps determining a single case of chronic plague, but whenever such a case is found it is well worth the additional expense. In many instances the lesions will show beginning scar formation, indicating that the disease was received a considerable time previously.

Plague in Mice.—In connection with the careful examination of all rodents to discover chronic plague, if it should be present, the examination of mice should never be omitted. Many laboratory workers find this exceedingly difficult and distasteful by reason of the smallness of mice and the consequent length of time which must be employed in making the examination. As a rule in the beginning of plague eradicative measures, before there has been any material reduction in the rat population, very few infected mice will be found. The reason for this is the fact that whenever rats and mice come into open competition the rats destroy the mice. As the rat population is reduced, mice grow bolder in their habits and forage in places where they have not previously been. In this way they are very apt to pick up infected rat fleas and themselves become infected. Inasmuch as mice are house dwellers by preference, and thus come into intimate contact with man, their importance in the plague problem is greatly increased.

Plague in Ground Squirrels.—The discovery of plague in ground squirrels (*Citellus beecheyi*) in 1908, brought the squirrel into prominence as a distributer and perpetuator of bubonic plague. Plague exists among ground squirrels in infected regions in two forms, acute and chronic. The acute plague is generally seen in those situations in which plague has only recently been introduced. After the disease has existed for a few years the great bulk of the squirrels found will have chronic plague. In making careful surveys of the prevalence of the disease among ground squirrels, small areas will be found, for example, isolated valleys, in which acute plague is occurring, while the surrounding area produces squirrels with chronic plague. In such a situation the death rate among the acutely infected squirrels is very high and not infrequently the ground about their burrows is seen covered with skeletons of these animals. Frequently large numbers of fleas are found in such places. In areas in which chronic plague exists it has been noted that squirrels which are taken alive and subsequently artificially infected with plague in the laboratory show a higher resistance to the disease than squirrels taken from regions in which the disease has never been known to exist before.

The method of dissecting ground squirrels differs in no particular from that employed in the examination of rats. The peripheral lymphatic glands should be completely exposed. In order to do this accurately it should be borne in mind that in ground squirrels the lymph glands in the neck vary from four to five in number on either side, lying in a curved line around the thyroid gland. The axillary glands in ground squirrels are apt to be surrounded by pinkish fat which on cursory examination might be mistaken for diseased lymphatic tissue. The glands draining the posterior portion of the body should always be subjected to the most careful examination, as in ground squirrels they are more frequently involved than those of the axillary or cervical regions. There is a median inguinal gland just above the buboes in the midline. This gland should always be examined, it being borne in mind that it does not exist in rats or in guinea-pigs. There is a set of posterior inguinal glands and a set of pelvic glands which lie just at the bifurcation of the aorta.

Infected glands are usually surrounded by a hemorrhagic area with a gelatinous exudate. The bubo itself is dry, somewhat mealy, and varying in color from salmon to bloody. Sometimes the gland is not surrounded by an exudate. Sometimes the bubo will contain a little blood-tinged pus, or the entire contents may be made up of grumous reddish pus. The visceral pleura occasionally presents small subserous hemorrhages. The spleen is enlarged and usually of a deep red color and firm consistency. If decomposition has taken place it is soft and usually slate colored.

In *chronic plague* in ground squirrels the postmortem findings vary considerably. There may be a few caseous granules in the spleen, as abscess in the liver, or several glands showing necrosis with large and numerous caseous foci in the liver, spleen, and lungs. The buboes are sometimes quite large and cheesy. The lungs may show a pneumonic consolidation and are usually rather gray in color, with caseous, purulent foci. The caseous areas may show beginning organization. As in chronic plague of rats, adhesions of serous surfaces are sometimes seen.

The bacteriology of squirrel plague is practically the same as that of rat plague. The bacillus which is found is indistinguishable from that discovered in other animals having plague.

Plague Eradication and Prevention.—Since plague is primarily a disease of rodents, and secondarily and accidentally a disease of man, man's safety from the disease lies in the exclusion of the rodent and his parasites. This is the basis of all preventive and eradicative work. If man can live in rodent-free surroundings he need have no fear of plague, because if there be no rodents there can be no rodent parasites, and for all practical purposes the flea may be considered as the common vector of the disease from rodent to rodent and from rodent to man. The eradication of bubonic plague therefore means the eradication of rodents.

In America, as we have seen, there are two rodents which are comprehended in this problem, the rat and the ground squirrel, and apparently each plays a very distinct rôle in the propagation and perpetuation of the disease. The rat is distinctly domestic in its habits, and therefore comes in more or less intimate contact with man. It is also a frequenter of the great highways of the world, traveling long distances in ships and to a limited extent on trains. It is the producer of acute outbreaks, the conduit for the carriage of the virus from its perpetuating reservoir to the body of man. The ground squirrel, on the contrary, is not a dweller in human habitations, does not travel except by short migrations, and is an almost negligible factor in the direct transfer of the disease to man. Its great function in the plague scheme is that of a rural reservoir from which from time to time the disease flows over to the suburban rat, thence to his city cousin, and thence to man. This condition is not peculiar to America alone, since in China and Thibet the marmota (*Arctomys bobac*) and allied species perform a similar function.

The problem divides itself into two parts, (1) plague eradication and (2) plague prevention.

In the city the fight is directed against the rat and its parasites, and aims to prevent the spread of the disease from them to man. The campaign is conducted along the following lines:

Plague Eradicative Measures.

I. Deratization.

1. Rat slaughter: (*a*) Poisons—chemical (solid and gaseous), biological; (*b*) traps—cage, snap, barrel, etc.; (*c*) shooting, clubbing and other forms of violence; (*d*) natural enemies—cats, dogs, ferrets, etc.

2. Rat eviction: (*a*) Destroying rodent habitations;

(*b*) rat-proofing—permanent, temporary, and by elevation.

3. Rat starvation: (*a*) Proper disposal of edible refuse; (*b*) rat-proofing of food supplies.

4. Prevention of rat multiplication: (*a*) All the above; (*b*) harrying.

II. Depulization.

1. By the destruction of the host.

2. By direct destruction of the flea itself: (*a*) Disinfection of rodent habitations and human habitations in which human or rodent cases have been discovered; (*b*) pulicides—carbon bisulphide, kerosene, chlorinated lime, etc.; (*c*) ordinary domestic cleaning methods; (*d*) pneumatic suction apparatus; (*e*) depulization of domestic pets.

III. Delineation of the Infected Zone.

1. Inspection of: (*a*) The human dead; (*b*) the human living; (b^1) contacts to human and rodent cases; (b^2) in infected localities.

2. Examination of rats: (*a*) Macroscopically; (*b*) bacteriologically.

3. Plague barometers.

IV. Prevention of the Spread of the Disease.

1. From man: (*a*) Isolation; (a^1) actual cases; (a^2) suspicious cases; (*b*) disinfection; (b^1) environment—habitation, clothing, etc., cases; (b^2) excreta (sputum in pneumonic cases).

2. From rats: (*a*) Prevention rat migration; (a^1) via natural avenues (sewers, etc.); (a^2) via vehicles (trains and ships).

3. By education of the general public.

In the country the measures follow the same general line as in the city and are modified only to meet existing conditions, such as the species of the rodent to be combated, the density of the population, and the different character of the buildings. In America, the only rural animal found to have plague, if we except a single instance of plague infection in the wood-rat (*Neotoma fuscipes*), is the ground squirrel (*Citellus beecheyi*); therefore attention is focused on the latter species. From the city and the national viewpoint this is plague preventive work; from the country point of view it is plague eradicative work. To avoid confusion, it will be classed as a preventive measure, because the work of decitellization is a protective measure of national and international importance.

The work of prevention is directed against the rodent and its parasites lest they import and nourish the seeds of pestilence, later to distribute them to mankind. The plan of campaign is as follows:

PLAGUE PREVENTIVE MEASURES.

I. Urban.

1. Legal: (*a*) Rat-proofing ordinances; (*b*) garbage and refuse-disposal ordinances; (*c*) sanitary regulation of food storehouses, stables, bakeries, warehouses, etc.; (*d*) notification and inspection in suspicious illnesses or deaths.

2. Physical: (*a*) Quarantine against rats—outgoing, incoming; (*b*) rat-proofing of wharves and railroad warehouses; (*c*) periodical disinfection of ships; (*d*) laboratory examination of rodents.

II. Suburban.

1. All the foregoing.

2. Creation of ground-squirrel free zones.

III. Rural.

1. Decitellization: (*a*) Trapping, hunting, poisoning: (*b*) laboratory examination to discover new foci of infection and to delineate their boundaries; (*c*) public education and cooperation.

2. Inspection of: (*a*) The human dead; (*b*) suspicious human illnesses.

I. DERATIZATION.—1. *Rat Slaughter.*—It should be borne in mind that when the extermination of a given species is to be attempted, reliance cannot be placed on any single method. The tremendous fertility of the rat and its ability to survive in the most unfavorable environment makes it necessary that the campaign of deratization be approached simultaneously along every avenue of murine existence.

(*a*) Poisons: When skilfully prepared and intelligently distributed, poisons kill off a certain percentage of the rodent population. This measure has proven very efficacious in the hands of Blue at San Francisco and Rucker at New Orleans. The biological products depend largely upon the bacillus typhi murium of Loeffler, and aim at the production of epizootics which are not harmful to man. Unfortunately, this has not proven a very certain or satisfactory means of killing rats, and moreover this organism is pathogenic for man.

The chemical poisons, such as arsenous acid and phosphorus, on account of their cheapness and certainty of action, have given very good results. Of the two, arsenous acid is perhaps the more preferable owing to its stability, tastelessness, and non-combustibility. Barytes (crude barium carbonate) will kill rats, but on account of its metallic taste is not readily taken by them. Strychnine is a valuable agent, but is expensive, and because it is often distributed on the small grains is less convenient to handle and is more dangerous to children and domestic animals. When used in grain it is apt to be taken by birds, whose death will usually raise a storm of protest from the lover of the song-birds. When used to kill rats, a favorite method of distribution is to split open a prune and place the toxic agent in the center. Powdered squills is sometimes used, and is toxic for rats.

Whatever the agent employed, it should be distributed in as attractive a menstruum as possible. In the case of arsenious acid, it should be incorporated in a base of some fatty material, such as lard sweetened with sugar, flavored with oil of anise or musk, and colored a light pink. Phosphorus is most safely incorporated in glucose. Its liability to spontaneous combustion should be borne in mind. It is well to change the base frequently, alternating between cheese, lard, mutton fat, corn meal, and ground fish, such as salmon. The mass should be of such consistency as to permit its spreading easily on slices of bread, which are afterward cut into small cubes about three-eighths of an inch square.

In distributing poisons care must be observed lest they be taken by children or domestic animals. An accurate record should be kept of every place in which poisons have been put, and frequent inspections should be made to determine the results obtained. When it is decided to cease poisoning in a certain neighborhood, it is wise to collect any remaining portions of the toxic morsels lest they be taken in some unexpected way in the future.

(*b*) *Traps.*—Trapping rats not only assists in decreasing their numbers, but also enables us to detect murine epizootic plague by laboratory methods in time to prevent its becoming human epidemic plague. Their long association with man has given rats a wary cunning which is remarkable, therefore trapping is an operation requiring great ingenuity and patience, as well as a thorough knowledge of their habits. The large wire cage has the advantage of catching the animals alive, and very frequently more than one at a time. In certain situations, however, the snap, guillotine, or dead fall traps seem to give better results. In placing traps the environment should be changed as little as possible and advantage taken of the usual rodent runways. It should be borne in mind that in daylight the rat's eyesight is somewhat defective, producing an agoraphobia, but by depending on their vibrissæ they can run along a side wall with celerity

and ease. Traps therefore should not be placed in large open places, but in a narrow runway or beside a wall. Great care should be exercised in choosing baits; they should be changed frequently, and should be some delicate, odorous morsel which the rat is not in the habit of getting. Traps should be visited, emptied, and reset every other day.

Barrel traps are useful in warehouses where rats exist in great numbers. They consist of a cask half-full of water and having a lid which will tilt and precipitate the animal into the water beneath. A large piece of rancid cheese attached to the middle of the lid serves to attract the rat. A board, one end of which rests on the floor and the other on the chimes of the barrel, ensures the approach of the rat from the proper side.

Captured rats should be labeled to show where, when, and by whom secured. They should be treated with some efficient pulicide for the protection of those handling them, and if they are to be examined they should be transported to the laboratory in flea-proof containers.

In cold-storage warehouses rats have been successfully eradicated by suspending a bait between two heavily charged overhead electric wires from which the insulation has been removed for a short distance. The hungry rodent, crawling over the wires, shunts the current through its body and falls unconscious into a tub of water in which it is drowned.

There has been patented a system of tunnels and traps to be installed into ships at the time of construction. It includes registering devices to indicate the number of rats in the trap, and after a sufficient number have been captured they are driven into a pit where they are killed with gas and then removed. The system was installed into a hotel at Coronado Beach, Cal., and seems to promise much.

(*c*) Shooting, Clubbing, and Other Forms of Violence.—In situations in which rats are unusually abundant, *e.g.* abattoirs, stockyards, food markets and provision warehouses, large numbers may be killed by shooting with a twenty-two-caliber rifle or by "rat drives," the animals being forced into some confined place and killed with clubs or large knives. This measure is rarely of any great value.

(*d*) Natural Enemies, Cats, Dogs, Ferrets, Etc.—As natural enemies of the rat, dogs, cats, weasels, ferrets, snakes, and owls take first place. In the open, owls are very successful rat-catchers, and in certain latitudes non-poisonous snakes have proven effective in ridding warehouses and stores of rats. Dogs, cats, weasels, and ferrets are very useful in decreasing the rodent population, but on account of their susceptibility to pest it is deemed wise to limit their activities to normal times, lest they carry the disease from their prey to man.

2. *Rat Eviction.*—The homeless rat is exposed to the attacks of its predatory enemies; it has little chance to multiply and it must constantly be on the lookout for new sources of food supply. Rat eviction is of value in another important way—it removes the rat from the home of man. If this eviction is permanent, the danger from plague has been removed.

(*a*) The Destruction of Rodent Habitations.—This is important not only in that it evicts the rat, but it also affords an opportunity to kill the fleas which are generally found in the rat nests. Furthermore, the tearing up of old sidewalks and planked-over backyards is the first step toward their replacement with concrete or similar rat-proof material. When the rat warren is in piles of rubbish, its destruction is of value as a clean-up measure quite as much as an antipest measure.

(*b*) Rat-proofing, Permanent, Temporary, and by Elevation.—Of all the antiplague measures yet devised by man, the one which is of greatest and most lasting value is permanent rat-proofing. A rat-proof city shall not fall from plague. Rat-proofing acts not only as a means of plague eradication—it is the fortification against its subsequent attacks. The subject is therefore of great importance to the general public, both from the sanitary and commercial viewpoints. Rat-proofing serves the purpose of protecting the inmates of the building from plague and of excluding the rat from its food supply and habitation. It is the insulation against the rat which is to be applied as a general measure in all plague-infectible localities, especially those which have suffered from predations of the disease. Permanent rat-proofing costs money, but it must be regarded as plague insurance from both the commercial and the humanitarian aspect.

Concrete has been found to be the best rat-proofing material for general use. It is fairly cheap, and its permanency is unquestioned. Concrete foundations, basements, and floorings should be installed in houses, stables, warehouses and markets where food products of any sort are stored. Particular attention should be paid to buildings or places where domestic creatures are fed. This applies particularly to chicken yards, which, on account of the amount of uneaten food usually scattered about, are overrun with rats. If the yard be paved with concrete and provided with rat-proof wire screening, the chicken yard will be less of a menace.

Galvanized iron has been used as a temporary makeshift, but is not wholly satisfactory. If used, it should be regarded as a temporary measure only.

If buildings are elevated eighteen inches above the surface of the ground, and free access to the space beneath allowed for ingress and egress of the natural enemies of the rat, rat-proofing by elevation is secured. This measure is of value in treating small frame structures in which other methods of rat-proofing are contraindicated by reason of their cost. It is a temporary measure.

Whatever method of rat-proofing is used, it should be remembered that rats will enter a building through doors and windows, hence these should be carefully guarded against rodents. Rats (particularly the *M. alexandrinus*, which, fortunately, is not plentiful in the United States) will also enter buildings by way of the roof, hence this avenue of ingress should be closed against them.

3. *Rat Starvation.*—It is useless to expect the rat to take poisons or to be attracted by the baits in traps as long as there is an abundance of food which can be easily obtained. Therefore rat starvation is an eradicative and preventive measure of great importance. Furthermore, rats, like every other living creature, will not stay where there is an inadequate food supply. This probably accounts for the various migrations of rats described in so many different countries.

(*a*) Proper Disposal of Edible Refuse.—The days when the rat served as the public unpaid scavenger are passing. The health departments of the large cities now require the disposal of garbage in water-tight, well-covered metal containers, and the careful collection of such material in covered wagons and its final destruction by incineration or reduction. This is an important sanitary measure, not only on account of its effect on rats, but also because of its effect in doing away with a breeding place for flies. Equal care must be taken in the disposal of wastes from vegetable, fruit, and meat markets. Other waste products, such as stable manure, which furnishes both bed and board for the rat, should be stored in metal-lined boxes, which are frequently emptied and the contents incinerated or shipped to the country for use as fertilizer.

(*b*) Rat-proofing of Food Supplies.—Groceries, meat, fish, vegetable and fruit markets, restaurants, bakeries, and all places where food is prepared or sold for human consumption are great dispensers of rat pabulum. The barriers to be erected against rats will vary according to the nature of the premises.

Markets and other places where foods are constantly being shifted about should be well-protected against rats by the use of heavy wire screening with not over one-half inch mesh. Elevators and other places for the storage of grains or hay should be rat-proofed and cats installed to keep them rat-free.

(4) Prevention of Rat Multiplication.—The starved and evicted rat, harried from place to place by the incessant warfare which is being waged against him, "remote, unfriended, melancholy," has small chance of multiplying. The Japanese observers have argued that as the rat population diminishes, the breeding rate among the survivors increases because of the relative increase in the food supply and the number of rat-harboring places. If deratization has been attempted by a simultaneous, systematic attack on the rats' home and source of aliment, conditions unfavorable to breeding are brought about. It is probably impossible to exterminate the species absolutely in a given city, but this is not necessary to the eradication of plague. If the rat population is kept within fairly low limits and is not congested, rat plague will die out from purely natural causes. Or, should it be introduced into a sparse and scattered rodent community, the disease will soon exhaust the material necessary for its perpetuation.

II. Depulization.—The flea is the intermediate agent for the transference of the germs of plague between the body of the moribund rat and that of another rat or of man. If we rid ourselves of the mammalian host on which this insect lives, we need have little concern about the rat flea. In time of epizootic or epidemic plague it is necessary, however, that every factor in the transmission of the disease be taken into consideration.

(*a*) Rodents' Habitations.—During the destruction of rodent habitations, large numbers of fleas are met with in the rat nests, which are most commonly found beneath wooden floors and lumber piles and in accumulations of rubbish and manure. Some of these fleas may be pest-infected, certainly all are capable of becoming plague-germ vehicles; therefore their destruction is necessary. It is even more important that fleas be killed in human habitations in which human or rodent cases have been discovered.

The flea is covered with a heavy chitinous armor and breathes through a row of small openings or spiracles situated laterally along the abdomen. This is the flea's vulnerable point, hence the attack on this insect is made through its respiratory apparatus. Fumigation with sulphur dioxide is probably as good a method as we possess. Formaldehyde is valueless as an insecticide. The sprinkling of fresh chlorinated lime in rat nests will kill the resident fleas at all stages of their development. Liberal applications of crude cresylic acid also seem effective. An emulsion of water and kerosene, distributed in a fine spray is a fairly efficient pulicide, especially when mixed with banana oil and wood alcohol.

(*b*) Ordinary Domestic Cleaning Methods.—It is desirable, both for the comfort and the safety of persons living in the infected zone that their houses be kept flea-free. The frequent beating of rugs and carpets in the bright sunshine and the thorough removal and incineration of dust will kill many fleas and destroy their eggs. The treatment of floors with a kerosene emulsion or similar pulicide will kill the eggs, larvæ, and nymphs in the floor cracks.

(*c*) Pneumatic Suction Apparatus.—Many of the pneumatic cleaning devices now on the market will completely remove the dust from carpets, rugs, hangings, and furniture. Inasmuch as it is in dust that flea eggs are found, its removal and destruction will rid a building of fleas. This measure is particularly important in places of public congregation, theaters, churches, and schools, which are usually not well cleaned by the ordinary methods.

(*d*) Depulization of Domestic Pets.—There are many houses in which fleas persist in spite of careful cleaning and the liberal application of pulicides, and it is not uncommon to find that a cat or dog is the flea importer. The remedy is obvious, either to exclude such animals from the house or to keep them flea-free by frequent baths.

III. Delineation of Infected Zone.—It is essential to the successful conduct of an antiplague campaign that accurate knowledge be secured as to the extent and distribution of the infection, both in the human and rodent populations.

1. *Inspection* (*a*) of the Human Dead.—When plague makes its appearance in a community, ignorance prompts its concealment. Furthermore, its diagnosis will puzzle anyone who has not seen the disease or who is not expecting to discover a case. Then, too, there is always the fear of injury to commercial interests, a psychological phenomenon which would eradicate disease by proclamations and denials. The inspection of the human deaths, particularly among Asiatics, is therefore an important measure. It is usually accomplished by refusing to grant a burial permit until the body has been viewed by an authorized inspector. Necropsies should be held in doubtful cases.

(*b*) Of the Human Living.—It is equally important that living human contacts to both (a^1) human and (b^1) rodent cases be kept under surveillance until this period of incubation is past. This is not an eradicative measure in the strictest sense of the word, because, in the absence of ectoparasites man is an almost negligible factor in the spread of the disease, but it is of value in that it affords opportunity for the early administration of prophylactic or curative treatment. For the same reason it is well to keep all persons who live in heavily infected districts under fairly close observation.

2. *Examination of Rats.*—As has been noted above, the discovery of the infection among rodents is of value, in that it affords an index of the extent and distribution of the epizootic, so that immediate steps may be taken to prevent the disease being transferred to man. It is a measure which should be a routine practice in all large seaports lest the disease should be imported and smoulder in the rodent population, its arrival being discovered only after human beings have been attacked. It is not difficult nor expensive, and will pay for itself in the security from plague which it affords, at the same time preventing the commercial losses which are attendant on the announcement of the appearance of the disease among human beings.

3. *Plague Barometers.*—Another method of outlining the plague zone has been by the use of the guinea-pig as a plague barometer. Taking advantage of the natives' love of household pets and the propensity of the flea to get on the guinea-pig, the Indian Plague Commission placed two or three guinea-pigs in each house in the infected zone. Householders were instructed to notify the health authorities as soon as a pig sickened or died. The sick or dead pig was then examined, and if found to be plague-infected, the premises from which it was taken were subjected to the usual antiplague disinfection and other measures.

IV. Prevention of the Spread of the Disease.—Once having delineated the infected zone, it is the endeavor of the sanitarian to prevent its enlargement and to protect those living in the zone itself.

1. *From Man.*—As has been previously pointed out, in the absence of ectoparasites man plays a small rôle in the spread of plague.

(*a*) Isolation affords a way to separate (1) actual and (2) suspicious cases from their parasites, and is a wise measure. It also reacts to the benefit of the patients themselves, as it ensures their treatment by

persons who have acquired skill in the treatment of plague.

(*b*) Disinfection of the (1) environment from which the patient has been removed is important, not only because of the destruction of the insects and bacteria, but also because of the effect it has on the general public. The disinfection of the (2) excreta is indicated in the pneumonic cases in which the sputum is loaded with the plague bacillus. The stools and urine are not known to be infectious.

2. *From Rats.*—The prevention of the spread of the disease from rats has been fully discussed under the headings "Deratization" and "Depulization," but it may be noted that the prevention of rat migration has an effect in preventing the scattering of the seeds of pestilence. When rats are cut off from their homes and food supplies, they naturally will migrate through sewers and other subterranean passages, but occasionally over land. All openings into sewers which could be used as rat runways should be closed or rendered impervious to rats. The idea should be not to keep the rat out of the sewer, but to keep him in the sewer, where he is harmless to man. The prevention of rat migration by trains and ships will be discussed elsewhere in this paper.

3. *By the Education of the General Public.*—It may be taken as axiomatic that no public health campaign can succeed in its fullest extent without the intelligent cooperation of the general public. It is not to be expected that the public will lend their aid in the suppression of a disease about which they know little and of whose existence in their community they are usually very doubtful. There is only one way to meet this phase of the problem, and that is by the education of the public as to what plague is, how it is carried and what the public's duties are in its prevention and eradication. The exact truth as to the situation should be told, and if the lesson is repeated often enough and patiently enough, surprisingly good results will be obtained. Every walk of life, every stratum of society, should receive this instruction; the business interests, the women's clubs, the churches, the schools, the social organizations must be included in this campaign of publicity. Every householder unconsciously becomes a sanitary inspector; every housewife, as she puts the lid carefully on the garbage can, becomes an agent of the department of public health; every schoolboy reads into the familiar lines about the cat and the mat and the rat the great lesson of plague. Truly, publicity is the handmaid of sanitary science, particularly with regard to bubonic plague.

Plague Preventive Measures. 1. *Urban.*—The foregoing outline of the eradicative measures to be used against plague naturally suggests those to be put in force for its prevention. Until efficient barriers have been erected against the rat, there is no maritime commercial center in the world which can be regarded as free from the danger of pest invasion.

(*a*) *Legal.*—In both the city and the country laws are necessary to enforce the destruction of rodents and to bring about their isolation from the home of man. This should be first a matter of State law, declaring the presence of rodents in and about places of human occupation to be a menace to health; and secondly, requiring that property-holders make a reasonable effort to prevent the residence of rodents on their premises. The law should also provide a penalty for its infraction. The States of California and Idaho have enacted such laws. Cities and counties may accomplish much the same result by ordinances, and may make further provisions as their needs require.

(1) Rat-proofing Ordinances.—Rat-proofing ordinances should be specific, and should state the character of the rat-proofing which shall be used in the different classes of buildings. Boards of Health should be charged with the enforcement of such ordinances, and should be given power to condemn rat harbors, or to order their rat-proofing under penalty of condemnation after a reasonable time has been given in which to complete their rat-proofing. Such measures, if enforced, guarantee "building the rat out of existence," and, aside from their value as a plague prophylactic, prevent much destruction by rats, and in some instances by fire.

(*b*) Garbage and Refuse Disposal Ordinances.—Ordinances relative to the manner of disposal of wastes, particularly those which furnish rat pabulum, should be enacted and enforced. The water-tight metal garbage can with close-fitting lid should be the standard, and the ordinance should carry a penalty for the disposal of garbage in any other receptacle, and should state the degree of cleanliness in which the can is to be maintained. The collection in sanitary vehicles and final disposal of the collected materials should also be regulated by ordinances enforced by the Board of Health. Wastes from food markets, both wholesale and retail, require similar careful regulation.

(*c*) Sanitary Regulation of Food Storehouses, Stables, Bakeries, Warehouses, Etc.—Unregulated places where food is stored or prepared furnish an ideal environment for rat habitation and propagation, unless great care is taken. Ordinances requiring that they be maintained in a cleanly, rat-proof and rat-free condition react not only to the prevention of plague but also to the general health of the community. It was found that the antiplague work done by Blue at San Francisco and by Rucker at New Orleans, not only eradicated plague but also reduced very greatly the incidence of infectious diseases in that city. It is also interesting to note in passing that the sanitation of the stables in that city not only reduced the number of rats and flies very greatly, but also caused a great falling-off in the disease of horses.

(*d*) Notification and Inspection of Suspicious Illnesses or Deaths.—In cities which have had plague, or which are in steamship communication with ports in which plague exists or has existed, physicians should be required to report to the health department all cases which are actually plague or suspected of so being. Such ordinances, if occasionally brought to the practitioner's notice, keep before his mind the possibility of the occurrence of plague in his practice.

2. *Physical.*—(*a*) Quarantine against Rats, Incoming, Outgoing.—Since the prime object of plague preventive work is the reduction of the rodent population, it is necessary that the importation of rats be prevented. It is also important that the exportation of rats from infected ports be prevented. The best way to accomplish this is by periodic fumigation of ships, the great disseminators of plague. "Where ships go, there plague will go." Therefore vessels should be fumigated just prior to sailing from infected ports, lest they carry plague rats as an unwelcome addition to their cargo. Ships not so fumigated should be fumigated on arrival. If the nations of the world would cooperate to secure the periodic fumigation of ships to kill rats, and would undertake the surveillance of outgoing passenger and freight traffic at infected ports, ship-borne plague would become a thing of the past. Probably the best agent for fumigation to kill rats is sulphur dioxide. To be effective, every compartment in the entire ship must be treated simultaneously with gas of a minimum strength of three per cent., five hours' exposure being given. If ships are fumigated prior to taking cargo, care must be observed lest they again become rat-infested, the rodents being carried into the holds in freight, or by climbing on board by way of the mooring tackle. Freight should be inspected prior to loading, and cargo originating in rat-infected surroundings should not be accepted for shipment. Vessels should be sheered off from the dock, and all lines and timbers over which rats could pass to the ship should be guarded by large metal funnels

securely lashed on. (*b*) As an aid to the prevention of the shipment of rodents in freight, wharves and warehouses should be rendered rat-proof and maintained rat-free.

3. *Suburban.*—The chronicity of the disease in ground squirrels ensures its perpetuation without the extermination of the host species. The ability of the squirrel flea to transmit the disease to rats permits the spread of the disease from the rural squirrel to the city man through the chain of suburban and urban rats. Furthermore, the gradually enlarging boundaries of the disease among ground squirrels forecasts its continued spread throughout the species. This is the most serious aspect of the problem, because the citellus is a widely distributed species.

Beginning with Oregon and Washington on the west, the life zone of the *Citellus columbianus* extends eastward across Idaho, Montana, North Dakota, and South Dakota to mid-Minnesota. Northern California is occupied by the *Citellus douglassi*, while the central and southern portions of that State are inhabited by the *Citellus beecheyi*. This species occupies the lower mountain passes and is thus in contact with the *Citellus grammurus*, whose life zone extends from the southern border of the distribution of the *Citellus columbianus* on the north to the Rio Grande on the south. On the southern half of the eastern border of California the *Citellus grammurus* is bounded by the *Citellus fisheri*, while its eastern limitation is the *Citellus franklini*, which has been found as far east as mid-Michigan. It is also probable that the *C. franklini* is distributed to a certain extent in the eastern States, as colonies are known to exist in western Massachusetts. The *C. fisheri* is distributed in a narrow strip along the lower half of the eastern border of California.

From the foregoing it may be deduced that the spread of the disease in the ground squirrel might some day cover the nation with a pall of plague reaching from the Pacific to the Alleghenies. Fortunately, the work of eradicating the focus has been begun in time and is being relentlessly prosecuted.

(1) Decitellization.—The lines of attack are very much the same as in the combat against the rat, due allowance being made for the difference in habits and environment of the two species.

(*a*) Trapping, Hunting and Poisoning.—Many ground squirrels may be caught in spring traps or snares. These should be marked by a rod about three feet long and bearing a small red flag on the top. This prevents loss of traps. Traps should be visited every few hours, lest the catch be stolen by birds or small mammals. Snares should be made of brass wire. They are useful in taking samples for laboratory work, because the squirrel is not injured in any way. It should be borne in mind that squirrels do not live long when caught in a trap and exposed to the sun.

The shotgun is the best weapon for hunting squirrels either for laboratory examination or eradication. Twelve or sixteen gauge guns and number eight shot seem to give best results.

Strychnine is a valuable agent in poisoning squirrels, but has the disadvantage of being taken by other animals and by birds. Carbon bisulphide is very useful and kills them readily if put in the squirrel burrows properly. It also has the advantage of killing the fleas in the burrows at the same time.

(*b*) All squirrels secured, whether shot, trapped, poisoned, or found dead, should be subjected to laboratory examination. The technique is the same as for rats.

(*c*) Public Education and Cooperation.—What has been said of the value of public plague education in cities applies with equal force to the country. The farmer must be taught how to kill ground squirrels and he must be encouraged to rid his premises of them. He is usually very glad to do this, on account of the destructiveness of the citellus to crops, and is not hard to secure his cooperation.

(2) Inspection of (*a*) the human dead and (*b*) suspicious human illnesses. If man would let the squirrel severely alone there would be little danger of contracting plague from it direct, but, unfortunately, this is not always done. In the case of hunters and persons engaged in handling rats and squirrels, they may be Haffkinized, but thus far the general public has not taken very kindly to this method of protection, and cases from ground squirrels are so rare in proportion to the number of people handling them that this means of prophylaxis cannot be urged. However, one or two cases of plague occur each year from contact with squirrels, therefore, it is wise to insist on an inspection of the dead in the infected area during the period of greatest epizootic plague prevalence. An inspector should always be available for the inspection of cases of human illness which are thought to resemble plague.

3. The Creation of Ground-squirrel Free Zones.—It has been shown above that plague is transferred from the country ground squirrel to the city rat by way of the suburban rat and that the transfer in each case takes place in the area in which their life zones overlap. If this area be decitellized, then the danger of the transference of the disease from rural ground squirrel to suburban rat is obviated. This is sound in both theory and in practice for it has been found in California, where a great squirrel free zone has been thrown about the Bay cities, that rat plague does not exist at present in them, despite the fact that it exists in the country squirrels thereabouts. This zone is kept free of squirrels by a patrol of hunters and trappers and forms an efficient barrier against the introduction of plague from the rural focus.

W. C. Rucker.

Plantain.—The flowering plant of *Plantago major* L., *P. media* L., and *P. lanceolata* L., three common European weeds, of which the first and last have made themselves pretty well at home in our fields and dooryards. They are very slightly acrid and bitter, somewhat astringent, and quite mucilaginous; containing a little of some sort of *tannin*, some *resin*, some "*bitter extractive*," and considerable *mucilage*, but no more active substances. They are almost obsolete as medicines, but were formerly esteemed as astringents, hemostatics, and even antispasmodics, and were used locally in leucorrhea, hemorrhoids, conjunctivitis, and scrofulous eruptions.

The order *Plantaginaceæ* is a large one, of several hundred species, but none having active properties. The seeds of one, *P. psyllium* L., known commercially as "Flea-seeds," have an abundant mucilage, like that of flaxseed, and are employed in the arts for sizing cloths, etc., and occasionally in medicine as collyria or demulcent washes. W. P. Bolles.

Plants, Poisonous.—It is generally agreed in toxicology that the term "poison" should not be applied to any substance which produces its injury through mechanical means. Following this terminology, we exclude from consideration in this article all such substances as cowhage, which produces intestinal injury chiefly by the piercing quality of its hairs, the sharp awns of the many grasses so fatal to grazing animals, the prickles and thorns of thistles, brambles, cactuses, and similar plants, which act mechanically, at least chiefly, notwithstanding that their presence often produces abscesses from which blood poisoning may result. From this article are excluded also all the ordinary disease germs. Although, strictly speaking, such diseases are the results of poisoning by these minute plants, growing within the system, their proper treatment pertains to bacteriology and pathology.

Since most of the more important poisonous plants are, by virtue of their activity, available for medicinal purposes, they are discussed elsewhere in that connection. Not only are their poisonous effects and the treatment there considered, but descriptions ample for their identification, in the condition of drugs, are provided. In many cases such drug descriptions have been supplemented by others, pertaining to the plants themselves, often with illustrations, in order to provide for their identification in cases of poisoning by the fresh material. The present article is intended to supplement the above by considering important poisonous plants not used as drugs. At the same time many of the latter will be referred to at the proper points in this system, and the other articles upon them will be duly cited.

General Recognition.—The question is frequently propounded, "Is there any general rule by which a poisonous plant can be recognized at sight?" To this question an emphatic negative must be returned. There are certain characteristics which frequently accompany poisonous properties, but this is not true in all cases; and, on the other hand, these characters may exist in the absence of such poisonous properties. Of such characters are the peculiar lurid purple color seen upon the stems of the castor oil, cicuta, conium, pokeberry, dogbane, and many other plants, though shown also by the harmless angelica. A narcotic odor is common to many of the most poisonous plants, but is wanting in many others. An acrid taste is probably the most common characteristic, and constitutes the best safeguard which we possess, since it is likely, especially in the fresh article, to furnish a warning before a dangerous quantity has been consumed. Thus the potato, though ordinarily quite bland, imparts, when poisonous, a peculiar bitter, nauseous, and slightly acrid taste. Even this taste guide, however, fails in many notably poisonous substances. It may be added that milky-juiced plants are usually to be regarded with suspicion.

Principal Poisonous Families.—Of the two hundred and eighty or more families of plants, a number are recognized as being specially rich in poisonous species; but not all of the species of any family are poisonous, and important food plants are usually found closely related, in the same family, to violent poisons. Thus the family *Solanaceæ* contains the deadly mightshade, stramonium, and henbane, yet yields the potato, the egg plant, and the tomato; and even the potato itself may at times be poisonous. In the *Euphorbiaceæ* we find the manchineel, croton, and euphorbium, together with the cassava; and we have indeed poisonous varieties of the latter. Many similar illustrations might be cited. It is, therefore, not deemed feasible to essay a classification based upon botanical or any other general relationship, although, as a matter of convenience, the characteristics of several highly poisonous families are given below. While only a practical botanist can be expected to utilize this method of recognition to the fullest extent, yet surgeons in the army and navy and other travellers may gain great assistance by recognizing suspected plants as pertaining to the following families:

Apocynaceæ (the Dogbane Family).—This large family, of more than a thousand species, chiefly tropical, is probably, all things considered, the most commonly and powerfully poisonous. Its members are mostly heart poisons, well illustrated by apocynum, strophanthus, and oleander. Its poisonous constituents are bitter and chiefly glucosidal, though many alkaloids are contained, and a number of them, or the extracts containing them, enter into the manufacture of arrow poisons, especially in the Old World tropics. Poisoning accidents by members of this family are rather common in tropical regions, sometimes occurring through the use of the stems for spitting meat, stirring food, or in similar culinary operations. The botanical characters are as follows: Juice usually milky; leaves (in the poisonous species) opposite, simple, exstipulate. Flowers regular, perfect, five-merous; calyx inferior, persistent, imbricated; corolla tubular, the limb usually rotate, convolute; stamens five, borne upon the corolla and alternating with its lobes, the anthers two-celled; pistil dicarpellary, the carpels distinct or united; the ovary two-celled or with two parietal placentæ; styles united or divided up to the simple stigma; fruit usually of two follicles, occasionally drupaceous; seeds frequently plumose.

Araceæ (the Arum Family).—This monocotyledonous family is well illustrated by the calla and calamus. Its members are chiefly tropical, and produce thick, somewhat succulent stems, frequently climbing tree trunks, and usually large, somewhat succulent, cordate leaves similar to those of the calla. A great many species produce bulbous or tuberous stem bases, commonly regarded as roots. Some of these, as the taro (*Calocasia esculenta*), are important foods. Others would be so but for their poisonous constituents. In a few cases, where these poisonous properties are mild, they are destroyed by thorough cooking, while in others this method fails and attempts thus to use them may result disastrously. The injurious principles fall into three classes: First, as in the seeds of peltandra and skunk's cabbage, needle-shaped raphides of calcium oxalate, occurring in great abundance, and irritating mechanically; second, as in our common wild turnip, acrid juices which are partly destroyed by drying; third, powerful alkaloids, some of them, or the extracts containing them, used in the manufacture of arrow poisons. The flowers of the aroids occur densely massed upon a cylindrical (as in calla) or a globular (as in skunk's cabbage) spadix, enclosed or subtended by a spathe (the white portion of the calla), though this is sometimes obscure. The plants are dicœcious, or the staminate flowers are on the upper, the pistillate on the lower portion of the spadix. Rarely the flowers are perfect. There is usually no perigone, though sometimes this exists in the form of a number of scales. The filaments are very short, their anthers two-celled, the cells separated by a broad connective and opening dorsally. The ovary is variable in structure, the stigma terminal, small, sessile, or on a very short style. Fruit usually a berry, occasionally inflated.

Cactaceæ (the Cactus Family).—Beyond remarking that many leafless and spiny or succulent plants which do not pertain to this family are frequently mistaken for cactuses, little need be said of its characters. The juice is bland and never milky, the flowers are showy, polypetalous and polyandrous, and the inferior fruit is a many-seeded berry. In desert regions, in the absence of food, and more especially of drink, the flesh and juice of cactuses are often utilized. In such cases it should be borne in mind that while the spiny species are usually innocent, those which are unarmed, or nearly so, like the night-blooming cereus and the anhaloniums, are often narcotic or cardiac poisons.

Campanulaceæ (the Harebell Family), including *Lobeliaceæ* (the Lobelia Family).—The two divisions of this family here named have been regarded by many botanists as distinct families. Certainly there is a marked distinction between their properties, the former yielding roots rich in inulin and sometimes edible, whereas the Lobeliaceæ contend with the Apocynaceæ for first rank among poisonous families. The nature of the constituents and the character of the poisoning are pretty uniform and have been sufficiently detailed under Lobelia. Since the poisonous species are very widely distributed throughout both temperate and tropical regions and are quite showy and attractive, their recognition is unusually important; fortunately it is also quite easy. The juice is acrid and almost always milky; leaves alternate, ex-

stipulate, simple, and commonly abundant; flowers perfect, mostly showy, usually five-merous; calyx tube adherent, the limb mostly regular and persistent; corolla tubular, epigynous, irregular and oblique or two-lipped, its tube fissured on the upper side; stamens five, inserted upon or with the base of the corolla and alternate with its lobes, the filaments coherent for the most of their length, as well as the anthers.

Cucurbitaceæ (the Cucumber Family).—Notwithstanding that this family is rich in edible fruits, like the pumpkins, melons, and cucumbers, yet it contains also a very large number of poisonous species. The poisonous properties pertain usually to the roots or the fruits. The former class is typified in bryonia, and has been sufficiently considered under that title. The latter is illustrated in our accounts of colocynth and elaterium, and need not be further considered. No difficulty need be experienced in the identification of the *Cucurbitaceæ*, which are tendril-bearing vines, usually herbaceous, and the flowers of which are invariably constructed like those of the plants named above, though they are occasionally small or even minute.

Euphorbiaceæ (the Spurge Family).—The general and poisonous properties of this family have been considered in Vol. IV. The plants are readily recognized by their milky juices, in connection with the unisexual flowers, which are themselves inconspicuous, though often surrounded by showy modified leaves resembling a flower circle, as in the "Christmas rose." The perigone and androecium are so extremely variable as to be difficult of any brief characterization. The ovary and fruit are almost uniformly three-celled and the latter few-seeded.

Iridaceæ (the Iris Family).—This monocotyledonous family almost uniformly contains irritant poisonous oleoresins, well illustrated by that of the medicinal *Iris*. Owing to their acrid properties they are not very likely to cause poisoning, except through their medicinal employment. Nevertheless, owing to the fleshy and obviously nutritive character of their rhizomes or tubers, they are not infrequently resorted to as famine foods in some countries, and disastrous results have sometimes thus occurred. These plants are perennial herbs with narrow, distichous, often succulent leaves. The flowers are perfect, with an adherent six-parted convolute and marcescent perigone. The stamens are three and adherent to the outer perigone segments. The ovary and seed pod are commonly three-celled, with a three-parted style, and the ovules and anatropous albuminous seeds are numerous.

Leguminosæ (the Bean Family).—This family has already been briefly considered in Vol. V as to the general nature and properties of its poisonous constituents. As poisons, its members present peculiar dangers, which, upon the whole, are not equalled by those of any other family. These dangers lie in the fact that, while the poisonous constituents are very widely and irregularly distributed, and extremely subtle and uncertain, the family is at the same time the most highly nutritious as to albuminoid constituents in the vegetable kingdom. Even such edible articles as peas and beans are not entirely free from poisonous properties, which become apparent when they are fed in large quantities as stock foods. Although the poisonous properties pertain to all three of the subfamilies, they are most common and conspicuous in the Papilionaceæ. The members of this family are rather easily recognized by their almost uniform habit of producing a legume for a fruit, and by their highly developed exalbuminous seeds. In the Papilionaceæ the leaves are alternate, stipulate, and usually compound, the flowers papilionaceous and nearly always perfect, the calyx more or less gamosepalous, the five or ten stamens almost always more or less coherent. In the two other subfamilies the flowers, though often irregular, are not papilionaceous, and the stamens are commonly wholly or nearly distinct.

Liliaceæ (the Lily Family).—This very large monocotyledonous group is now, with good reason, divided into the Smilaceæ, Melanthaceæ, and Convallariaceæ as distinct families. Nevertheless, since they agree, excepting the Smilaceæ, as to their poisonous properties, the entire group is here considered. The plants are mostly herbs, growing from bulbs or fleshy rhizomes. The juices are usually bland, though sometimes, as in the onions, acrid. Indeed, the poisonous species have mostly acrid juices. The leaves are parallel-veined and usually sheathing at the base. The flowers are regular and possess a six-parted perigone in two circles. The family is distinguished from the *Iridaceæ* by its six stamens, which are usually free, or nearly so, and distinct. The ovary is three-celled and usually superior, the styles distinct or united. The pod is three-celled, the seeds are numerous and highly albuminous. This family, like the *Iridaceæ*, is very liable to cause poisoning accidents, owing to the succulent and nutritious properties of its underground portions and even of its herbage. The nature of its poisonous constituents, both chemically and physiologically, is too varied for any general description.

Loganiaceæ (the Nux Vomica Family).—This is here referred to as being a small family, closely related to *Apocynaceæ* and almost equally poisonous. It is closely similar to that family in its structural characters, but lacks the milky juice and the annular stigma. Accidental poisoning is scarcely likely to occur from its members, except through their medicinal employment, and those subjects are fully treated elsewhere.

Oxalidaceæ (the Oxalis Family).—This small family, for a long time regarded as part of the *Geraniaceæ*, is readily recognized by the close similarity of all its members in foliage and flower structure to the genus Oxalis, represented by the wood sorrel, the sheep or lady's sorrels, common garden weeds, and by many species cultivated in the conservatory. The herbage of these plants contains oxalic acid and, like the meadow, field, or kitchen sorrel (*Rumex acetosella L.*) has, when eaten in excess, caused serious or even fatal results, both to children and to adults.

Papaveraceæ (the Opium Family).—This small family is almost uniformly narcotic-poisonous, very many of its species being also irritant. Its constituents are preëminently alkaloidal, and these alkaloids are very numerous and varied in their mode of action. Owing to their commonly irritant properties these plants are not likely to cause poisoning, except through their medicinal use. They have commonly milky or colored juices, mostly compound or lobed leaves, perfect flowers (usually regular), their parts free and, except as to the carpels, distinct. The seeds are numerous and small.

Pinaceæ or *Coniferæ* (the Pine Family).—The large family of cone-bearing evergreens is too well known to require description. Its constituents and properties have been sufficiently indicated in our accounts of *Juniper*, *Savin*, *Turpentine*, etc. Similar constituents exist generally throughout the family. Poisoning is not likely to occur, owing to the acrid and excessively disagreeable character of the tissues.

Ranunculaceæ (the Buttercup Family).—This large family is distinguished by its alternate, exstipulate leaves, flowers which show neither adhesion nor cohesion in any of their parts, innate anthers, anatropous ovules, and the small embryo in fleshy albumin, taken in connection with the acrid juices. These acrid juices are commonly cutaneous and internal irritant poisons. Attempts to utilize them for blistering purposes have been made, but the blister is not readily controlled. A great number of the species contain, in addition, principles which, upon absorption, act as cardiac paralyzants, of which aconitine may be taken as the type.

Simarubaceæ (the Quassia Family).—The constituents and properties of these plants have been suffi-

ciently discussed in connection with quassia and simaruba. Their consumption so as to cause poisoning is almost impossible, owing to their very bitter taste. A curious case of poisoning by Ailanthus is recorded below under "Poisonous Leaves."

Solanaceæ (the Potato Family).—A description of the characters of this highly narcotic family is not called for, since pretty much all of the species likely to cause poisoning have been already considered in connection with the drugs, Belladonna, Henbane, Stramonium, etc., or below in connection with Solanum.

Umbelliferæ (the Parsley Family).—This very large family, although it yields many important edible products (carrot, parsnip, parsley, celery, angelica, etc.), contributes also such violent poisons as conium, cicuta, and ænanthe. Its species are very readily identified. They usually possess, especially as to the poisonous species, hollow stems, petioles which are dilated and sheathing at the base, leaves pinnately compound, usually decompound, as seen in celery and parsley, flowers in (usually compound) umbels, these flowers usually minute, with five superior calyx teeth, five epigynous petals and stamens and fruits having the general structure of the well-known conium, anise, coriander, fennel, etc.

Violaceæ (the Violet Family).—Although not at all likely to be consumed in poisonous quantities, except as overdoses of medicine, the violets should be remembered as containing one or more emetico-cathartic poisonous constituents, very similar to emetine, and long mistaken for it. The violets are so well known that no description of them appears called for.

Local Cutaneous Poisons.—Poisonous plants can be conveniently divided into those locally poisonous to the skin and those internally poisonous. The first-mentioned class will be first considered.

They represent all grades of irritation, from a mild and brief itching to a dangerous or even fatal inflammation. The milder of these groups can be accorded but the briefest mention. A large number of them produce no effect upon most persons, but have been at times recorded as irritating to certain individuals with a highly sensitive skin, or who are subjects of idiosyncrasy. Illustrations of this class are seen in the fresh herbage of *Veratrum*, in various species of *Cypripedium*, *Catalpa*, *Rhododendron*, and *Kalmia*, and in *Vanilla*. In a number of cases the nature of the poison has not been ascertained, and it is possible that it is due to the presence of animal or vegetable parasites, or other foreign bodies. Others, like the various nettles (*Urtica*, *Urticastrum* [*Laportea*], *Urera*, etc.) are regularly irritating, but the irritation is temporary, though often very painful, and unless complicated does not call for treatment. In the last-mentioned genus of tropical American shrubs the stinging hairs of the ordinary nettle are magnified into needle-like prickles, several inches in length, intensely poisonous, and causing severe inflammation when contact with them is extensive and violent. The nature of this poison and its treatment have not been investigated, though doubtless much the same as in the nettles. Very similar to the nettles are the stinging hairs upon the various species of *Jatropha*, *Tragia*, and others of the *Euphorbiaceæ*, *Sicyos* in the *Cucurbitaceæ*, *Echium*, and others in the *Boraginaceæ*. Those of the *Euphorbiaceæ* have also tropical relatives (*Hura*, etc.), in which the hairs are magnified into spines, the effects of which are severe.

The important cutaneous poisons, those requiring our attention, pertain chiefly to the families *Anacardiaceæ* and *Euphorbiaceæ*.

The poisonous members of the *Anacardiaceæ* are numerous, and their effects are of extremely common occurrence and very severe. The poisonous constituents, their mode of action, symptoms, and treatment are in all cases either identical or so closely similar that they can be readily considered under the one subject of Rhus poisoning, the further consideration of the respective individuals being confined chiefly to their description and recognition.

Rhus Poisoning.—The principal agent concerned in this accident is the herbage of *Rhus radicans* L., the common Poison ivy or oak, Climbing or Three-leaved ivy or sumach, Mercury, or Black mercury. There is considerable difference of opinion as to whether Linné's *R. toxicodendron* is identical with his *R. radicans*, but the title, as here used, includes both. The plant is a slender North American shrub, and occurs wild to some extent in Europe, where it has been introduced. It may lie prostrate upon the ground, though it prefers to climb shrubbery or trees, in sunny locations, or upon fences or walls, to which it clings by false or non-absorbing roots. Sometimes, especially southward, it grows with an erect, self-supporting stem. Having thus attained a support, its branches spread or droop outward to a considerable distance, being thus very apt to brush against the faces of those walking along country roadsides. Flower and leaf habit are well displayed in the accompanying cut (Fig. 4273). The trifoliolate, or occasionally quinquefoliolate leaves sometimes reach a foot and a half or even two feet, including the petiole, in length. The leaflets are very thin and present a peculiar satiny lustrous appearance. Although usually apparently smooth (sometimes conspicuously hairy on the lower surface), they in reality bear an infinite number of extremely fine and short hairs. The flowers are of a greenish yellow and are followed by small drupaceous, pale green, smooth fruits, borne in loose bunches, quite unlike those of the ordinary red sumac.

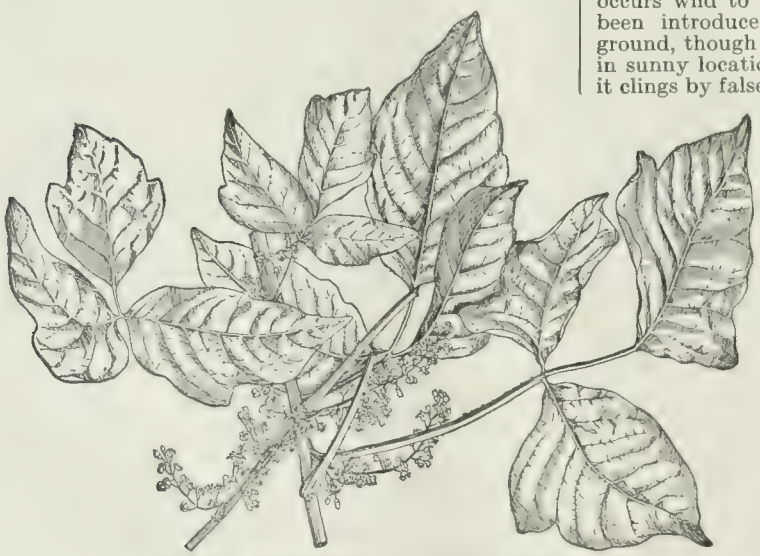

Fig. 4273.—Rhus radicans. (Two-fifths natural size.)

Some of the conditions by which poisoning can occur from this plant are in dispute. On theoretical grounds, if what is known of the nature of the poisonous constituent be taken into consideration, actual contact in some form appears to be requisite; yet innumerable and well-authenticated experiences render this view quite untenable. There is the widest differ-

ence in the susceptibility of different individuals, some being apparently incapable of being poisoned by it under any circumstances. Others, who have been exposed to it frequently for many years without result may suddenly become severely poisoned. Others again are extremely sensitive to its action, the most serious, or even fatal, results ensuing from even a moderate contact. Finally, cases are of common occurrence in which poisoning occurs apparently without any contact whatever, a strong wind blowing over the plant from a short distance constituting a sufficient occasion. It has been suggested that in such cases the pollen grains constitute a medium of transportation, but such occurrences take place when no pollen grains are present. It seems hardly credible that the almost microscopical hairs can be active in these cases, notwithstanding that experiment has demonstrated their power, in very small number, to effect slight poisoning when directly applied to the skin of sensitive persons, under specially favorable conditions.

Much speculation has existed, and many conflicting statements have been published, as to the nature of the active constituent, but the laborious researches of Pfaff have gone far toward clearing up this subject. He has located the poison in the fat or fixed oil which exists in fractional percentage, and which has been called *toxicodendrol*. This is an alcohol-soluble fat, in which character it resembles croton oil and its relatives. Its chemical nature is very incompletely known. Reasoning by analogy, we should assume that the oil is not poisonous in its own form, but only through its freed fat acid. If, as originally claimed by Maisch, who called it *toxicodendric acid*, this decomposition product be volatile and active, all of the inconsistencies regarding its action would be removed. The same or similar fat existing underneath the bark acts similarly, and here again it is notable that many cases of poisoning have been recorded as occurring by contact with the smoke emanating from a smothered fire of the wood of the plant. It is also stated that certain very sensitive persons cannot remain in or near a room where the tincture of the fresh drug is being bottled without the certainty of being poisoned. The milky juices of other species of Rhus, especially the Japanese lacquer tree, act similarly, and a case is on record in which the emanations from a bottle of this lacquer poisoned the faces of those smelling it, though there was no contact. Poisoning did not result where the substance came into contact with the mucous membranes of the mouth and nose.

There exist in the leaves, besides toxicodendrol, a small amount of resin, some tannin, wax, and other unimportant constituents.

Poison ivy has been highly recommended by homeopathic practitioners as a medicinal agent, upon the theory of *similia similibus curantur*, and it even found its way once into the United States Pharmacopœia, though it was dropped immediately afterward. Making the most liberal allowance, we are obliged to conclude from the evidence at our command that its medicinal activity is practically *nil*.

Ivy poisoning first appears as minute, clustered, itching papules, which soon become surrounded by a bright erythema, in part produced by the inevitable scratching. The papules have by the next day become minute, deep-seated, eczematous blisters. For several days this appearance is not much changed, nor are the burning and itching diminished. Then the surface of the blisters gets rubbed off, the watery exudation moistens the surface affected and often spreads the disease to other parts. The blisters finally become pustular, and then crusts and scabs cover the surface. The first appearance is always local, and if contracted in any of the usual ways is on either the hands or wrists or the face. In the latter situation the swelling is always great, the eyelids generally becoming completely closed by it. From the hands it easily extends to the breasts or male genitals, on the latter of which the burning is exceedingly hard to bear; occasionally it becomes general. The course of the affection in a single spot covers usually five or six days, but it may often spread over twice that time when different parts of the body are successively invaded. It heals without a scar, but is a little apt to return on successive summers.

There is rarely any difficulty in establishing a diagnosis. The symptoms present some superficial resemblances to those of erysipelas, but in the latter disease the underlying tissues are swollen and hard, whereas in ivy poisoning the effects are superficial and the surface is soft and somewhat fluctuating.

Fig. 4274.—Rhus vernix. (Two-fifths natural size.)

Numerous remedies and specifics are in use against Rhus poisoning; still its course, when fairly begun, is not often really aborted. The measures for its treatment may be divided into the following classes: (1) The destruction of the poisonous constituent; (2) the prevention of friction due to scratching the affected surface, and the prevention of the spreading of the poisonous matter; (3) the relief or prevention of itching and pain from atmospheric irritation.

The first of these results can be fairly well accomplished if measures are taken very promptly after exposure and before the symptoms of poisoning have fairly presented themselves. Ordinary washing is inadequate, unless very thorough indeed; and it is, in fact, liable to spread the poisonous substance over a wider surface. Washing with a great abundance of common cheap laundry soap, or even the application of a thick layer of this soap to the surface, has yielded good results. Washing with a strong solution of sugar of lead is a favorite method with some, and lime water, black wash, and other alkaline applications are useful. The discovery of the fatty nature of the poison serves to explain to some extent the principles of this line of treatment, the alkali probably saponifying the fat and destroying its activity. The second-named object

is attained by the use of vaseline or some similar application, and this also accomplishes part of the third object, protection against the effects of the atmosphere. These applications should be made as lightly as possible, though thickly. Excellent results have been attained by applying the fluid extracts of grindelia, eriodictyon, and similar resinous substances, as well as collodion. In these cases the effect is probably due to the deposit upon the surface of a thin protective coating resulting from the evaporation of the

Fig. 4275.—Rhus diversiloba. (One-half natural size.)

alcohol. Relief of the irritation is to be obtained by the application of carbolic acid. An excellent method is the use of the official lime liniment to which from one to five per cent. of carbolic acid has been added. To any small areas which exhibit a specially irritable condition, a solution containing ten per cent. of the acid may be applied. Great care should be taken, however, that no large area, and especially that no extremity, be covered up by even the weaker solution. Such a procedure will inevitably kill and cause the loss of a finger or of the whole hand. A saturated solution of oxalic acid, cautiously applied, is highly recommended by some practitioners. As the eczema dries away, zinc ointment may profitably be applied to take the place of the other applications. The Cheyenne Indians are said to employ with great success an infusion or decoction made from the herbage of *Astragalus nitidus* Pursh., a near relative of the famous loco weed (*A. mollissimus* Presl.). This infusion is applied just when the eruption takes on its "watery" character. Since the constituents of this plant are entirely unknown, the principle involved in its employment cannot be stated. The fresh juice of the wild or great celandine, or jewel weed (*Impatiens fulva*) is said to have been used with excellent results.

Almost precisely similar in action to poison ivy is the Poison dogwood or elder or Swamp or Poison sumac (*R. vernix* L.; *R. venenata* D. C.) (see Fig. 4274). This species is an erect-branching shrub or small tree with a smooth ashy-gray bark, of swamp lands, throughout Eastern and Central North America. The habit of the leaves and inflorescence is indicated in the accompanying cut. The leaves are very characteristic, on account of their deep red petioles. The leaves sometimes reach a length of one and a half to two feet, are nearly smooth, and green on both surfaces. Flowers and fruit are very similar to those of the poison ivy.

The two species of Rhus above described pertain to the section *Venenatæ*, characterized by smooth fruits, and most, if not all, of the species of which are poisonous. The Japanese lacquer tree (*R. vernicifera* D.C. or *R. vernix* Thunb.) has been already referred to. The lacquer is prepared from its milk juice, which frequently produces severe poisoning, as does the herbage. The tree closely resembles our *R. vernix* L. Species which quite closely resemble *R. radicans* are *R. microcarpa* (Mx.) Steud. (*R. toxicodendron microcarpa* Mx.) of our North Central States, *R. michauxii* Sargent (*R. pumila* Mx.) of the Eastern United States, and, in the West, *R. rydbergii* Small and *R. diversiloba* T. et G. (*R. lobata* Hook.), the *Californian* or *Pacific Poison Oak* (see Fig. 4275). The celebrated *Coral Sumac*, *Mountain Manchineel* or *Bumwood* of Florida and tropical America, has been referred to this genus as *R. metopium* L. or *R. oxymetopium* Griseb., but is now called *Metopium linnæa* Engl. (see Fig. 4276). Its close relative in Cuba, *M. venosum* (Griseb.) Engl. has similar poisonous properties. These are small trees or large shrubs, and their fruits are reddish instead of greenish-white like the others named.

The genus *Comocladia* P. Browne (*Dodonæa* Plum.) represents shrubs and trees of the central portion of tropical America, including the West Indies, which are violently poisonous. Several species are known as *Guao*, and a number are here illustrated (see Fig. 4277). Poisoning by these species has been successfully treated with an application of collodion. The following possess, in their respective localities, histories of

Fig. 4276.—Metopium. (One-half natural size.)

poisoning similar to those of the *Venenatæ* and *Comocladia* described above: in Chili the *Llithi* (*Lithræa caustica* Miers (*Rhus c.* Hook.) (see Fig. 4278); in Mexico, the *Copaljiote*, *Cuajiote* or *C. Blanco*, *Guajilote* or *Stinking Wood* (*Pseudosmodingium perniciosum* (H. B. K.) Engl. (*Rhus p.* H. B. K.); in Eastern Asia, *Melanorrhoe laccifera* Pierre; in the East Indies, *Holigarna ferruginea* March.; in Southeastern Asia, *Gluta renghas* L.

The fixed oil of the cashew or caju nut, the ripened

ovary of *Anacardium occidentale* L., a small tree, native to tropical America and largely cultivated and naturalized in other tropical countries, yields the vesicating principle *cardol*, evidently very similar to the poisonous element of Rhus. This substance exists in specially large amount in the middle layer of the pericarp, and the fatty substance thence exuding frequently causes poisoning. Cardol ($C_{21}H_{30}O_2$) is soluble in alcohol and ether. In the crude condition it varies from yellow to reddish or brownish, but can be decolorized. Poisoning by it, and its treatment, are practically identical with those pertaining to Rhus.

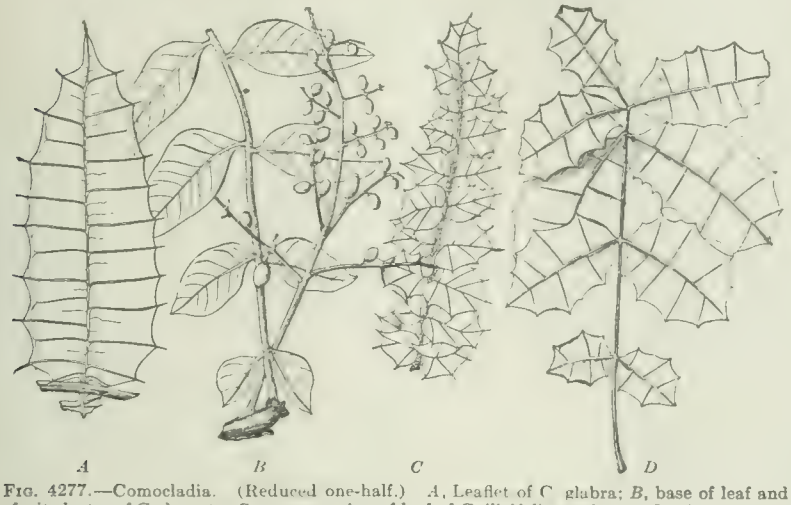

Fig. 4277.—Comocladia. (Reduced one-half.) *A*, Leaflet of C. glabra; *B*, base of leaf and fruit cluster of C. dentata; *C*, upper portion of leaf of C. ilicifolia; *D*, leaf of C. platyphylla.

The only other cutaneous poisons important enough to require consideration here are certain acrid juices of the Euphorbiaceæ. Types of this class are *Alvelos* and *Euphorbium* (which see). Others are referred to in our article on *Euphorbiaceæ*. In most of these cases the poisoning agent appears to be resinous. In croton oil and some others they are apparently fat acids. In the former class the saponification treatment offers little promise. In both cases protective and soothing applications are equally efficacious as in Rhus poisoning. Manchineel is the large tropical American (chiefly West Indian) tree *Hippomane mancinella* L. It bears large, thick, ovate, acute, finely serrate leaves and an apple-like fruit containing several silvery seeds. Its milky juice is abundant and is the poisoning agent, its active constituent being apparently volatile. Treatment is much like that applicable to Rhus poisoning.

Internal Poisons.—In considering the poisonous plants which act through the entrance of their constituents into the circulation or into the alimentary canal, the primary requirement appears to be their identification. This, in a majority of cases, is most readily effected by reference to the objects themselves, rather than to the symptoms as in cases of poisoning by chemical substances. This fact has determined the following classification of these objects as plant parts.

To discuss all poisonous plants would require a large volume, and it has been deemed wise to treat the subject from the standpoint of a North American work, considering all plants of importance, or likely to become so, as poisoning agents in our own region, and including, from outside of this region, only such as are of primary importance. Moreover, no attempt is made to enumerate all those known to possess poisonous properties, since it is clear that many of them are not at all likely to be eaten. A still further restriction of the subjects is made by omitting, except by mere mention, those poisonous plants or plant parts which become effective only through their medicinal employment, these having been sufficiently treated in the materia medica portion of our work.

Fruits and Seeds.—These products are placed first because of their greater liability to being eaten. Contrary to popular ideas, the number of poisonous fruits and seeds in North America is small. Even in country districts, where correct knowledge of this subject should be found, many perfectly innocent substances are commonly regarded as poisons.

Belladonna (fam. *Solanaceæ*).—Undoubtedly this is our most important poisonous fruit, its seeds containing the active constituents pertaining to the roots and leaves. The plant is rare in a wild state in this country, though very common in Southern and Central Europe. Its scarcity, however, renders it on some accounts the more dangerous, since it is thus not well known. It is a highly attractive, purple-black, shining, juicy berry, as indicated by one of its common names, "black cherry," and has been often eaten by children in the regions where it abounds. The accompanying illustration (see Fig. 4279) is ample for identification. The plant is a tall, widely spreading, smooth perennial herb, somewhat resembling the pokeberry plant, though not so large and wanting the strong purple stem coloration of the latter. A description of the symptoms caused by belladonna or atropine will be found under *Belladonna*.

Fig. 4278.—Lithræa caustica (Two-thirds natural size.)

Bittersweet, True and False.—Rather closely related to belladonna is the true Bittersweet (*Solanum dulcamara* L., fam. *Solanaceæ*). It is found both in Europe and in America, and grows commonly in the edges of swamps and along streams, especially where

the water is stagnant, or where the ground is subject to overflow. Occasionally also it grows in other localities, as about shaded stone walls and fence rows. The branches are long, slender, sprawling, and widely spreading over bushes, and the fruits are pendulous. Nothing more attractive than these fruits can be imagined. They are of a ruby-red color, smooth, shining, and somewhat translucent, and children are very apt indeed to eat them. Their poisonous properties are rather mild unless large numbers are eaten. The seeds appear to be the poisonous portion. The properties are partly those of the drug Dulcamara, but more intense, and the poisonous constituent appears to be solanine.

False Bittersweet (*Celastrus scandens* L., fam. *Celastraceæ*) has been considered in the same connection. Its fruits are also attractive, but possess an acrid taste; hence they are not likely to be eaten in quantity. Their poisonous properties, due probably to a small amount of saponin, are comparatively slight.

Potato Fruits.—The small berries which develop upon potato plants are mildly poisonous, especially when unripe, in the same way as are the berries of true bittersweet. They have a nauseous, acrid, and disagreeable taste, and are not at all likely to be consumed.

Fig. 4279.—Belladonna. Branch reduced one-half; fruit natural size.

Black Nightshade.—The fruits of black nightshade (*Solanum nigrum* L., fam. *Solanaceæ*) may be dismissed with the same remarks which have been applied to potato fruits. This plant grows like a tall, slender, and erect potato plant, in similar situations to those of bittersweet, though usually in dryer ground and more in the vicinity of barns and waste places. It is not very abundant, though somewhat common in the United States, as indeed in almost all other parts of the world. Its fruits are a little larger than large peas, and are of a greenish-black color. The fruits of many tropical species of Solanum are similarly, some violently, poisonous.

Other North American berry-like or fleshy fruits requiring consideration in this connection are the baneberries, or cohoshes, red and white, pertaining to the genus *Actæa* and the fruit of the yew.

Actæa (fam. *Ranunculaceæ*) is a genus of several species, probably more numerous than generally admitted by systematic botanists, distributed from Japan across Asia and the most of Europe, and in North America from ocean to ocean. According to ancient, and to one very recent authority, the half-score species of Cimicifuga are also included; but to most botanists familiar with the plants in a state of nature, an absurdity is involved in this association. The red and white berries have been recorded as poisonous, the medical botanist Lindley saying of them that they produce death with violent delirium, emesis, and catharsis (see Fig. 4280). The active constituents of the baneberries have not been investigated, but are in all probability similar to those of larkspur seeds and stavesacre. Not enough is known of their action to suggest anything more than rational treatment, consisting of prompt evacuation, followed by alleviation of the painful symptoms, and support to the circulation, which is depressed as in poisoning by hellebore.

A. *B.*

Fig. 4280.—Actæa. *A*, A. rubra; *B*, A. alba. (Two-thirds natural size.)

Yew Berries (fam. *Taxaceæ*).—It was for a long time supposed that the American creeping yew was a mere variety of the European, which latter is recorded as having produced various poisoning accidents. Now, however, it is recognized that they represent distinct species. The foliage and fruits are here illustrated. The plant is an evergreen and the fruit is of a beautiful bright scarlet, frequently with a somewhat glaucous surface (see Fig. 4281). The poisonous constituent, present in the seed and foliage, is the alkaloid *taxine* ($C_{37}H_{52}NO_{10}$), which is bitter, readily soluble, in its free state, in alcohol and ether, but not in water, and is precipitated by silver nitrate. Its action is very imperfectly understood, though it is compared in a general way with that of digitalis. The following symptoms have been recorded: nausea and retching

without much vomiting, dilated pupil, convulsions interrupting a semi-comatose condition, a cold and clammy skin, and difficult respiration. No cases of poisoning by the American plant have been recorded, though it doubtless acts similarly.

Fig. 4281.—Taxus. Branch slightly reduced; ament and fruit × 2. (After Britton and Brown.)

Phytolacca or *pokeberry* has already been considered as a drug. The so-called berries are in reality stone-fruits. They are of a beautiful and tempting appearance, being of a dark purple black, shining and juicy, and are not rarely eaten by children (see Fig.

Fig. 4282.—Phytolacca. (One-half natural size.)

4282). After a little time the taste becomes acrid, so that large quantities are not usually consumed. The seed, which is the poisonous portion, is enclosed in a crustaceous endocarp, which is usually not crushed in eating, so that the seed is protected for some time against the digestive juices. Meantime the pulp itself is somewhat laxative, so that the dejection of the pyrenes in an entire condition is to be anticipated. Treatment should consist in prompt emesis and catharsis, followed, if irritant symptoms should appear, by that applicable to poisoning by pokeroot.

Other Fleshy Fruits.—In this connection brief reference may be made to the fact that although the common May apple or mandrake berry is commonly and freely eaten, yet two cases are recorded of poisoning by it, one resulting fatally. The symptoms were those of poisoning by podophyllin, although narcosis came on very early.

Such seeds as those of the cherry, plum, and peach are in all respects similar to bitter almond, and are capable, when eaten in excess, of causing prussic-acid poisoning. Two cases are reported in which intestinal impaction of wild cherry stones, followed by the freeing of the seeds by maceration, resulted in poisoning, one of the cases proving fatal. Excessive indulgence in eating the sweetish fruits of any species of juniper may result in poisoning similar to that by the ordinary medicinal juniper.

The fruit of *Tamus communis* L., the Black bryony (fam. *Dioscoriaceæ*) grows upon a tendril-bearing vine of Northern Africa, Southern Asia, and Southern and Central Europe. It (Fig. 4283) is an active emeticocathartic poison, producing powerful diuresis, and apparently acting much after the manner of squill.

In Southern and Central Europe, as well as in cultivation for lawn ornament, occur the peculiar fruits of *Daphne mezereum* L., which are actively emeticocathartic and diuretic; they are used for fish poisoning, and sometimes poison children. They contain the glucoside *daphnin* ($C_{15}H_{16}O_9.2H_2O$) which is neutral, soluble in hot water and hot alcohol; also the amaroid daphnetin, which is a feebly acid and astringent principle, similarly soluble. We here figure also the fruits of *Hedera helix*, the common ivy, which are discussed under the title *Ivy*, and those of *Ligustrum vulgare*, or privet, considered under the title *Oleaceæ*.

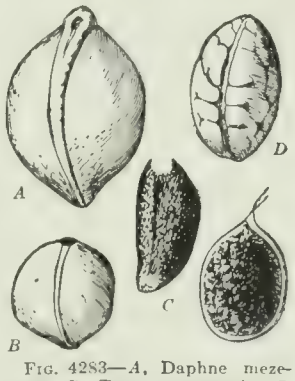

Fig. 4283—*A*, Daphne mezereum; *B*, Tamus communis; *C*, Ligustrum vulgare; *D*, Hedera helix. (After Holmes.)

Finally, reference may be made to the fact that mild narcotic properties pertain to the common elderberry, notwithstanding the freedom with which this fruit is eaten. Small animals, like barnyard fowls, have been recorded as suffering from intoxication from eating them. Cooking or fermentation appears to destroy these properties.

Stramonium.—Among the non-fleshy fruits and seeds, probably the most important poisoning agent is Datura or stramonium, the common thorn apple. An examination of our illustration (see *Stramonium*) will show that the fruit is large and conspicuous, and very likely to attract the attention of the curious or hungry. Growing as it does in waste places in cities, whose inhabitants are not accustomed to observing vegetation, it not infrequently happens that its seeds, which are contained in abundance, are eaten, especially by young people. It is also stated that in India and other Oriental countries where this plant abounds its seeds are often eaten by starving people in times of famine, with widespread fatal effects. The Thugs were said to use them freely for the purpose of stupefying their intended victims. Such assassins were called *Dhaturias*. The symptoms are identical

with those described under *Stramonium*, as is the treatment.

Henbane.—Closely related in every way to stramonium is henbane. The plant is similarly a large, coarse, widely spreading herb, with clammy foliage and heavy narcotic disagreeable odor. Its capsules are not more than half so large as those of stramonium, and they discharge by the separation of a terminal lid. Poisoning by these seeds is not common.

Cicuta.—Small fruits, usually spoken of as seeds, are those of conium and cicuta. The former has been sufficiently considered under that title. Poisoning by the latter, except as part of the plant itself, which subject will be considered under roots, is not at all likely to occur. The same may be said of the seed-like fruits of our wild parsnip, which are said to be somewhat poisonous, the action being partly acrid-irritant and partly narcotic. No authenticated cases of poisoning are recorded. The fresh juice is said to blister and the root is regarded with suspicion.

To be classed with ergot, as poisonous constituents of grain, are the darnel, the cockle, and perhaps the seeds of other species of plants in the pink family.

Lolium, Darnel, Bearded Darnel, Ivraie (Fr.), *Lolch, Taumelkorn* (Ger.), is the fruit (grain or *caryopsis*, commonly miscalled seed) of *L. temulentum* L. (fam. *Gramineæ*), an Asiatic grass, growing commonly in grain fields there and in Europe, and so introduced in this country. The general structure of this seed is that of a grain of wheat or rye. It is about a fourth of an inch long, and comes away with the palets attached and enclosing it, is convex on one side, grooved on the other, of a light brown color, smooth, starchy in structure, and gradually develops a bitter taste after chewing. Its presence in flour, if in large quantity, can be detected by the appearance of the starch grains, which are much smaller than those of wheat starch, nearly circular, white-margined, the rest of the body without markings, and having a peculiar brightly shining surface. The poisonous constituent is the alkaloid *temuline* ($C_7H_{12}N_2O$), existing with *temulentic acid*. There is a good deal of obscurity regarding the mode of action of this poison, but the substance is in general classed as a narcotic of the delirifacient type, producing much nausea, dizziness, and headache, with drowsiness. There is also at first considerable irritation of the stomach and intestines. Darnel-contaminated flour is not dangerous unless the substance is present in very large amount, from which condition a number of fatal cases have resulted.

Cockle or *corn cockle*, the seed of *Agrostemma githago* L. (*Lychnis G.* Scop., fam. *Caryophyllaceæ*), is very common in grain fields, more so in Europe, where it is native, than in this country. The plant is a slender herb, two or three feet high, the branches terminating in handsome purplish flowers about an inch broad, and having the general appearance of a common single-flowered pink. The seeds are produced in a one-celled capsule and are numerous, black, and about as large as morning-glory seeds. Their active constituent appears to be a kind of saponin which is exceedingly common and abundant in this, the pink family. The properties of the poison are those of saponin, and a percentage of the seeds in the flour sufficiently large to produce fatal results is scarcely to be expected.

The closely related plant *Vaccaria vaccaria* L. Briton (*Saponaria V.* L.; *V. vulgaris* Host.), the cow cockle, cow herb, or field soapwort, produces seeds which are apparently identical in action with the corn cockle. This plant is at present spreading widely through the grain fields of the Western United States, and the seeds are becoming increasingly abundant as a constituent of grain. Although they are rather easily screened out, yet their possible presence in flour is to be recognized as a distinct source of danger.

Ricinus or *castor oil* seeds have been rather fully considered under *Castor Oil*, so far as constituents and activity are concerned. These shining, reddish, and purple-spotted, bean-like seeds are very pretty and attractive to children. Their tendency to be *eaten* to excess is the greater because they have a bland and nutty flavor, quite free from the nauseous odor and taste of castor oil, unless they have become old and rancid. The common cultivation of the plant for lawn decoration conduces to accidents. In one case, a city resident, moving to the suburbs where a quantity of these seeds were strewn upon the lawn, fed them to his horses with the remark that it was a pity to see all those beans going to waste. The effect upon the horses was fatal.

Several other Euphorbiaceous seeds were formerly much cultivated in gardens for use as cathartics, under the name of spurge or spurge seeds, and this habit has not entirely died out. They produce, in overdoses, poisonous results similar to those of ricinus.

Coral Bean.—Acting by a toxalbumin similar to ricin, or even more like abrin (see *Jequirity*), the seeds of several species of *Sophora*, especially *S. coralloides* Benth. (fam. *Leguminosæ*), have produced fatal poisoning in Texas and the regions to the southwest. These coral beans resemble a common bean in form, some being larger, some smaller, and are of a bright scarlet color. They grow in a brown or brownish cylindraceous pod, which is constricted between the seeds, so as to resemble beads upon a stick, and separating readily into its one-seeded joints. Treatment of this poisoning has proved difficult and uncertain.

Lupines (fam. *Leguminosæ*).—Many species of the genus *Lupinus* (wild bean or blue bean) are employed, in both Europe and America, either as fresh fodder or for the production of a hay very similar to clover hay. Although these fodders are used upon a great scale, with only the best results in most cases, yet wholesale and fatal poisoning has at times resulted. Many observations, together with some careful experimentation, have apparently determined the fact that the poisoning is due to the seeds, which resemble small beans and are produced in bean-like or pea-like pods. When the herbage is eaten previous to the formation of these seeds, or after they have been discharged from the pods, no bad results follow; but if the seeds are eaten, especially when ripe, either acute or chronic poisoning may follow. The symptoms indicate a poison similar in its general nature to digitalis or, still more so, to sparteine or ononis. There is cerebral congestion, with frenzied and very active delirium. The heart is slow and strong, the blood pressure high. Convulsions, with extreme alternations of strength and weakness, and finally prostration occur. There is powerful diuresis, the urine being often bloody, as in digitalis poisoning. Death usually occurs in acute cases within two hours of the appearance of the first symptoms.

Æsculus.—The common horse chestnut (seed of *Æ. hippocastanum* L., fam. *Hippocastanaceæ*) is regarded as slightly poisonous, and certainly contains acrid saponin-like principles (*argyræscin* and *aphrodæscin*) which, consumed in large amount, would prove disastrous. Deprived of this principle by powdering and maceration in alcohol, the residue of the kernel is highly nutritious (protein eight per cent., fat seven per cent., non-nitrogenous extract containing among other constituents fourteen per cent. of sugar), and it is now being so manufactured in Germany. It is readily conceivable that, as this industry extends, insufficient purification may lead to the distribution of a poisonous product. A western and southwestern species (*Æ. pavia* L.), the buckeye, is apparently much more active, various fatal cases of poisoning by it being on record. Its poisonous constituent is similar to, but distinct from, argyræscin. The symptoms are violent emesis and catharsis, convulsions, and other common accompaniments of poisoning by the saponin group. It would appear from the accounts that narcosis comes on rather more quickly

than in cases of poisoning by other saponin-containing drugs.

Poisonous Barks.—In the nature of the case, poisoning of human beings by barks is not at all likely to occur, except in medical cases where a poisonous bark has been taken by mistake or overdoses of the bark have otherwise been given. It is true that many barks are employed by savages as arrow poisons (see *Curare*), but this subject scarcely pertains to the present article. The poisoning of stock by the eating of nutritive barks is in general prevented through the natural instinct of the animal. In times of scarcity of food, however, grazing animals sometimes eat the bark of the common locust tree (*Robinia pseudacacia* L.) with poisonous results. This tree pertains to the family Leguminosæ, or bean family, so noted for its production of albuminoid nutrients. Its poisonous constituent has been determined by Power as a toxalbumin, very subtle and difficult of isolation. Nothing is known of the treatment, except what is derived from a knowledge that the chief symptom is extreme nausea with violent retching, persisting for days, accompanied by dizziness and great depression. In animals marked salivation has been noticed. The barks of wild cherry and of several Ericaceous plants are poisonous to stock in the same way as their foliage, and the latter will be considered under *Herbage*. The barks of various species of elder (*Sambucus*) are more or less poisonous, though it does not appear that they produce accidents. This subject will be considered under *Roots*.

Poisonous Roots.—Besides the true roots, that name is generally applied by the public to all underground parts, such as mandrake, lily of the valley, Solomon's seal and other rhizomes, the potato and the artichoke, which are tubers, and the onion and garlic which are bulbs. All these are therefore here considered together.

The two important poisonous roots of our region are pokeroot and Cicuta. Probably no year passes without some fatal cases of poisoning by these, and it occasionally happens that quite a number of them occur at about the same time.

Pokeroot has already been considered at length as a drug, under that title, and its fruits have been elsewhere discussed in this article. The root has been quite often eaten by mistake for horseradish, which it rather closely resembles, and for other edible roots. The strong acridity of horseradish tends to avert the suspicion which would otherwise be excited by that of the pokeroot. When freshly dug it is quite attractive, being large, whitish, fleshy, and succulent, and containing large amounts of starch and sugar, so that it is readily mistaken for a wholesome and nutritious article. Suspicion once aroused, pokeroot is easily recognized. The base of the partially hollow stem, which is usually present in a broken condition, is seen to be divided by thin transverse partitions. The surface is finely papillose, and usually presents a spiral appearance, and the cross section exhibits a conspicuous concentric arrangement of the tissues. Since the young shoots are often cut and eaten as a substitute for asparagus, portions of the root are apt to be thus taken by too deep cutting. Thorough cooking ameliorates but does not destroy its activity.

Cicuta (Water Hemlock, Cowbane, Brook Tongue, Children's Death, Spotted Parsley, Beaver Poison, Muskuash Poison, etc.) is the root of various species of the genus *Cicuta L.*, fam. *Umbelliferæ*, a genus closely related and very similar to conium, some of the species even having gone by that name (see Figs. 4284 and 4285). These plants grow in swamps or other wet locations, along lakes, streams, and ditches throughout almost the entire North Temperate zone, and are particularly common and abundant in Eastern and Central North America. Our illustrations give an excellent idea of the roots, foliage, inflorescence, and fruits. The plant grows to a height of from three to five feet, and branches and spreads rather widely. The stems and leaf bases are thick, hollow, crisp, and juicy, and the former are usually more or less purplish and glaucous. The base of the petiole clasps the stem. The leaf blade as a

Fig. 4284.—Cicuta maculata roots. (One-half natural size.)

whole, though successively much divided into small segments, is very large, often two feet or more broad and long, and is thin and quite green. The entire plant is smooth, and exhales a not unpleasant odor when bruised. The fine white flowers are in decompounded umbels, terminating the branches. The

Fig. 4285.—Cicuta maculata. (One-fourth natural size.)

base of the stem, when longitudinally cut, exhibits thin transverse partitions, though these are obscure in some species. The roots, in fascicles like dahlia roots, are usually from three to ten in number. They have about the consistency of a raw potato, are starchy, crisp, and juicy, somewhat aromatic, and not un-

pleasant to the taste. They are externally of a brownish color, internally white. They are about the size of Jerusalem artichokes, which they somewhat resemble and for which they have been mistaken. Boys visiting swamps for calamus often get hold of them. Frequently also they are turned out in ditching operations, and they have then been experimentally eaten by workmen with fatal consequences. The aromatic stem and the fruits have also been mistaken for angelica. The constituents are believed to include coniine (see *Conium*). Cicutoxin is also a very active constituent. Although the nature of the poison partakes of that of conium, yet there is far more of a tendency toward irritation and convulsions. Tremors, violent contractions and relaxations of the muscles, astonishing mobility of the eyeball and eyelashes, widely dilated pupils, frothing, often bloody, of the mouth and nose, epilepsy, and after death a peculiar greenish fluid in the stomach and exuding from the mouth, cold, contracted, pale surface and some diarrhea have been noted. Prompt emesis by

Fig. 4286.—Œnanthe crocata. Reduced. (After Holmes.)

the aid of zinc sulphate has been found effective. The further treatment is indicated by the symptoms.

Œnanthe Crocata.—In Europe this species, closely related and rather similar to cicuta, is regarded as taking first rank among poisonous plants. Like cicuta, it grows in damp soil and produces a fascicle of fleshy roots (see Fig. 4286). Its leaves bear a strong general resemblance to those of celery, and it is free from disagreeable or warning taste. The symptoms of poisoning are only in a minor degree similar to those resulting from cicuta, and the nature of the poison is probably quite different. The symptoms develop very rapidly, death frequently occurring within an hour or two. Dryness of the mouth, with great thirst, vomiting, then dizziness, slow and weak pulse, pale and cold skin, reduced blood pressure, pupils greatly dilated and failing respiration, inducing convulsions, result. Death occurs apparently from heart failure. Judging from these symptoms, it would appear that the administration of digitalis would constitute a rational line of treatment.

Sambucus or *Elder* (fam. *Caprifoliaceæ*). (See Fig. 4287.)—Apparently closely related to cicuta as a poison is the root of the common elder, and probably

Fig. 4287.—Sambucus canadensis. (One-third natural size.)

of other species of the genus. These roots (or more properly rhizomes) are elongated, cylindrical, crooked, somewhat branched, whitish, and possessed of a rather thick, juicy bark. Commonly, some small shoots can be seen upon them, and these are usually of a bluish-purple color at the place where the young leaves are forming. When bruised, these roots exhale a rather disagreeable odor, and the after-taste is acrid. Coniine is said to have been extracted from some of the elders. The symptoms of poisoning are much like those from cicuta, and promptly fatal results have been recorded.

Iris or *Blue Flag* rhizome (fam. *Iridaceæ*), growing commonly in swamps or low ground, along with calamus or sweet flag, is liable to be mistaken for the latter. The distinctions between the two, once known, are sufficiently easy for recognition. Iris grows in small or only moderately large clumps, while calamus covers large patches, almost to the exclusion of other growth, and usually in wetter situations. Its leaves are longer, narrower, less thick

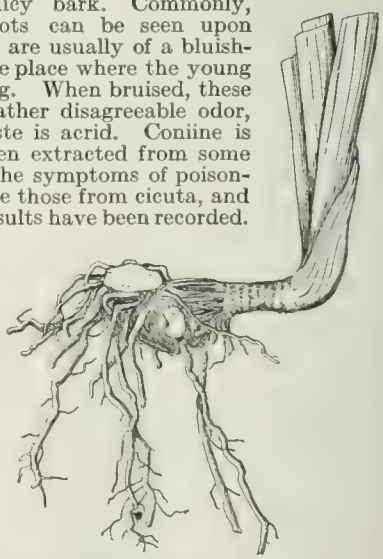

Fig. 4288.—Iris versicolor. (One-half natural size.)

and fleshy, and are greener, lacking the bluish-green tinge of iris. The plant is also taller. The rhizome of calamus is long and rather uniform in thickness for a considerable distance. That of iris is much thickened at short intervals. Calamus is bitter and somewhat acrid, so that the acridity of iris, though greater, is apt to be endured by the heroic calamus chewer, thinking that he has the rhizome of the latter. The properties of iris have already been considered (see Fig. 4288). The fresh rhizome is much more irritant and violently emetic and cathartic than the dry drug.

Veratrum (fam. *Melanthaceæ*).—Growing in the same swamps with iris, though usually in more wooded or shaded situations, veratrum is often found. Although a mistake is here not easy, such a possibility should not be overlooked, as the rhizome is fleshy and succulent. Beyond referring to our illustration and to our account of the drug (see Fig. 4290) this subject requires no discussion.

Camas.—Various western species of the genus Zygadenus Mx., of the same family with Veratrum,

Fig. 4289.—Death Camas. (One-fourth natural size.) (After United States Department of Agriculture.)

are known by this name, and several of them are recognized poisons, especially *Z. venenosus* Watson, or Death camas, a name which has been applied to a polymorphous species, or a group of very similar species, according to the varying views of different botanists. In all probability most, if not all, of the species of this genus are poisonous, but only the death camas has produced serious results. The genus is characterized as follows: Plants smooth, perennial, from rhizomes or bulbous bases, the stem bearing linear, somewhat succulent leaves, and terminating in a raceme or panicle of yellowish-white or greenish-white marcescent flowers, the perigone six-parted, its segments gland-bearing near the base. Stamens six, borne at the base of the perigone but free from it, the anthers cordate or reniform. Ovary three-celled with three styles. Pod completely dehiscent and containing narrow, angular seeds. The genus is closely related to veratrum. *Z. venenosus* is here figured (see Fig. 4289). It is extremely common and abundant in Montana and other Northwestern grazing regions, and is very destructive to stock. All parts of the plant appear to be poisonous. The bulb, which is especially so, is recognized among the Indians as dangerous to man because of its close resemblance to several edible species. It appears to be bitter at times, quite free from bitterness at other times. It is considered fatal to about twenty per cent. of the sheep poisoned by it. The symptoms are said to be uneasiness followed by incoordination, then muscular paralysis, especially of the posterior limbs. There are dizziness, disordered vision, regurgitation of frothy matter, salivation and weak respiration, with little cerebral disorder. The nature of the poisoning may thus be regarded as paralysis of the motor centers, progressing from below upward. The nature of the poisons is unknown, though the indications are those of one or more glucosides. They are extracted both by alcohol and by water. Potassium permanganate appears to be a very efficient antidote.

Closely related to Zygadenus, and by some botanists regarded as pertaining to it, is *Chrosperma muscætoxicum* (Walt.) Kuntze (*Melanthium m.* Walt.; *Amianthium m.* Gray) the Fly poison, Crow poison, or Fall poison, a common bulbiferous perennial of sandy soil of the Eastern United States, especially near the coast, and in parts of the Southern Central States. It reaches a height of two to three feet, bears long, linear, grass-like leaves, nearly an inch in breadth at the base, and large, much-branched panicles of greenish-white flowers, about a half inch broad. The perigone consists of six distinct parts, without glands, and is marcescent. The stamens are six in number, and borne upon the base of the perigone segments. Ovary and pod are three-celled, the latter splitting only at its upper portion, the styles persistent upon the valves. The ovoid brown seeds are few and are apparently more poisonous than any other part of the plant. As its names indicate, this plant, especially the seeds, is in use as an insecticide, and it is poisonous to birds. Little is known about the nature and treatment of the poisoning, but it appears to be in a general way quite closely related to veratrum.

More or less closely allied to the above-named bulbs, as well as to colchicum, are those of various species of *Narcissus*, *Hippeastrum*, and *Amaryllis*, which are severely poisonous. A number of species of agave, pertaining to this family (the *Amaryllidaceæ*), as well as of Liliaceæ, yield so-called soap roots, used for their detergent properties on account of their large content of saponin, and for the same reason actively poisonous.

Other similar articles, poisonous if eaten, but not likely to be eaten except through mistake, are podophyllum, sanguinaria, leptandra, arum, and actæa, all elsewhere considered, and all so strongly acrid and disagreeable, or even painful, that no considerable amount could be consumed by a sane individual.

With convallaria, aconite, Solomon's seal, and apocynum the case is somewhat different.

Convallaria (see *Lily of the Valley*) rhizome is sweetish and not unpleasant except in the after-taste; and it is so highly poisonous that it would not be improbable for a child to eat enough to produce poisonous symptoms. So common an ornamental plant requires no description.

Aconite.—The fresh tuber of this highly ornamental garden flower is said not infrequently to have been mistaken for horseradish, incredible as this may seem. Its biting taste is even exceeded by that of the horseradish, so is not apt to excite suspicion, but it even more closely resembles other roots which might grow in the garden beside it. It is to be regarded as an exceptionally dangerous article. Its toxicology has

been sufficiently described under the title of the drug.

Apocynum or *Dogbane* possesses a long cylindrical rhizome, running horizontally at a short distance below the surface, and fleshy and milky-juiced. It has an amylaceous taste, only slightly acrid, and might be eaten. Its properties have already been discussed.

Violet.—The roots of pansies and all other violets, though not likely to be eaten, should be remembered as possessing emetico-cathartic poisonous properties, almost identical with those of ipecac.

Euphorbia.—The large, fleshy, and milky-juiced roots of *E. corollata*, *E. ipecacuanha*, and other euphorbias, have been well known and much used cathartics.

E. corollata is known as the blooming, white, purslane, or large-flowered spurge, apple root or wild hippo, and is abundant in Eastern and Central North America. It reaches a height of about three feet, is slender, widely branched and smooth, and the flower clusters which terminate its branches are subtended by showy and petal-like white involucres, each bract of which bears a green gland at its base. The root is cylindrical, an inch or more in thickness, and one and a half or two feet long, of a very dark or blackish brown externally when dried, much lighter brown when fresh. It has a thick white bark in cross-section and a radiate spongy central cylinder. Its taste is at first sweetish and pleasant, though the after-taste is a little acrid. Its active constituent is a resin. Overdoses are very powerfully emetico-cathartic, the action being much like that of ipecac.

E. ipecacuanha is known as the white, wild, North American, milk, or spurge ipecac or ipecac spurge, and is very abundant in sandy soil along the Atlantic coast. Its very slender, much-branched stems are numerous and prostrate, so as to form a sort of a mat-like growth. The leaves are of most diverse forms on different plants, ranging from narrowly linear to broadly oval. The herbage and inflorescence may be light green or more or less purple. The root itself is vertical, much longer and more slender than that of the last, rather lighter in color, but the woody center more yellowish. Its properties, as well as its uses, are identical with those of the last.

Potato.—Our consideration of poisonous roots may well close with a few words concerning the poisonous properties of the tuber, and more especially of the sprouts, of the common potato. The potato at all times contains traces of the highly poisonous alkaloid solanine, and probably others, but ordinarily the percentage is too slight to produce perceptible effects. Since the greater portion of this poison exists in the external layer, the peeling of potatoes which contain it in excess, may easily prevent trouble. The substance appears to exist in greatest amount in the rhizome of the potato, upon the end of which the tuber develops. It is therefore much more likely to be present in the young ("unripe") potato than when it is fully developed. Similarly, when the sprouts (young rhizomes) develop upon potatoes in storage, the solanine becomes present in them in considerable quantity. When the sprouts are first forming and of a lurid purple color, the percentage of poison is large, gradually decreasing as they elongate, thicken, and whiten, and especially as they put forth green leaves. Wholesale poisoning has resulted when, in times of scarcity, an attempt has been made to eke out the potato supply by consuming the young sprouts. Potato tubers which form above ground or at its surface, so that they are exposed to the atmosphere and develop a purplish-green color, also contain larger amounts of solanine. Finally, it may be mentioned that very serious results have followed the eating of potatoes containing black fungus spots, the solanine percentage being greatly increased in and just about the spots themselves.

Similar to the potato, in that it is perfectly wholesome under some conditions and highly poisonous under others, is the cassava, manihot, or tapioca root (fam. *Euphorbiaceæ*), so largely used as a food in tropical America. Of this root there are two varieties —the one sweet, the other, bitter. The former is in general not poisonous, or not so much so but that thorough cooking renders it wholesome. Nevertheless, a small percentage of hydrocyanic acid is almost always contained in or to be yielded by its bark or the tissues near it. In the bitter variety an important amount of this deadly poison is always found, so that it is not safe to employ it, even for the manufacture of tapioca, without a thorough preliminary maceration and perfect cleansing. There are certain species of yams eaten in the East Indies which also have to be treated by thorough washing in order to remove a poisonous bitter constituent, although not in this case hydrocyanic acid.

The poisonous nature of the roots of belladonna, bryonia, spigelia, caulophyllum, colchicum, squill, and hellebore, will be found discussed elsewhere.

Poisonous Herbage.—In the nature of the case poisonous herbage is far less likely to be eaten by human beings than are fruits, seeds, or roots, and similar organs. Nevertheless, the use of leaves as salads and potherbs, especially in times of scarcity of food, as during famines or in the course of explorations, renders necessary a careful attention to some of them. Furthermore, the frequency of stock poisoning through their use is greater than that resulting from any other portion of the plant; and a reference to the more serious stock-poisoning agents is not out of place in an article of this kind.

As human poisons, tansy, aconite, chelidonium, lobelia, henbane, conium, belladonna, and viola, may be dismissed with the statement that they are scarcely likely to become effective except through accidents attending their use as drugs, which subject will be found discussed under their respective titles in that connection. Tobacco may poison, partly in this way and partly through its use as a popular narcotic, or during its application for parasites infesting plants and domestic animals, under which circumstances it has frequently caused poisoning by its entrance to the system through wounds or other openings in the skin. The symptoms and treatment of tobacco poisoning are elsewhere fully described. Absinthium is a well-known poison, either acute, through overdosage, or chronic, through the use of beverages containing it. Both forms of poisoning are described under its title. A sufficient reference to poisoning by the foliage of the cedars, pines, hemlock, and other Coniferæ of the savin or arbor vitæ type will be found under the poisonous family Pinaceæ. Related to these, but acting through its poisonous alkaloid, is the yew or taxus, which subject has been presented in speaking of its fruit. Poisoning by any of these is extremely unlikely to occur. The same is true of poisoning by the buttercups, clematis, etc., of the Pulsatilla type, in the poisonous family Ranunculaceæ. The foliage of the elder has already been stated as open to the same suspicions as those affecting its bark and root, and it need not be further considered. The foliage and flowers of lily of the valley, or convallaria, contain the same poisonous constituents as those of its rhizome, and there is the same slight possibility of poisoning accidents being caused by it. The occasional use of the stem and herbage of cicuta, mistaken for angelica, has already been mentioned. It contains the same constituents as the roots, and the symptoms and treatment are identical. Poisoning by the herbage of the black nightshade (see the section on Fruits and Seeds) is said to have occurred, although it is claimed that this herbage has been used as a potherb, after cooking, without injury. It is certainly open to grave suspicion. Should poisoning by it occur, it would doubt-

less be found identical with that of solanine from other sources. Another plant whose herbage has not been recorded as causing poisoning, but which, for obvious reasons, is to be regarded with caution, is the pokeberry, or phytolacca. Watercresses, though commonly regarded as quite innocent, are capable, when eaten in large excess, of producing dangerous and extremely painful symptoms. In one case seen by the writer, a painful, severe cystitis was established in this way. The possibility of an abortion being produced by this article, as well as by horseradish, is worthy of consideration.

Probably the two most dangerous leaf poisons in existence, all things considered, are stramonium and veratrum. The former has been fully discussed as a drug, and under poisonous seeds. It possesses the peculiarity of flourishing in periods of drought, resulting in famine conditions. The whole aspect of the plant is luxuriant and succulent, and a temptation

Fig. 4290—Veratrum viride. (One-fourth natural size.)

to consume it under such circumstances may often be great. As a matter of history, numerous poisoning cases have occurred in this way, especially in India. Other cases are recorded in which travelers destitute of food have ignorantly eaten it. Veratrum (fam. *Melanthaceæ*) is a plant which grows in swamps in the vicinity of caltha, or American cowslip, the herbage of which is eagerly sought in many sections for cooking purposes, appearing as it does in early spring when fresh vegetables are scarce. Various cases are on record in which the foliage of veratrum has thus been mistaken and eaten with serious consequences. Veratrum poisoning is discussed elsewhere.

The young shoots of *Tamus communis* (see the section on Fruits) have been eaten like asparagus in the Old World with serious results.

Sorrel.—This name has been applied to two groups of plants, very different from a botanical standpoint, but agreeing in their sensible properties, constituents, and toxicology. The name *Wood Sorrel* has been applied to the common *Oxalis acetosella* L. (fam. *Oxalidaceæ*), which is very common in cool woodlands in both the Old and the New World, and bearing white or pinkish tinged and veined flowers. The trifoliolate leaves closely resemble a small clover leaf, but are somewhat fleshy, and the whole herbage is strongly acid. Oxalic acid, free and combined, is the poisonous constituent, and is said to have been first derived from this source. A number of very slender, branching species, with smaller and yellow flowers and smaller leaves, grow commonly as garden and roadside weeds and are known as ladies' sorrel or ladies' sour-grass. In tropical regions hundreds of species occur, some of them very large. Many species are favorites among household flowers. All have the same composition and properties.

The other group represents the sheep sorrels or field sorrels, namely, *Rumex acetosa* L. and *R. acetosella* L. (fam. *Polygonaceæ*), pernicious weeds growing in poor, gravelly, or sandy soil throughout the northern hemisphere. They are used to some extent as ingredients of salads. These also contain oxalic acid and have, like oxalis, caused fatal poisoning of both children and adults. The treatment and symptoms may be inferred from the above statement that oxalic acid is the active agent. It may be added that very large quantities of either are required to produce dangerous effects.

Ailanthus or *Tree of Heaven* (fam. *Simarubaceæ*).—These nasty-smelling leaves are not at all likely to be eaten either by human beings or by domestic animals. It is said even that flies will not visit decayed meat when hung in the branches of these trees. The leaves have been utilized for the manufacture of substances both odious and toxic to flies. They have also, like the bark, been somewhat utilized in medicine; they contain a peculiar nauseous green oil, as well as an amaroid. This oil has been indefinitely stated as possessing poisonous properties. The bitter substance, though stomachic in medicinal doses, is a gastric irritant in larger doses. Chronic gastritis of a rather serious type is reported as having occurred in all members of a family, as the result of having drunk the water of a well in the vicinity of these trees. The roots extended into the water in great numbers and probably the leaves also had blown into and accumulated in the water.

Kalmia.—The members of this genus, the American laurels (fam. *Ericaceæ*), are distinctly poisonous, being frequently fatal to sheep, though not at all likely to be eaten by man, since the foliage is very bitter and disagreeable. The large species (*K. latifolia* L.) is the well-known mountain laurel or calico bush, spoon wood, or ivy bush, so common throughout Eastern North America. The smaller species of common occurrence is *K. angustifolia* L., the small, dwarf, or sheep laurel, lambkill, calfkill, or kidkill. It grows in more open situations, on dry hillsides, and rarely exceeds three feet in height. Its leaves are mostly in whorls of three, its flowers less than half as large as those of the other, and of a deep rose color. Other small species are more rare. The poisonous constituent of the laurels is the amaroid *andromedotoxin* ($C_{31}H_{51}O_{10}$), a neutral crystallizable substance, rather soluble in both alcohol and water. Mineral acids color its solution bright red. It is an extremely poisonous substance, and has been said to be, in the pure state, more emetic than either emetine or apomorphine, and more toxic than aconitine. Animals are not fond of laurel, eating it only when other food is scarce. The common symptom of poisoning by laurel is narcosis with muscular weakness. Animals become quiescent and stupid. In the early stages a staring glassy eye is notable, with great disorder of vision, objects being apparently distorted. A staggering gait progressively develops, and finally the animal

lies down and goes into a condition of stupor. There is no disposition either to eat or to drink, the reappearance of such desire being a pretty sure indication of

Fig. 4291.—Pieris mariana. (Two-thirds natural size.)

recovery. A thin liquid frequently flows from the mouth. Stomach digestion is apparently completely paralyzed. There are faint convulsive movements

Fig. 4292.—Ledum latifolium. (Two-thirds natural size.)

of the limbs, and death finally ensues from general weakness, specially of the respiration.

The poisonous constituent described above occurs commonly in this family, other members of which have poisonous records by reason thereof. The most important of these is *Pieris mariana* (L.) B. et H. (*Andromeda M.* L.), which bears the suggestive name of stagger bush (see Fig. 4291). It grows throughout the Atlantic region as far north as New England, preferring shrubbery along the salt marshes. It is a shrub, from three to five or six feet high, and its profuse flowers are whitish or purplish and of a waxy appearance. A flowering branch is here figured. The symptoms of poisoning by stagger bush are identical with those resulting from laurel. In this connection the *Rhododendrons* may be mentioned as having precisely similar poisonous properties.

Ledum or *Labrador Tea, Marsh, Swamp, Continental* or *James tea*, and *Marsh rosemary*, are names applied to the two species (fam. *Ericaceæ*) *Ledum groenlandicum* Oeder. (L. *latifolium* Ait.), the broad-leaved and *L. palustre* L., the narrow leaved (see Fig. 4292). They are marsh shrubs, the former ranging from Greenland through Northern North America, the latter extending also through Northern Europe and Asia. The broad-leaved species has been a much used substitute for tea among British-American voyagers, and is only moderately narcotic. The narrow-leaved species is much more active. Both are

Fig. 4293.—Prunus serotina. (One-half natural size.)

somewhat used medicinally in domestic practice. The narrow-leaved species is distinctly narcotic, the symptoms closely resembling those of laurel poisoning. If, as claimed, andromedotoxin is not a constituent, some very similar body must be present. A flowering branch of ledum is here figured. The leaves are well distinguished by their somewhat thick and leathery texture and their smooth upper and brown woolly lower surfaces. The flowers are white.

The leaves of such plants as the cherry, peach, plum, etc. (fam. *Drupaceæ* or *Rosaceæ*) yield appreciable amounts of hydrocyanic acid. Although the consumption of injurious quantities by human beings is not at all likely to occur, yet the leaves of the common wild cherry constitute a well-known and much-dreaded stock poison. The branches, trimmed out for fence rows or broken down by boys in search of the fruit, have very frequently been recorded as poisoning cattle, often fatally (see Fig. 4293). An unexplained but well-established fact is that cattle will eat them from the living trees without ill effects, but will be poisoned upon eating them in a wilted condition. That the effects are due to the hydrocyanic acid liberated is fully evidenced by the effects.

Delphinium or *Larkspur* (fam. *Ranunculaceæ*).—The general subject of larkspur, as to constituents

and activity, has been considered under the title of *Staphisagria Seed*. So well known a garden flower scarcely requires description. The accompanying illustration of *D. glaucum*, the tall larkspur, often miscalled aconite, gives a sufficiently good idea of the genus in general (see Fig. 4294). Some of the species are larger, many much smaller. The flowers are usually of some shade of blue, sometimes purplish. Many species abound in the grazing regions of Western North America, and they are much dreaded as stock poisons by herders, though the poisoning of human beings is not recorded, and is not likely to occur. These poisons are to be classed partly with aconite, to a lesser extent with stavesacre, as to the nature of their effects. The symptoms are muscular incoordination, motor paralysis, beginning at the posterior extremities, great cardiac and arterial weak-

Fig. 4294.—Delphinium glaucum. (One-third natural size.) (United States Department of Agriculture.)

ness, and hypersensitive skin, with the special senses not affected. Convulsive tremors, especially of the posterior limbs, come on early and are followed by convulsions which increase in violence, and in one of which the animal usually dies. Death appears to be due chiefly to failure of the circulation. Atropine has been found a fairly good antidote, and potassium permanganate has also been found useful.

Loco Weeds (fam. *Leguminosæ*).—Although poisoning by this famous group is confined practically to stock, especially horses and sheep, yet no article on poisonous plants could be considered complete without reference to it, particularly as it represents a very large and varied class of leguminous poisons which more or less affect the human system as well. The loco weeds pertain to the two genera *Astragalus* and *Aragalus* (*Oxytropis*), and knowledge as to their specific identity is in a number of cases indefinite and uncertain. They are perennial herbs, growing mostly in tufts or hummocks, with a dense rosette of radical leaves and papilionaceous, mostly purple or purplish flowers in spikes or racemes. The leaves are elongated and pinnate, the leaflets mostly numerous and more or less oblong or varying from ovate to obovate. The fruits are constructed like small pea pods, the seeds mostly resembling small peas and often rattling loosely in the dry pod. The herbage is without disagreeable taste. Animals are not naturally disposed to eat it; but having once done so, in case of scarcity of other food, they become ravenously fond of it and forsake all else in order to eat it. The poisonous constituents are not known, though great efforts have been made to isolate them. All indications point to their being of the nature of toxalbumins. Whatever they are they are excreted in the milk of the mother, since suckling lambs are frequently fatally poisoned together with the mother. Poisoning may be either acute or chronic, the latter being much more common. The symptoms are chiefly cerebral. There are incoordination and remarkable disorders of vision, though rarely blindness, and this usually in acute poisoning. The effect upon the vision seems to be that of causing objects to appear distorted. A similar effect upon hearing is observed. There are great and progressive disorders of nutrition, and these are especially referable to the skin and its appendages, sheep frequently losing the whole or part of their fleece and the teeth becoming loosened. Death, in cases of long duration, is usually from malnutrition. Very often the animal dies as a result of accidents, incurred either through frenzy or through weakness incident to the poisoning, such as falling into the water while drinking, and being unable to rise again. There is no known treatment for this form of poisoning other than to remove the cause and apply general restorative treatment.

Henry H. Rusby.

Plasmodidæ.—The family of Hæmosporida containing the malarial genera *Plasmodium* and *Laverania*. A minute ameboid parasite grows within a red corpuscle and develops a black pigment, melanin. These common protozoans are carried by mosquitos. Birds and mammals have characteristic species. See *Protozoa*.

A. S. P.

Plasmodium.—The sporozoan genus including the parasites causing malaria. There are three important species: *P. vivax*, producing tertian malaria; *P. malariæ* which produces fever every seventy-two hours; and *P. falciparum*, the cause of subtertian, estivo-autumnal, or pernicious malaria. See *Protozoa*.

A. S. P.

Plasmolysis is the term used in a general sense to denote the disorganization of the achromatic part of the cell, in opposition to *karyolysis*, which is applied to the complete disorganization of the nucleus. *Achromatolysis* is, accordingly, used as a synonym for plasmolysis and *cytolysis* is often used in the same sense. The word plasmolysis, having been introduced by a number of investigators working along special lines, is frequently used in a more narrow sense to indicate the destruction or degeneration of the protoplasm of certain forms of cells. Thus, for example, plasmolysis is by a large number of writers applied only to such changes in the red blood cells, and is used interchangeably with *erythrocytolysis*. In this condition the soluble substances of the red cell escape into the plasma so that the red cells become smaller (microcytes) or come to consist only of the outer envelope (red cell shadows). Through the imbibition of fluids such cells may become swollen. Grawitz uses the term to indicate solution of the red blood cells and the production of hemoglobinemia. In the case of nerve cells,

plasmolysis is applied to the simplest disorganizing changes in the achromatic part of the cell. In the case of bacteria, plasmolysis is used to indicate the formation of clear spaces beneath the capsule, due to the shrinking of the plasma, as may be observed in bacteria held in a salt solution.

ALDRED SCOTT WARTHIN.

Plasmomata.—Tumors composed of plasma cells (see *Granuloma*) occur occasionally in the bone marrow with the clinical characteristics of a malignant tumor, and with or without the formation of metastases. This type of tumor is also called myeloma. Some of the tumors designated chloroma, which grow chiefly in the flat bones of the skull or in the orbital region in young children, may also belong to this group. A third variety of plasmoma occurs in the tongue and pharynx and is possibly due in some cases to a local proliferation of plasma cells in connection with chronic inflammation, especially of a syphilitic nature, but other forms appear to be true tumors. All of these growths when malignant have the clinical characteristics of sarcomata.

Microscopically, they are composed of loose, fibrous, more or less vascular stroma, generally very scanty in amount, in the meshes of which lie cells with the morphological characteristics of plasma cells. These have large, deeply staining nuclei, excentrically placed in the cell body, the chromatin material of the nucleus being arranged in radial fashion. With the basic stains such as methylene blue and hematoxylin, the cell body stains a bluish color, often showing fine granules. There is usually a small vacuole in the cell body, lying on the side nearest the nucleus.

F. C. WOOD.

Plasmorrhexis is the term applied to processes of disorganization in the protoplasm of the cell, in opposition to *karyorrhexis*, which is used to denote similar processes in the nucleus. It is now usually employed as a synonym for *cytorrhexis*. By the many writers plasmorrhexis is applied to these changes as occurring in the red blood cells alone, and the word is used as a synonym for *erythrocytorrhexis*. The process is characterized by the formation of small granules or globules in the protoplasm of the red cell, and the escape of these from the cell; or the formation of minute prickles or globules over the surface of the cell, giving it an appearance of a gooseberry or mulberry; or the formation of variously shaped processes. Plasmorrhexis may be regarded as the stage immediately preceding plasmoschisis.

ALDRED SCOTT WARTHIN.

Plasmoschisis.—The partial or total disorganization of the cell through fragmentation or splitting of its protoplasm (also termed *cytoschisis*). It is characterized by the snaring off of the processes developed through plasmorrhexis, and the formation of round, oval, disc-like, angular, or thready bodies, which may be homogeneous or granular; or by the separation of the protoplasm from the nucleus. The term is used, particularly with reference to the disintegration of the red blood cells, as a synonym for *erythrocytoschisis*. It is believed by many investigators that the blood plates are nothing more than specially formed products of the plasmorrhexis and plasmoschisis of the red blood cells.

ALDRED SCOTT WARTHIN.

Plastein.—If rennin solutions are allowed to act upon solutions of proteoses a partial coagulation of the latter occurs. The substance which becomes insoluble has been called *plastein* and by some the process is regarded as a synthesis of proteoses into a greater complex.

F. P. U.

Plastic Surgery.—Plastic reparative surgery is that department of the operative art which contemplates the repair of defects and deformities, congenital or acquired. Limited in its early history to the restoration of parts destroyed by trauma, plastic surgery has, in the course of centuries, widened its range of utility until its present achievements have been carried to all parts of the body covered by the general integument and to many of the cavities lined with mucous membrane. When the nose is destroyed by lupus, the eyelid shrivelled out of all semblance by chronic inflammation, the palate cleft, the fingers webbed, or the arm bound down by the scars of a burn; when a gastric or vesicovaginal fistula, an eversion of the bladder, or a ruptured perineum makes life a burden—a plastic operation is the only measure of relief.

INDICATIONS.—Congenital or acquired defects and deformities demand the resources of plastic surgery when, from their exposed position, æsthetic reasons make their removal desirable, or when disturbances of function and impaired utility are plainly due to them in parts that are hidden from view. Hence it is evident that, regarding the imperativeness of plastic operations, cases in which they are indicated may properly be divided into two groups, in which the necessity to interfere varies as much as the end to be obtained. In the first class of cases the operation is designed merely to improve the appearance of the patient by removing a distorting scar, by suturing the fissured lobule of an ear, or by elevating a depressed nose. Here the indications for an operation are far from imperative, and it is not infrequently the importunity of the patient that impels the surgeon to operate. It is well to remember that operations done solely for cosmetic effects are ordinarily the least satisfactory; it is within the experience of almost every surgeon that results obtained by plastic operations in this group of cases, although eminently gratifying to himself and deemed excellent by his colleagues, are sources of deep disappointment to the patients themselves. In the second group of cases the chief indication for operative measures is the repair of defective function or the protection of parts that are exposed. When the absence of the lower lip, destroyed by lupus or noma, permits of the continuous loss of saliva, derangements of the digestion and of the general health necessarily follow. When the lower eyelid is everted or lost, the defect causes characteristic changes in the eye and face which often make vision imperfect, and the overflow of tears adds the suffering from an eczema to the other ills of the patient. A large urethral fistula at the peno-scrotal angle, while neither disfiguring nor detrimental to health, is a bar to the full exercise of the procreative function. In each of these cases the indication for recourse to plastic surgery is apparent, and its imperativeness is commensurate with the impairment of function caused by the deformity. To this group of cases belong extensive destruction of the lips, the nose, or the eyelids; cleft palate, cicatrix from burns, or webbing of the fingers; fistulæ, urethral, vesico-vaginal, or recto-vaginal; lacerated perineum, and exstrophy of the bladder. In this group of cases must also be included those in which the operative production of a defect is to be immediately followed by its closure by plastic means. Thus an ulcer of the leg that has proven refractory to all other means frequently yields to excision and immediate transplantation of skin; or an extensive epithelioma of the lip can be relieved only by extensive ablation of the part, the large defect being at once closed by dermatoplasty.

In considering the urgency of a plastic operation, it is necessary to consider the pathological nature of the defect which it is intended to overcome. A loss of substance may be congenital, traumatic, or the result of destructive neoplasms, like lupus, ulcerative syphilides, or epithelioma. In congenital deformities

plastic operations are generally not urgently demanded, unless, as in the case of deficiency of the rectum, the life of the child depends upon their correction. But there are milder cases, congenital in character, in which great deformity can be avoided by early interference. This is true in cases of harelip associated with cleft palate. In simple fissure of the lip the surgeon may abide his time. In complicated cases, on the other hand, early closure of the labial cleft must be advocated, since it has an undoubted influence in approximating the edges of the bony cleft and greatly increases the probability of success in subsequent attempts to close it. In two complicated cases in which I have thus operated during the first week the results was eminently satisfactory. Due regard should necessarily be paid to the general nutrition of the child before a plastic operation of considerable severity and entailing the loss of no slight amount of blood is performed. Defects that are traumatic in origin almost invariably demand removal by plastic operation while the wound is in condition to promise immediate union. This applies particularly to wounds of the face, the soft parts of which are so mobile that they may be stretched to almost any extent, provided the soft structures be thoroughly lifted from the bone. When suppurative processes have been established it is, as a rule, best to delay operative procedures until complete cicatrization shall have taken place. When the loss of substance is inflicted by the surgeon in the removal of malignant growths, its immediate repair is indicated, since there is every reason for believing that when this is accomplished the danger of recurrence of the primary disease is materially decreased. In such cases the all-important object of the operation is the removal of all diseased tissue, irrespective of the size and form of the wound that remains. In the category of defects that result from destructive inflammations, or from tuberculous or syphilitic ulcerations, operative measures are never indicated untii the complete cessation of the original disease has taken place. It is in these cases that patients are most importunate in their demands for relief, and injudicious haste on the part of the surgeon is most frequently followed by disaster. Until a lupous or syphilitic ulceration is entirely under control, until, indeed, the whiteness of the cicatrix and the absence of other evidences of constitutional vice give us reasonable assurance that there is no tendency to recurrence, a plastic operation should not be attempted. An operation too soon performed will often give a new impetus to a disease that has simply been dormant.

Nomenclature.—A number of terms have been suggested as suitable for designating plastic operations. French and German writers generally prefer the word autoplasty (*αὐτός*, self, and *πλάσσειν*, to form). In rare cases, in which the transplanted tissue is taken from a subject other than the patient, this term is evidently inappropriate. To overcome this objection, Velpeau and Guérin have suggested the word unaplasty, signifying to form anew or again. In this country and in England these terms have been generally discarded for the less objectionable one of plastic surgery. When, however, such an operation is performed for the repair or new formation of a particular part the latter properly gives to the operation a particular name. Thus the formation of a nose is called rhinoplasty; of the lip, cheiloplasty; of the eyelid blepharoplasty; of the mouth, stomatoplasty; of the urethra, urethroplasty, etc.

The underlying basis of plastic surgery is the inherent vitality of the various tissues of the body. This permits them, after partial or total separation, to maintain an independent existence for a greater or less period, and to form new and permanent attachments when brought into contact withfreshly wounded surfaces in proximity to, or at a distance from, their original sites. The introduction into defects of strips of epidermis, of the cutis vera, of tendon, of nerve, or of bone, which have been entirely severed from their former connections, constitutes transplantation or grafting. In plastic operations proper, this severance is never complete, a small bridge always being left through which the part to be utilized in the closure of a defect continues to live under the influence of the circulatory, and probably, also, of the nervous, apparatus of the structures whence it was taken, until perfect agglutination in its new position ensues. This occurs in from twenty-four to forty-eight hours, when no untoward complications in the process of wound repair supervene. By the end of a week the union is solidified by the free interchange of blood-vessels between the edges of the defect and the part inserted into it. In wounds of skin more than in those of any other structure is there a manifest tendency to early and firm repair, without which plastic operations would rarely succeed.

Methods.—The pathology, nature, and extent of a cutaneous defect, and the condition of contiguous parts, will direct the surgeon in the choice of one of a number of methods that are at his disposal. Thus he may utilize the integument from a near or distant part of the body for its closure. Referring, for the present, to the former method only, I will state that the skin in the vicinity may be made serviceable by (1) traction, (2) by gliding, and (3) by transplantation of skin flaps. While typical illustrations of each of these methods differ sufficiently from each other to warrant a separate consideration of each, it is well to bear in mind that in their practical application the simpler often merges into the more complicated procedure.

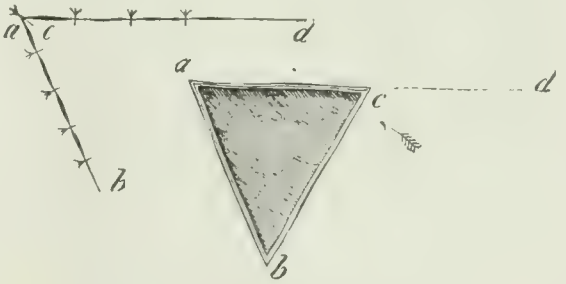

Fig. 4295.—Closure of a Triangular Defect by Gliding.

1. The method of closing a cutaneous defect by traction on the vivified edges of the integument surrounding it is based on the extent to which skin can be stretched and yet regain its vitality. This is well illustrated after removal of the breast in which even the largest wounds can ordinarily be readily closed. In the surgery of the face, however, plastic procedures by traction alone are justified only in wedge-shaped or oval defects, the margins of which can be easily approximated and retained in position without dangerous traction on the sutures. If there be any strain on them after complete closure of the wound, it may be relieved by an incision through the skin on either side of the wound, parallel with, and at a short distance from it. This method is therefore applicable for the closure of fissures and fistulæ and for the removal of prominent and ungainly cicatrices.

2. When the size and form of a defect preclude the possibility of its closure by traction alone, the skin in the immediate vicinity may be dissected up in a patch of requisite size, and by a process of gliding be brought edgewise into the position of the part to be repaired, where, after proper adjustment, it is retained by sutures. Triangular and rectangular defects, such as result from the partial removal of the lower and upper lip, respectively, can be best remedied in this way.

This method of operating by gliding, although mentioned by Celsus, as Linhart suggests, was probably practised before his time, since every operator, even if without previous knowledge, would naturally adopt it.

3. The above methods are applicable only when the integument in the *immediate* vicinity of the defect can be utilized. If this is not feasible the borrowed integument, after being given the shape of the defect and being raised from its substructure, is transferred into the defect, but retained in relation with the tissues of its former position by means of a pedicle. Around

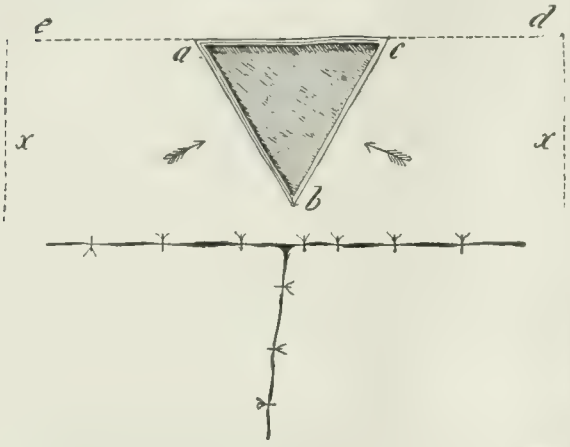

Fig. 4296.—Closing a Triangular Defect by Gliding from Each Side, the Tension being Relieved by the Incisions *x*, *x*.

this latter the flap must then necessarily be turned or twisted. Such a flap, in being transferred to its new site, may be made to describe an arc of 90°, or even 180°. In order that the raw under-surface of the flap may be everywhere in contact with the subjacent surface, the skin bounding this must in part be displaced. "This displacement, however, should be effected in such a way that the displaced skin, retaining a connecting pedicle for its support, may be made to change places with the transplanted flap, and thus contribute, as far as it can, a covering for the surface that has been left bare." As illustrations of

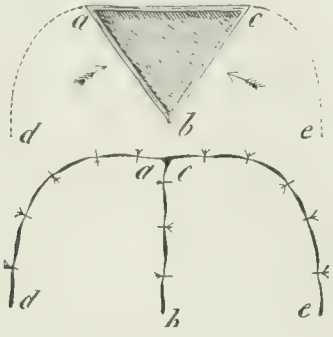

Fig. 4297.—Closing a Triangular Defect by Flaps Obtained by a Curvilinear Incision on Each Side.

this method may be cited the formation of a nose from the forehead, and of the upper eyelid from the integument of the temple.

Although every case requiring a plastic operation is a law unto itself, there are certain characteristic forms of defect the effacement of which can be effected in well-defined ways. In following the diagrammatic representations of Denucé, Szymanowsky, and König, the reader must bear in mind that the shaded parts of each illustration represent the defect, that the dotted lines indicate the incision, and the arrow the direction in which a flap is to be displaced. The supplementary illustration, in each case, indicates the appearance of the parts after union (König).

(*a*) Small triangular defects may often be closed by gliding the angles of the wound toward its center, and suturing the edges, which, when the integument is freely movable, can readily be brought in contact

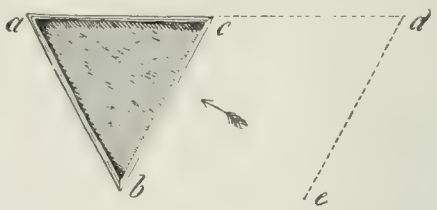

Fig. 4298.—Closing a Triangular Defect by Gliding a Quadrangular Flap. (Diffenbach.)

with each other in the form of a small triradiate star. If the defect is too large to be closed in this manner, one or two flaps may be easily prepared by carrying a straight or curvilinear incision from one or two angles of the triangular defect. Figs. 4295, 4296, and 4297 illustrate the manner of sliding the flaps into position. Should the tension of the flaps be too great, liberating

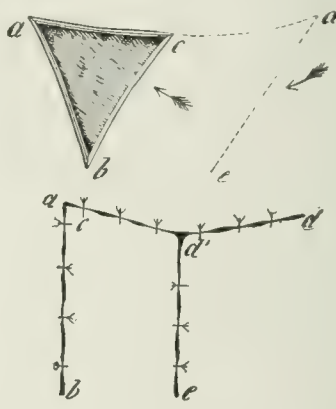

Fig. 4299.—Method of Closing a Triangular Defect so as to Avoid having an Area to Heal by Granulation.

incisions may be made (Fig. 4296, *x*, *x*), the wounds thus left healing by granulation. If, in addition to the incision *cd*, a second incision (Fig. 4298 *de*) be made, parallel to the side of the triangle, a quadrangular flap will be obtained for the closure of the defect (Dieffenbach, blepharoplasty), and a small triangular wound left to granulate. If the first incision be made at an

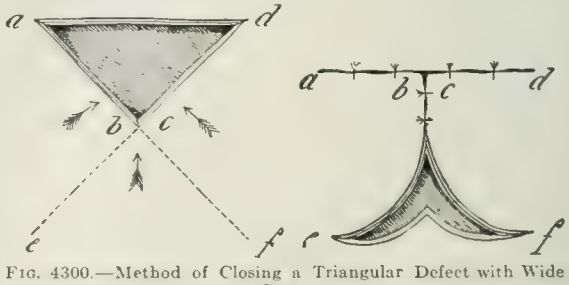

Fig. 4300.—Method of Closing a Triangular Defect with Wide Base.

angle to the margin of the defect, and the second be made in the manner already described, the wound can generally be entirely closed by sutures (Fig. 4299). When the triangular defect has a large base, as is often the case after removal of an epithelioma from the lower lip, straight or semilunar incisions carried from the apex in the direction of its sides (Fig. 4300)

will outline two flaps that, by sliding, can be brought into apposition along a line at right angles to the base of the original defect. Burow, of Königsberg, has devised a method of closing triangular defects which, probably because it sacrifices healthy tissues, has not received the attention which it merits. It is practised

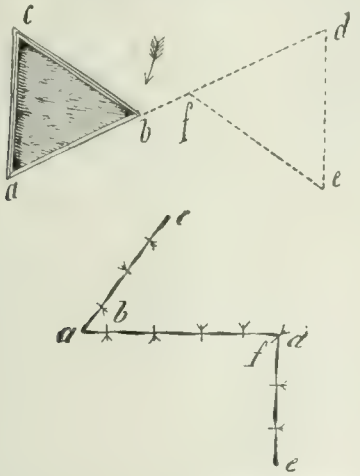

Fig. 4301.—Burow's Method of Closing Triangular Defects.

as follows: From the base of the defect, and continuous with it, a straight or curvilinear incision is made (*bd*, Fig. 4301), somewhat larger than the base of the defect. From the side opposite to this a triangular piece of integument (*fed*), equal in dimensions to the defect, is removed. The flaps *cbd* and *afe*, being then dissected

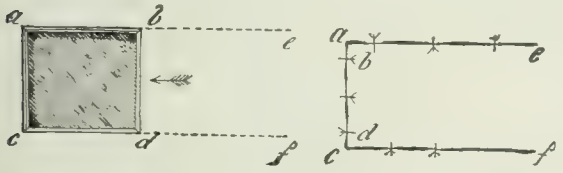

Fig. 4302.—Closure of a Quadrangular Defect by Gliding a Flap from One Side.

up and glided along the base line *ad*, readily close the wound. If the defect is a large one, Burow sacrifices two smaller triangles of healthy integument.

(*b*) Quadrangular defects can, as a rule, not be effaced by suture alone. It is usually necessary to continue the incision in one or two directions, making

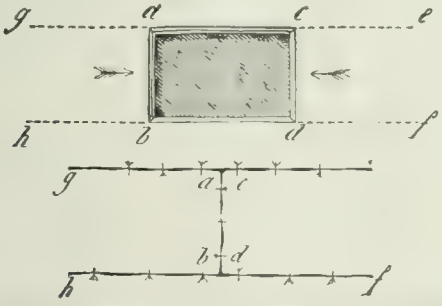

Fig. 4303.—Closure of a Quadrangular Defect by Gliding a Flap on Each Side.

one or two flaps, after the method of Celsus (Figs. 4302 and 4303). The tension on these flaps will be materially decreased by making angular or semi-lunar liberating incisions as indicated in Fig. 4304. When the defect is a large one, smaller flaps may be obtained from three directions as illustrated in Fig. 4305.

Quadrangular defects may often be closed by the formation of one or two flaps, which are turned into their new positions around a broad pedicle (Figs 4306 and 4307).

(*c*) Oval and elliptical defects can generally be closed by a little traction along the line of their long axes. If the defect is broader, a liberating incision (Fig. 4308) may be made, for the purpose of overcom-

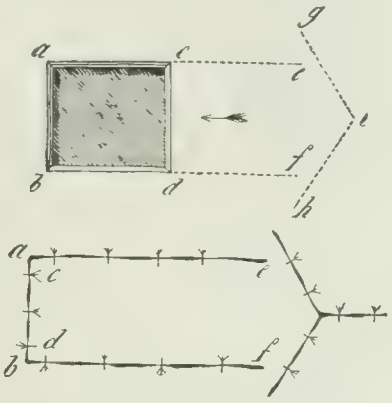

Fig. 4304.—Incision Made to Relieve Tension in Gliding a Quadrangular Flap.

ing dangerous tension in the sutures. Lisfranc closed defects by constructing two flaps from one side of the ellipse by an incision perpendicular to its axis (Fig. 4309). If this does not suffice, two curvilinear incisions, *bd*, *bc* (Fig. 4310), will facilitate the closure of the wound by two flaps that can easily be displaced to cover the wound. The flaps may also be so devised that they can be obtained from both sides, if the

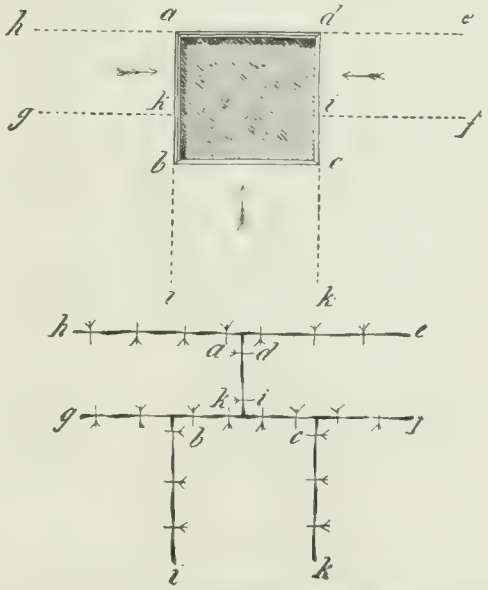

Fig. 4305.—Closure of a Large Quadrangular Defect by Gliding Flaps from Three Sides.

integument on one side be insufficient. Thus, by the incisions *ac* and *bd* (Fig. 4311), two semilunar flaps will be formed that almost completely cover the defect. Weber's method of obtaining two flaps from one side, the one underneath the other, is shown in Fig. 4312. It is especially serviceable in defects of the lips.

(*d*) Circular defects, if not too large, are most readily overcome by converting them into oval or

triangular wounds, preferably oval. If the defect is large, a semicircular flap must be obtained from the vicinity, and turned into the wound in the manner in which the quadrangular defect was closed.

It frequently happens that the integument in the immediate vicinity of the defect is unavailable for plastic purposes. This applies particularly to the

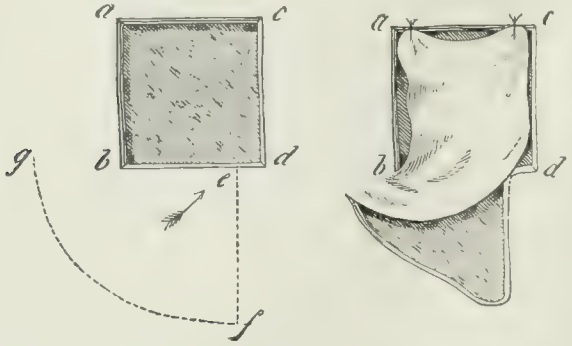

Fig. 4306.—Closure of a Quadrangular Defect by Turning a Flap with Broad Pedicle.

extensive ravages made in the face by lupus and noma. After the cure of those diseases, extensive cicatrices often remain in the skin for a considerable distance around the defect. It then becomes necessary to go to a part farther removed from the latter for healthy skin. Thus the surgeon may be forced to fashion an eyelid from the skin of the temple, or a nose from that of the forehead (Indian method, Fig. 4323). In

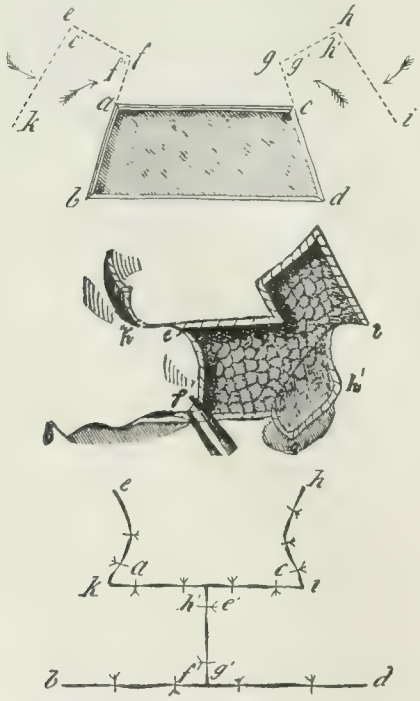

Fig. 4307.—Method of Closing a Large Quadrangular Defect by Two Flaps with Broad Pedicles. (Bruns.)

exceptional cases, it may even be deemed advisable to go still farther from the defect for a flap of healthy skin, as in the Italian method of rhinoplasty, in which the nose is formed from the skin of the arm (Fig. 4324). In the same manner, the place of a cicatrix from a burn of the wrist may be supplied by skin taken from the abdomen, or, as Maas demonstrated to the Congress of German surgeons in 1886, otherwise incurable crural ulcers may readily be closed with a flap of skin obtained from the sound leg. In

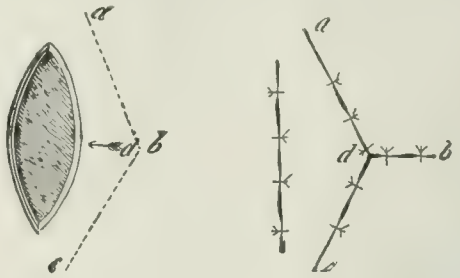

Fig. 4308.—Closure of an Oval Defect by Approximating the Edges, Tension being Relieved by Liberating Incision.

every case in which flaps are thus brought from a considerable distance, the part whence the integument is to be borrowed must be retained in relation with the defect for a varying length of time.

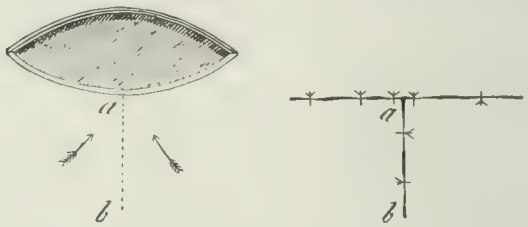

Fig. 5009.—Lisfranc's Method of Closing a Large Oval Defect.

In rhinoplasty after the Italian method, this is accomplished by appropriate bandages. In the case of Maas, the parts were retained in position by a plaster-of-Paris dressing until union was secured.

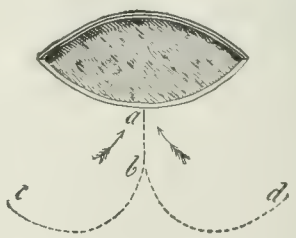

Fig. 4310.—Curvilinear Incision Providing Two Flaps for Closing a Large Oval Defect.

Nearly all plastic operations may be subdivided into a number of steps which refer, respectively, (1) to the preparation of the defect; (2) the formation and transplantation of a flap and the methods of

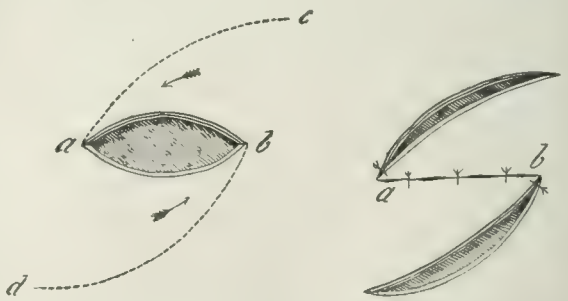

Fig. 4311.—Closure of a Large Oval Defect by Flaps Obtained by a Curvilinear Incision from Each Angle of the Wound.

assuring its vitality; and (3) the permanent and speedy closure of the wound.

1. The apposition of freshly wounded surfaces be-

ing practically an essential of success in plastic surgery, the first step in any operation of this kind is the freshening or vivifying of the defect. In recent traumatic defects, accidentally inflicted or produced intentionally by the surgeon in the removal of a neoplasm, this step of the operation is sufficiently simple. In cases of accident, it is well to bear in mind that the wounds are often irregular in the extreme and their margins bruised, lacerated, and ill suited to primary union. Here it is always essential to give the defects as regular an outline as may be,

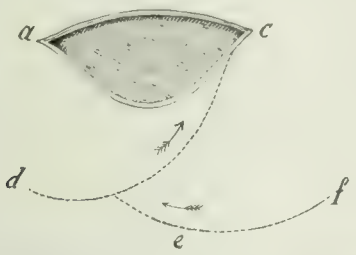

Fig. 4312.—Weber's Method of Obtaining Two Flaps for the Closure of a Large Oval Defect.

and to remove, with scissors or knife, the contused parts before attempting closure with or without the aid of a flap. When the defect follows the extirpation of a growth, and is to be closed at once by a plastic operation, every sacrifice must be made to procure radical removal of the neoplasm. The size of the defect is of secondary importance. Nevertheless, the incisions may be so arranged that the closure of the wound may be greatly facilitated. A glance at Fig. 4313 will make this sufficiently evident. In many cicatricial contractions and in congenital deformities, as in polydactylism, the preliminary step is also the formation of the defect for immediate closure. This is easily effected by the linear division of the cicatrix or connecting bands, and the restitution of the parts to their normal positions. When the defect has a free border, on the other hand, as in hare-lip, fistulæ, oral deformities, etc., the initial step of the operation is the paring or vivification of this margin, whereby the mucous, cutaneous, or cicatricial tissues are removed in such a manner as to procure a surface that is clean, smooth, and well adapted for primary union. Whether the paring be accomplished with scissors or knife, it is an essential of success that the border be removed in its entire thickness, since the presence of any undenuded spot in the line of proposed union destroys the possibility of a perfect result. To insure a broader surface for contact, and thereby greater probability of firm union, it is advisable to vivify the defect obliquely. This is particularly serviceable when, as in defects of a mucous membrane or of old cicatrices about the face, the margins are thin and would, if divided perpendicularly, offer a small surface for adhesion.

2. The most available material should be selected in forming a flap; its size should be such that tension is nowhere exerted, and every precaution must be taken to insure a sufficient blood supply. The shape and size of the flap vary according to the defect. It is to be remembered, however, that integumentary flaps invariably shrink after, and often before, their transplantation. The amount of retraction varies with the subsequent disposition of the flap. If a raw surface is brought in contact with a plane surface or denuded bone to which it can form adhesions, the danger of primary retraction is less imminent. Thus it is certain that a periosteal flap only slightly larger than a fissure in the palate will easily suffice for its closure, whereas almost twice the integument must be taken from the temple to form an eyelid. In all other cases it is well to make the flap one-fourth or one-third larger than the breach it is intended to cover. Operators of large experience can fashion the flap without a pattern. Dieffenbach always condemned its use, giving to the part to be formed ample dimensions at first, and remodelling it by supplementary incisions. It is certainly safer in all cases to make an accurate model of the part to be replaced, of paper, leather, adhesive plaster, or soft wax, which can be directly applied to the part from which the integument is to be taken, and serve as a guide to the lines of incision. The closest attention is required in the delineation and management of the pedicle. It should never, in a formal plastic operation, measure less than one-third of an inch in width, the probability of the survival of the flap being in direct proportion to the width of its pedicle and its capacity for arterial supply. As far as possible, therefore, the flap should be so outlined that the incisions will not necessitate the division of large arterial twigs. For the same reason, excessive torsion of the pedicle must be scrupulously avoided. Verneuil aptly proposes the name of hilum for this portion of the flap, since this term expresses its important function in the nutrition of the flap.

Into the composition of the flap there should enter, as far as possible, tissues histologically analogous to those of the part to be repaired. Skin should therefore, as a rule, be replaced by skin, and mucous membrane by mucous membrane; although the possibility of the convertibility, in the course of time, of the one into the other, should be borne in mind.

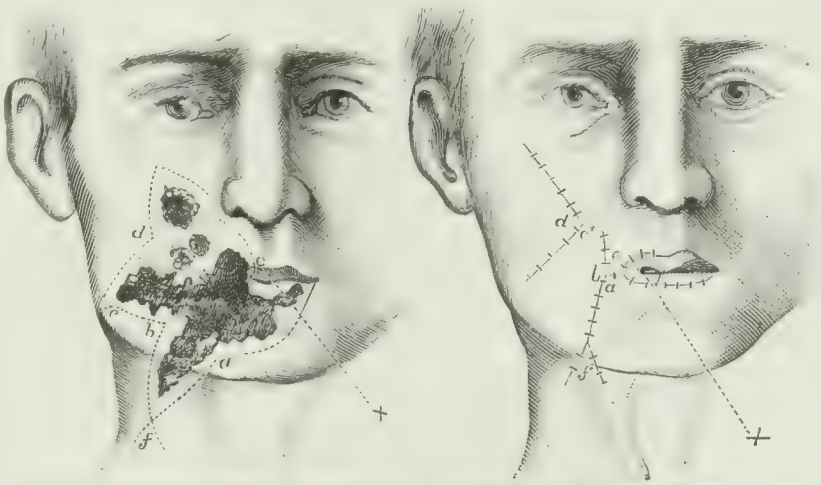

Fig. 4313.—Plastic Operation for Cancer of Lip. Showing (*A*) the proposed lines of incision, and (*B*) the completed operation.

Thus the integument may, without difficulty, be made to substitute the mucosa of the bladder or of the nares. Mucous membranes, however, do not, as a rule, assume the characteristics of common integument, although that of the vagina forms an exception. The mucous lining of the nares, of the lips, of the nose, and of the bladder may be exposed for years without sensibly approaching the appearance of the skin. When skin enters into the composition of a flap it should, as far as may be, resemble

that of the part lost. The delicate integument of the eyelid would not be suitable for repairing defects of the upper lip, nor would the appearance of the nose be improved by a patch of hair on its end. Above all things, the integument to be utilized for the flap should be healthy and freely movable.

The incisions being made, the integument, together with more or less of the subcutaneous cellular tissue, is to be dissected up from the underlying structures. The thickness of the flap should always be commensurate with its other dimensions. Large and thin flaps often succumb to defective nutrition. The subcutaneous cellular layer is an essential of all large flaps, since it is the medium through which the skin receives its nutrition. An excess of adipose tissue, however, is an element of danger to the vitality of the flap. It has been claimed that muscular tissue should not enter into the composition of a flap when it can be avoided, on the ground that muscle without function is speedily converted into fibrous tissue, and the presence of this cicatricial tissue may become an important factor in marring the final result in many plastic operations. In those upon the face muscular elements cannot be excluded, since they are directly inserted into the skin; nor would their exclusion be advisable, since without them the mobility of a newly formed lip or eyelid would be out of the question. The periosteum may also, in exceptional cases, be included in the flap in plastic operations. B. von Langenbeck and Ollier have thus sought to utilize the osteogenetic function of the periosteum in rhinoplasty and uranoplasty, in the belief that the new bone developed by it would give the normal resistance to the repaired part.

Verneuil, Sédillot, and others question the utility of this procedure, believing, and in some instances with good reason, that the inclusion of the periosteum in a flap is an element of danger to the vitality of the part whence it is taken, and that it increases the probability of sepsis. With modern wound treatment this is excluded. Regarding operations on the palate, the danger of necrosis after periosteal denudations is certainly theoretical. Langenbeck, who has probably operated oftener than any one else for cleft palate, by this method, has never seen the bone exfoliate. He has, however, noticed such an accident after rhinoplasty. Nor can there be any question as to the formation of new bone from periosteal flaps. In every congenital defect of the palate operated upon by this distinguished surgeon which was under observation more than four weeks after uranoplasty the formation of new bone was confirmed. It begins about the third week, and is completed at about the fourth week, although it subsequently gains in solidity. So far as time is concerned, the periosteal regeneration of bone after plastic operations may then be said to be chronologically analogous to that which takes place in the repair of fractures. Nor, any more than after fractures, is there any danger that the newly formed bone will subsequently undergo retrograde changes.

To increase the thickness and, therefore, the vitality of large flaps, and at the same time approximate the repaired part to the normal structure and function, very thick and even duplex flaps must often be formed. Thus, while a large defect of the lower lip may be covered with a flap from the neck, the new lip will be thin, devoid of muscular fiber, and, therefore, of movement, and soon becomes firmly attached to the lower jaw. It is preferable, therefore, when possible, to make the flaps of the entire thickness of the cheek, covered with skin and mucous membrane, which, when brought into position, subserve in the best manner possible the purposes of the part destroyed. Or it may be practicable, if it be deemed best to use the flap from the chin, to reflect the mucous covering of the alveolar border for a lining to the cutaneous flap. As will be seen in operations for rhinoplasty and exstrophy of the bladder, this doubling of the flap may be practised with two folds of skin, the lower of which subsequently becomes converted into mucous membrane. For this method Ad. Richard, in 1854, proposed the term "autoplastic par doublure."

3. The transplantation and permanent attachment of the flap constitute the last steps of formal plastic operations. At present all authors are agreed that, save in exceptional cases, the fixation of the flap should at once follow its formation as soon as all oozing has ceased. Tagliacozzi, however, in his rhinoplasties allowed the under surface of the flap, taken from the arm, to suppurate before fixing it in the new position. Graefe, on the other hand, successfully practised fixation while the surfaces were fresh. In very rare cases the old operation may be followed by good results. Thus the author, in 1876, saw Billroth close a gastric fistula with a flap that had been lifted from its surface one week before fixation, the reason given for this being that the suppurating surface would be less affected by the deleterious influence of the gastric juice than one recently prepared.

In 1889 Mr. Croft described an operation which was based on this principle, and which was particularly useful in relieving the scars following extensive burns. The writer employed it to relieve a dense scar which held the thigh firmly bound to the abdomen. A broad strip of skin, six, eight, or ten inches long, is lifted between parallel incisions from the underlying structures, but left attached above and below. Strips of gauze are inserted underneath for six or seven days until granulations have formed. The flap thereby becomes thickened. At the second operation, after the defect is vivified, the granulations are curetted from the flap, its attachment at one end is severed, and the placing in position follows as in the one-time operation.

In 1854 Roux was compelled by circumstances, in a defect of lip and chin, to resort to a practice which some writers have sought to elevate into a special method, that by successive migrations. "It consists in fixing a flap temporarily in a new position, from which, after the lapse of several weeks, it is removed by a second operation to a part nearer the defect, where, after a number of migrations, it is finally deposited." Buck has resorted to a somewhat similar expedient in extensive deformities of the face. It is only in these that it is ever practicable.

To facilitate the transplantation of a flap and to relieve tension, liberating incisions are often required. Thus, in harelip, success is not generally attainable without freely liberating the segments of the lip which are more or less bound down to the maxilla. Such liberating incisions cannot always be concealed, as in the instance cited. They should then be made as small as is consistent with the effect desired, and in the manner indicated (*g i h*, in Fig. 4304).

To close the wounds resulting from these liberating incisions is permissible only after the defect has been covered and when it is evident that closing the secondary incisions does not cause traction on the more important line of sutures closing the primary wound. Where there is any doubt, it is best to leave the liberating incisions unsutured, and the wounds to heal by granulation. In very many cases these wounds can at once be closed by skin-grafting or by using a Wolff or Krause flap.

The fixation of the flap by sutures forms the final step of the plastic operation. The care and accuracy in apposition of the raw surfaces observed in other surgical procedures are particularly demanded here. The absence of blood within the wound is an essential to success. Hence Dieffenbach, Lisfranc, and others often postponed fixation for two or three hours until all oozing had ceased. As Verneuil justly says, while admitting the value of this method in former times, "in our day operations are generally made under anesthesia, from which, when the patients awake,

they like to believe that the operation is completed: hence it is a source of great suffering to mind and body to delay the completion of the operation."

In closing the wound the continuous or interrupted suture may be employed. Whenever applicable, the buried subcuticular suture should be used. Suture marks are in themselves often quite disfiguring. As a rule, small needles should be used. The angles of the surfaces are first approximated. While the number of sutures must be sufficient for accurate apposition and the avoidance of wrinkles in the flap, an excessive number is doubtless harmful, since every suture, however fine, interferes in a measure with the circulation in the part, and every suture may become a source of suppuration. When considerable traction must be made to hold the flap in position, one or even two deep sutures of heavy silk may profitably be inserted far from the edges of the wound, as after amputation. In this way the tension on the more numerous superficial sutures is effectually removed. The material used for sutures varies according to the length of time they are to remain. In plastic operations about the face an iron-dyed silk probably answers the best purposes. These sutures can be removed, a few at a time, in from forty-eight hours to five or six days after the operation, according to the union obtained. When it is desirable to retain the sutures longer, as in operations on the vagina, silver wire is to be preferred, since metals produce vastly less reaction in the tissues than silk.

Regarding the after-treatment, little need be said. The wounds are frequently in a position where aseptic measures cannot be successfully carried out; as, for example, about the lips or nose. In these cases dry gauze compresses, held in position by properly adjusted bandages or adhesive strips, will go far toward supporting the parts and assuring primary adhesion. The writer has found gauze strips steeped in collodion an excellent dressing in many small plastic operations on the face. Wounds made for plastic purposes should be frequently examined to determine the condition of the parts, and particularly if a flap has been utilized. Immediately after its application a flap is cool, pale, and insensitive. Within from twelve to twenty-four hours, as circulation is established, its temperature rises, and a marked redness distinguishes it from the integument surrounding it. This redness easily yields to a bluish discoloration and excessive swelling, both indications of venous stasis, which, if not checked, often leads to sloughing. Loosening one or two sutures, or scarification of the flap itself, may avert such a result. If suppuration under the flap is suspected, the most dependent sutures must be removed for proper drainage. With proper precaution the presence of suppuration does not necessarily entail failure of the operation, since the flap may be held in position with small strips of adhesive plaster or by a number of sutures inserted at its salient points. For the last two or three years the writer has treated these wounds without dressings of any kind. The wound is painted with iodine and left open to the air. He has found that this treatment has a decided advantage of any hitherto used. The wound remains dry, free from irritating secretions, and heals rapidly. Halstead dresses these wounds with silver foil.

Supplementary treatment and even operations are often necessary after complete closure of the wound. Thus constant attention must be given the nostrils after rhinoplasty, the lower lip after cheiloplasty, lest the former close, or the latter become adherent. Or it may be that the contraction of the flap has not ensued to the degree anticipated, and the newly formed organ presents wrinkles of redundant skin. In the same way, the pedicle of a flap which has subserved its purposes must be excised if at all prominent. Such redundant masses can always be easily removed by oval incisions. In the case of the pedicle, several months must elapse before its excision is even to be thought of. A premature attempt in this direction of improving the result of a plastic operation may easily annul the advantages already obtained.

As has already been observed, every case requiring a plastic operation is a law unto itself. The more complicated the defect, the greater the study and practice required in overcoming it. When the destruction of tissue has been very extensive, as in noma, lupus, or burns, a single operation rarely suffices. Three, four, and even more operations may be necessary before the appearance of the face is in a measure restored. In these complicated cases, too much should not be attempted at one time, and an interval of from one to six months may often be advantageously observed between the different operations. It is in this way that the most successful workers in this field have, by repeated efforts, often extending over a period of two or three years, given a new life to individuals who, from very extensive destructions of prominent parts of the face, have been objects of disgust to themselves and of horror to those with whom it was their misfortune to come in contact.

Blepharoplasty.—Plastic operations in the eyelids as a rule come under the care of the ophthalmic surgeon. A full description of the various methods of blepharoplasty is given in the article on *Eyelids*.

Cheiloplasty.—The reconstruction of a lip after its partial or total destruction by injury or disease is termed cheiloplasty. In the preponderance of cases it is performed for epithelioma, and for the most part, therefore, is practised on the lower lip. The upper lip, also, at times is destroyed by noma, lupus, burns, or wounds, and thus becomes the subject of plastic repair. Except in cases of epithelioma these operations are particularly complicated, and tax the ingenuity of the surgeon through the involvement and distortion of the angle of the mouth and of more or less of the integument of the cheek or of the nose. Owing to the great variety displayed by individual defects of the lips, many methods have been devised for their relief. Only those are very serviceable in which a flap covered by integument without and mucous membrane within can be utilized. In all other methods, although at times they must be followed, the flap speedily becomes adherent to the maxilla, immovable, useless for mastication, and incompetent to retain the saliva. Another defect in the immediate result that appertains to almost all methods is the disparity in size between the sound and the reconstructed lip. The latter usually being smaller, the other projects far beyond, while the mouth presents an unnaturally contracted appearance. Still, this abnormal condition is recovered from after the lapse of a few months, the mouth being spontaneously remodelled.

In all cheiloplasties it is essential that the flap be obtained from the immediate vicinity of the defect, since failure is certain to follow any attempt to obtain it from a distance. The mobility of the parts during mastication is such that fixation of the arm cannot be maintained for a sufficiently long time or accurately enough to prevent the loss of the flap.

Cheiloplastic operations may be divided into: (1) Those that affect the lower lip; (2) those that affect the upper lip; and (3) those that affect the angles of the mouth, or the mouth as a whole (stomatoplasty).

1. Since the lower lip is repaired most frequently for epithelioma, the surgeon can often shape the defect in a way to facilitate its closure. If the neoplasm involve only a slight extent of lip, it should be removed by a V-shaped incision, when, ordinarily, no difficulty will obtain in closing the gap with deep sutures, even if the entire thickness of the lip has been removed. When the disease, however, covers a large area but is superficial, removal by a curvilinear incision is preferable, since the defect thereby produced will readily be supplied without plastic procedures. When the

entire lip is involved, in thickness as well as in height, rectangular or curvilinear incisions alone are serviceable for the removal of the neoplasm. When, as is often the case, the disease involves the angle of the mouth, the incisions must necessarily be more complicated and altogether regulated by the extent of the disease. Even in extreme cases the gap can often be closed by a combination of V- or W-shaped incisions. Weber mentions a case in which the disease was very extensive. When circumstances compel the surgeon to borrow the material for the flap from the chin or neck, the methods of Chopart, of Lisfranc, or

Fig. 4314.—Chopart's Flap in Cheiloplasty.

of Berg may be adopted. In Chopart's operation the diseased tissue is included between two parallel perpendicular incisions carried over the chin and on to the neck as far as the hyoid bone, if necessary (Fig. 4314) (Nélaton). When the diseased part is then removed by a horizontal incision, there remains a quadrangular flap which, when dissected up, is brought by a process of gliding to the level of the labial commissures, where it is retained by sutures. Lisfranc preferred to remove the neoplasm by a curved incision, from the center of which (Fig. 4315) a perpendicular cut of greater or lesser length, carried downward, outlined two flaps which, when detached, were brought into position. Berg also gave the defect a curvilinear outline, but preferred to use a single flap from the chin and side of the neck. Fig. 4316 shows the manner of delineating the flap, of bringing it into position, and of closing the primary and secondary wounds. If the upper margins of the flap be covered, from each angle of the mouth, by a portion of the vermilion border borrowed from the upper lip, the result will be excellent, although the oral aperture may temporarily be materially decreased in size.

Fig. 4315.—Lisfranc's Method of Cheiloplasty.

To accomplish the same end Serre, in the case of an extensive epithelioma of the lower lip, practised Chopart's operation, preserving the mucous membrane of the lip for a covering to the flap. It is almost needless to say that it is only in exceptional cases of very superficial neoplasmata that this method is at all applicable.

When the defect after removal of an epithelioma is triangular, with base involving the greater part of the lip, the operations of Dieffenbach or Malgaigne may be profitably resorted to. That of the German surgeon consists in making an incision on each side of the angle of the mouth toward the masseter and in the line of the labial fissure. The length of the horizontal incision is half that of the base of the defect. The quadrilateral flaps thus raised are brought together in the median line by their internal borders. The operation of Malgaigne differs from this in that he refrains from the use of the perpendicular incision. To overcome the redundancy of the upper lip, a triangular portion may be excised (Fig. 4317). In either operation the new lip can easily be lined

Fig. 4316.—Berg's Method of Cheiloplasty.

with mucous membrane, if that of the cheek be divided at a higher level than the integument in the horizontal incisions from the angles of the mouth. In cases in which the defect is triangular and shallow its closure by later incisions, after the method of Syme, presents many advantages. By this method the incisions are prolonged downward and outward for an inch, whence they are carried upward and outward for a varying distance. The flaps thus outlined are dissected off the bone and brought together in the median line.

Fig. 4317.—Malgaigne's Method of Cheiloplasty to Close a Triangular Defect with Broad Base.

The mucous membrane and skin are stitched together along the upper edge, and the triangular interval on each side is left to heal by granulations. (Fig. 4318). To facilitate union of the flaps, the tip of the spur left below the apex of the defect may be removed after the flaps have been raised (Nélaton). The very great advantage of this method over those preceding it is that, since the integument covering the chin is not disturbed, the flaps cannot sink or be drawn downward toward the neck, and the new lip will maintain its

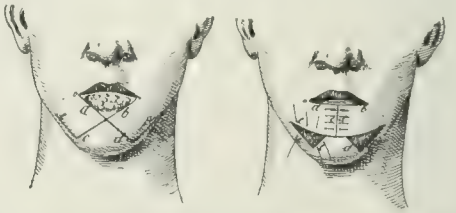

Fig. 4318.—Syme's Method of Cheiloplasty for the Closure of a Triangular and Shallow Defect.

original height. Quadrangular defects of the lower lip may be successfully overcome by resorting to two rectangular flaps taken from the chin or from the side of the chin. Sédillot (Fig. 4319) made the flaps at right angles to the line of the mouth from the side of the chin, while Bruns preferred to make them obliquely and from the cheek. When the flaps are raised they are turned on their respective pedicles, when their inner borders meet in the median line. When circum-

stances permit of a choice between the method of Sédillot and that of Bruns (Fig. 4307, diagrammatic), the former should be preferred, since in the latter there is considerable danger of traction on the cheeks with a resulting deformity. The operation of Sédillot also offers a better opportunity for covering the upper edges of the flaps with part of the vermilion border of the upper lip. When this is severed for half an inch or more on each side from the upper lip, the flaps forming the lower lip can be almost entirely covered. Schuh's practice of tattooing the edge of the lip for cosmetic purposes has probably never been followed by other operators. In 1869 Langenbeck first practised a cheiloplasty which has gained many followers in Germany. In this method the diseased lip is removed by a curvilinear incision. A flap is then

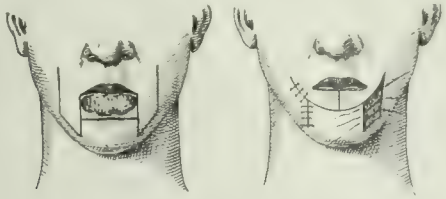

Fig. 4319.—Sédillot's Method of Cheiloplasty for Closing a Quadrangular Defect.

prepared from the integument of the chin (1), the base of which is on the side of the oral angle. The free extremity of the defect is not directly under the oral defect, but separated from it by a triangular portion of skin (2). Both flaps being raised, the lower is elevated into the defect, while the other is utilized in closing the breach below (Fig. 4320). The presence of the spur prevents the sinking of the lip.

When it is desirable, the upper edge of the flap may be covered with a portion of the mucous border of the upper lip. Gurdon Buck and Estlander closed defects of the lower lip with flaps taken from the upper. Buck, after removing the growth by a V-shaped incision, or by one horizontal and two perpendicular incisions in more complicated cases, brought the sides of the gap together directly, or, in the case of the quadrangular defect, by forming two horizontal lateral flaps which were secured to each other in the median line by pin sutures. After

Fig. 4320.—Langenbeck's Method of Cheiloplasty.

closure of the wound had been effected, a secondary operation was performed to transfer the redundant tissue of the upper to the deficient lower lip, and thus to restore the symmetry of the mouth. This operation is performed as follows: A point is selected about a finger's breadth below, and a little without, the oral angle on each side and marked by the insertion of a pin through the skin. Another pin is inserted on each side at the junction of the vermilion border of the upper lip with the skin, about one-fifth of the distance from the angle of the mouth to the median line of the lip; and a third pin on each side is inserted into the integument of the cheek, about an inch and a half above and without the angle of the mouth. The points indicated by the first and third pins are then to be united by an incision through the entire thickness of the cheek, and in like manner the points indicated by the second and third pins. A triangular flap is thus formed, with its base toward the angle of the mouth. From the point indicated by the first pin, a vertical incision is now made to the base of the jaw. The integument in this region being in a state of great tension, the edges recede and form a space for the reception of the triangular flap, with its apex toward the base of the jaw, and its base, including a portion of the vermilion border of the upper lip, supplying the deficiency of the corresponding side of the lower lip. When the operation on both sides is completed the configuration of the mouth is nearly normal.

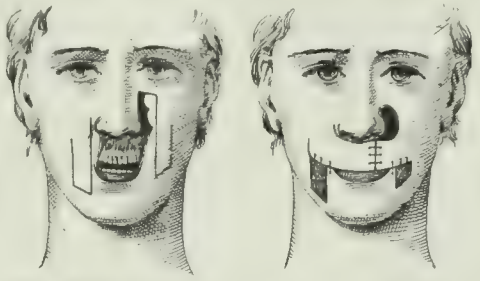

Fig. 4321.—Sédillot's Method of Cheiloplasty for Closing a Large Defect of the Upper Lip.

Estländer's operation differs from that of Buck in that the outer incision is curvilinear, and that the plastic operation at once follows the extirpation of the tumor.

(2) In reconstructing the upper lip, the operator has the choice of a number of methods. In cases of total deficiency, the method of Bruns, already referred to (Fig. 4307), yields excellent result. Bérard utilized two lateral flaps from the cheeks, including them between parallel horizontal incisions, carried outward to the masseter, the upper from the angle of the nose, the lower from the angle of the mouth. The flaps thus formed are brought into position by gliding, and united by pin sutures in the median line. A better operation for severe cases is that of Sédillot (Fig. 4321), which is performed as follows: On each side of the oral angle a quadrilateral flap, of the width and half the length of the lip, is outlined by two perpendicular incisions and one horizontal incision on each side. The inner of the perpendicular incisions is carried higher than the outer.

Fig. 4322.—Dieffenbach's Method of Cheiloplasty for an Extensive Defect of the Upper Lip.

When the flaps have been thus outlined, they are raised from the underlying tissues. The entire thickness of the cheek is included in the flaps, which are therefore lined with mucous membrane. When the flaps are brought into position, their lower borders meet in the median line, the inner borders are sutured to the upper margin of the defect beneath the nose, while the outer borders assume the position of the free border of the lip. With a little traction the mucous membrane and the integument of this border can be united by a number of very fine sutures.

When the defect of the upper lip is central and not very extensive, the method of Dieffenbach presents

much to recommend it. It consists in transfixing the cheek on each side of the angle of the nose, and forming a flap on each side by a curvilinear incision (Fig. 4322). When these flaps are raised from their attachments to the alveolar border, they are easily brought into apposition by their internal margins in the median line. The method of fixing the flap beneath the nose is also shown in the illustration. The advantage of this method, when it is applicable, is in the greater height given by the curvilinear incision into the flap in the median line, and in the fact that its free border is naturally covered by mucous membrane.

Ledran and Roux utilized one-half of the lower lip for repairing deformities in which the outer half of the upper lip was lost. Both of these operators transplanted a quadrangular flap with its pedicle outward. This method was greatly improved upon by Buck, who, placing the pedicle internally, temporarily reduced the length of the oral fissure.

Stomatoplasty.—Destructive ulcerative processes about the lips and the angles of the mouth occasionally give rise to deformities which, by greater or less closure of the oral aperture, interfere with the process of mastication, and eventually threaten the life of the individual. In extreme cases the labial fissure is contracted to a degree which compels the patient to live on liquid food alone. Until Dieffenbach's remarkable contributions to plastic surgery, it was customary to treat these cases by the insertion of a seton of silk or of wire. As in cases of syndactylism treated in this way, the result was generally unfortunate. Dieffenbach's method, which, unless the mucous membrane is everywhere adherent to the alveolar border, is as a rule successful, is performed as follows: On each side of the contracted oral orifice a narrow triangular strip is excised from the skin. The base of the triangle is internal, its rounded apex external and at the point where the angle of the mouth is to be. The excised triangular portion should include everything down to the mucous membrane, which remains intact in the floor of the wound. The mucous membrane is then divided in the floor of the triangle, thus forming an upper and a lower flap, which, when everted, will clothe the free borders of the new lips and meet externally at the angle of the mouth. The excess of mucous membrane is thus utilized in forming the vermilion borders of the lips.

Buck's method of stomatoplasty, already alluded to, differs somewhat from that of Dieffenbach. He makes an incision along the line of the vermilion border, circumscribing half of the mouth, and extending to an equal distance above and below. This incision should divide the skin and subcutaneous tissue, but not involve the mucous membrane. A sharp-pointed double-edged knife is then inserted between the skin and the mucous membrane, and these parts are separated from each other as far outward as the point proposed for the angle of the mouth. The skin alone is then divided with strong scissors along the line which is to separate the upper from the lower lip. The mucous membrane is next divided along the same line, but not so far outward, the difference in the length of the division of skin and mucous membrane being a little less than the thickness of the cheek. The angles at the outer ends of the two incisions are then carefully united by a single-thread suture, and the operation is completed as in Dieffenbach's method. To accommodate the mucous membrane to the borders of the lips, thin slices of integument must, as a rule, be pared from the upper and lower borders of the wound.

Melonoplasty.—The cheek is frequently entirely sacrificed in the radical removal of a carcinoma. This must be reconstructed by a flap turned up from the neck, the skin surface turned toward the mouth. After the flap is firmly healed in place, the base near the clavicle is separated, and turned over and attached to the raw surface of the cheek flap, forming the thickness of the cheek (Israel). A large flap from the cheek may also be used.

Rhinoplasty.—Notwithstanding the accumulated experience of generations of surgeons, and the closest attention to every technical detail that could further the results of rhinoplasty, it must still be admitted that the best nose that can be formed by a plastic operation is hardly as presentable as the natural feature that is even far removed from the ideal. It is far preferable, however, to the artificial nose formed of vulcanized rubber, and retained in position with collodion or by means of a spring. After a rhinoplasty that is at all successful, the catarrhal condition of the nose and pharynx is improved, the senses of smell and of hearing return, and the irritating cough which so often is present in extensive defects of the nose, rapidly disappears. A successful rhinoplasty is productive of benefits which cannot follow the use of any nose fashioned by prosthetic skill.

Since the time of Dieffenbach, rhinoplastic operations have been divided into the total and the partial. It is particularly in partial rhinoplasty that great strides have been made within the last half-century. To consider systematically the different operations for repair of the nose, nasal deficiencies, according to Gross, may be classified as follows: (1) Loss of the entire organ, bones as well as soft parts. (2) Destruction of the whole or greater portion of the cartilages, the bridge remaining intact. (3) Mutilations of the tip, as when a small piece is cut or bitten off, including a part of the wings. (4) Loss of one wing, either alone or together with the nasal column. (5) Perforation of the nose, either on top or at the side; in the latter case with or without participation of the cheek. (6) Sinking of the organ from destruction of the cartilaginous septum of the nose, the soft structures being but little, if at all, affected. (7) Loss of the column. (8) Multilation of the nose and upper lip, or the nose, lip, and cheek.

When the entire nose has been lost, there is generally a large pyriform aperture which allows free inspection of the nares and nasopharynx. For the alleviation of this condition, it is always best to fashion the nose from a flap taken from the forehead, by what is known as the Indian method. Before proceeding to a total rhinoplasty, the defects should be covered with a model of clay, wax, or dough, which should approximate as much as possible in size and form an ideal nose. Over this is accurately fitted a piece of soft leather or moleskin plaster, the lower margin of which is pressed into the nostrils and made to cover the nasal column. The shape of this piece of leather or plaster, when removed from the model, is pyriform, with its base below and apex above. A second piece of leather or of plaster, one-third larger in all its dimensions, should then be prepared from the first, the increased dimensions being allowed for shrinkage. The model thus prepared, when applied to the forehead, is shown in Fig. 4323 (Linhart). The plastic operation proper is preceded by freshening the edges of the defect. This must be done as liberally as possible, in order to procure a wide surface of contact for the flap. The vivified border should everywhere measure one-third or even half an inch in width. When this step of the operation is completed, the leather or moleskin model is applied either perpendicularly or obliquely to the forehead. The latter is probably the better method, since less rotation of the flap is required to bring it into position. When the forehead is decidedly low, no alternative is presented to the operator, since the central excision of the flap would necessitate the inclusion in it of a considerable portion of the hairy scalp. König and others maintain, however, that the frontal scar resulting from central location of the flap is less disfiguring than that which follows the other pro-

cedure. Lisfranc, Linhart, and von Langenbeck prefer to take it from the side. When the operator has applied his model in the desired position, an incision down to the periosteum is carried around it. The incision, as shown in the figure, begins at the right margin of the defect, is carried obliquely over the right eyebrow, and descends on the left side of the model, terminating above the internal end of the left brow. In terminating this incision, it is essential not to interfere with the angular artery, since the vascular supply of the new nose, in a large measure, depends upon the integrity of this vessel. The pedicle left between the ends of the incisions should measure from one-half to three-fourths of an inch in width. The flap thus outlined is now rapidly raised, being made to include, besides the integument, the aponeurosis and fibers of the occipito-frontal. In the lower part of the flap the periosteum can safely be included. Langenbeck included it in the entire width of the flap, except in the parts of which the column and alæ of the nose were to be formed. When hemorrhage from the edges and raw surface of the flap has been controlled, it is rotated into position in such a way that the raw surface looks backward, and its base naturally comes into contact with the freshened margin of the upper lip. The next step of the operation is the formation of the septum and alæ. This is readily accomplished by two oblique incisions, one inch in length (dotted line in Fig. 4323), which, running toward each other, are separated at their central ends by an undivided interval nearly an inch wide. When the triangular flap included between these incisions is doubled upon itself, the column and septum of the nose are perfectly formed. By an upward duplication of the lateral parts of the flap, the alæ and nostrils are next formed, and maintained by transfixing sutures. To facilitate the closure of the frontal wound and to obtain larger nostrils, Langenbeck does not remove the small triangular portions seen on each side of the base of the flap, but makes the central portion, from which the septum is made, rectangular and one inch wide. When the nose has thus been formed and the raw surfaces have been thoroughly cleansed, the new organ is brought into position and retaining sutures are applied. The most important sutures are those which hold the alæ of the nose to the cheek and the septum to the upper lid. For each wing and the septum three sutures are requisite; for the wings one externally, one internally toward the nostril, and one beneath toward the lip. Since it is the septum that most frequently fails to unite with the upper lip, unless extraordinary care be taken, it is advisable to make a special groove in the central part of the upper lip, three to five lines in length, into which the lower end of the septum is firmly implanted after it has been divested of cuticle. The operation is then completed by suturing the lateral margins of the new nose to those of the cheek, particular care being given to securing a good apposition of the pedicle in the upper end of the defect. If the wound in the forehead is very large, it may in part be closed by sutures, although the greatest caution must be observed to prevent traction on the pedicle. If the entire wound of the forehead is left to granulate no harm results, and the scar is probably not more ungainly than that which follows what is ordinarily an unsuccessful attempt at obtaining its closure by primary union. To maintain the patency of the nostrils, and at the same time to further adhesion of the double integumentary folds, it is well to introduce portions of a drainage tube into the nostrils after the operation is complete. The new nose may then be lightly covered with oiled silk and antiseptic gauze or lint, care being taken that no foreign material becomes adherent to the sutures.

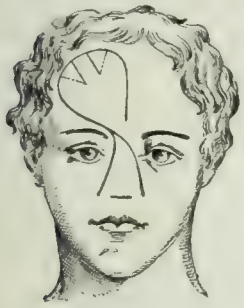

Fig. 4323.—Shape of the Flap to be Taken from the Forehead in the Indian Method of Rhinoplasty.

There are rare cases in which previous disease has unfitted the integument of the forehead or of the cheek for rhinoplastic purposes. Under such circumstances only is one justified in resorting to the Italian operation of rhinoplasty from the arm. The first step in this procedure is to outline a flap of integument from the inner surface of the middle of the arm, measuring four inches in length and three in width. The flap is raised between two parallel longitudinal incisions, but retained above and below in relation with the remaining integument. To prevent reunion a piece of oiled lint is placed underneath the flap. The inflammatory process which follows the elevation of the flap causes this greatly to increase in thickness, while its inferior surface, in from two to three weeks, becomes clothed with granulations and eventually cicatrized. When, after the lapse of this time, the flap is sufficiently thickened, its upper connection with the arm is severed by a transverse incision which leaves a wide raw margin at the upper end of the flap, which is sutured to the vivified margins of the nasal defect. This part of the operation Tagliacozzi usually performed in the fourth week after the first operation. Since it requires from one to two weeks before the lower end of the flap can be safely severed from the arm, the latter must be supported in relation with the head and face. Fig. 4324 shows Tagliacozzi's method of accomplishing fixation of the arm by means of a cap and jacket. Wutzer's apparatus for obtaining this end is somewhat similar. In taking the skin from the forearm or back of the wrist, he found it necessary to support the arm and forearm in splints. When

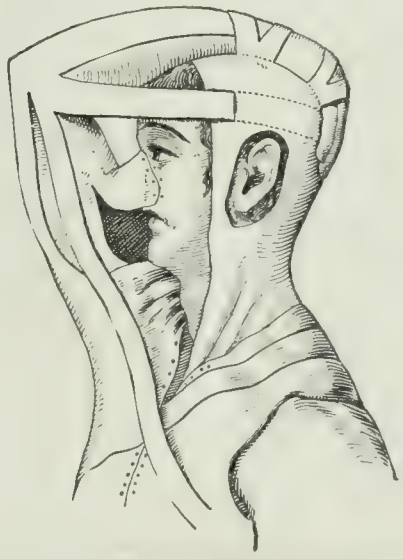

Fig. 4324.—The Tagliacozzi Method of Rhinoplasty.

such an apparatus has been worn for from one to three weeks, the upper end of the flap will have become firmly united to the apex and sides of the triangular nasal defect, and it is then safe to sever its brachial connections, when the formation of the wings and septum can be completed as in the Indian method. Graefe modified the Tagliacotian operation by at once fixing the flap to the vivified edges of the defect, thereby apparently curtailing the period of fixation of the arm. This, which is known as the German method, has found even fewer followers in recent times than the older operations. It manifestly gives greater

opportunity of shrinkage of the flap and subjects the patient to the annoyance of a large suppurating surface near the mouth, which by the older operation is cicatrized before it is transplanted. Dieffenbach exceeded both Tagliacozzi and Graefe in the extent to which he reformed the nose from a bracial flap, in that the entire nose, with the exception of one ala, was formed as the first step of the operation. After shrinkage and cicatrization had followed, the actual transplantation of the nose was effected in from six to eight weeks.

The operations thus far described, unless gangrene supervene in the flap, effectually close the nasal defect. For the most part, however, the newly formed nose, irrespective of its original prominence, sinks and contracts until eventually little more than an integumentary curtain closes the defect. To obviate this result a number of procedures have been adopted, among which that of Thiersch probably deserves most prominent mention. As the first step of the operation, he forms on each side of the defect a rhomboid flap from the cheek, the attached base of which is in relation with the freshened edge of the defect, its free border being external. When these flaps are raised from the cheek on each side they are inverted, so that the cutaneous surfaces look toward the nares, the raw surfaces outward, and in the median line are in contact with each other. The nostrils and septum being thus formed, a frontal flap is brought down to cover the flaps from the cheeks, the operation being completed in the ordinary way. Verneuil procured a permanent elevation of the bridge of the nose by a somewhat similar operation of superposition of the flaps. In this case the frontal flap was taken from the median line, and delected in such a manner that the cutaneous surface looked backward. Over the raw surface two quadrilateral flaps from the cheeks were brought by a process of gliding and united along the median line. Finally, Langenbeck and Ollier have given the new nose an osseous substructure by sawing a strip one-fourth of an inch wide from the nasal processes on each side. This strip, after being broken through its attachments below, is deflected toward the median line, where it meets its fellow of the opposite side. If the nasal bones are present and only depressed, which they generally are, they must be brought into position by the free use of the elevator.

König's method of obtaining an osseous framework for the repair of sunken noses, and for the permanent elevation of the nose after total rhinoplasty is virtually one of the superimposed flaps, both being taken from the forehead. A median flap of the requisite length and half an inch in width is formed from the forehead in the median line. The incisions bounding this narrow strip are carried down to the bone. When this flap is raised the external table of the frontal bone is raised with it as far as the root of the nose. The flap thus elevated is inverted, so that the cutaneous surface faces the nasal fossæ. Over the raw external surface a second frontal flap is then placed and fixed as in the ordinary Indian operation. In four cases in which König performed this operation for a sunken condition of the nose, the repaired organ retained its solidity after from one to nearly four years had elapsed from the time of the operation.

The partial destruction of the nose also presents many interesting peculiarities that require partial rhinoplasty. When the tip and alæ of the nose are intact, while the body and bridge are lost, the defect should be closed by a frontal flap. In such a case Linhart removed an epithelioma involving almost all the cartilages and a portion of the bony framework of the nose—only the margin of the nostrils on each side was preserved. Mutilations of the tip of the nose can also be repaired by a frontal flap.

The tip of the nose may also be repaired with a flap from the cheek (Linhart). The pedicle of this flap extends quite to the root of the nose; its broad end may be divided by two incisions for forming parts of the nostrils and septum, as in total rhinoplasty. Before the flap can be inserted, the remaining integument of the nose must be divided in the median line and reflected on each side. It frequently happens that with the tip one of the nasal alæ and the column are lost. To repair this defect the integument of the root of the nose, of the glabella, and of the internal angle of the orbit was utilized by Busch (Fig. 4325). The pedicle of the flap is placed on the healthy side of the nose, low down, and on a level with the defect. When the flap is brought into position, its lower portion forms the tip and column of the nose, while its upper part, when duplicated, replaces the lost ala. The repair of defects of the nasal wings can be accomplished by a number of procedures. When the defect is long but narrow, it is probably best, as Dieffenbach taught, to refrain from attempting a plastic operation, and to produce a similar defect on the opposite wing. In some cases it is advisable to excise the defect in a triangular way, and to close the breach with a flap from the side of the nose. Fig. 4326 illustrates the method of obtaining it and the incisions (dotted lines) necessary for placing it in position. In larger defects of a nasal wing it is advisable to procure a flap, quadrilateral in shape, from the cheek or from the upper lip. In Fig. 4327 the method of Bonnet is shown; to give the angle of the nose a more shapely form, and to facilitate the rotation of the flap, a wedge-shaped portion (*b*) may be excised from the base of the flap. In this operation the vermilion border of the flap must be removed, and the fissure in the lip is to be closed at once. Perforations of the nose resulting from wounds or ulcerative processes are generally seated at the sides of the nose. They may readily be closed by flaps of suitable shape and size, taken from the forehead, from the cheek, or from the opposite side of the nose.

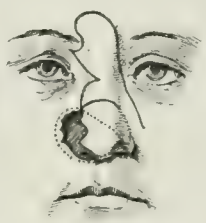

Fig. 4325.—Busch's Operation for Repairing a Nasal Defect.

The nasal column, when it alone is defective, can be admirably repaired from the central portion of the upper lip, which must be included between parallel perpendicular incisions. When the flap thus formed is brought in contact with the nasal septum, its mucous surface is of course exposed, and is eventually converted into skin.

In the most complicated of nasal defects, finally, other parts of the face are also, as a rule, deficient. This is particularly true of the upper lip, of portions of the palate, and of the cheek. In such complicated cases, as has already been intimated, many operations are required before the face can be made at all presentable. In cases of this character the lip, the angle of the mouth, and the nose all require separate operative treatment. If, however, from one to three years be devoted to the judicious management of such a case, the result will in every way repay subject and operator for their patience.

Fig. 4326.—Method of Closing a Defect of One Ala of the Nose.

Paraffin Injections in Reparative Surgery.—In order to fill up the scrotum of a very sensitive young man, which had been left empty after a castration, Gersuny in 1900 devised the ingenious method of injecting vaseline. Encouraged by the good result obtained in this case, he extended the procedure to cases in which other than the distinct cosmetic effect was desired. The result which Gersuny obtained in a case of urinary incontinence in a female, which had

resisted all other methods of treatment, was so brilliant that other surgeons at once took up the new procedure, and so its use soon became widespread. A considerable amount of good work has been done at von Bergmann's Klinik by Stein. He prepares paraffin, which should have a melting point between 42° and 43° C., by melting and filtering with a hot-water funnel, such as is used in the filtration of bacteriological culture media. The filtered paraffin should be put into wide-mouthed flasks, such as Erlenmeyer's, and plugged with cotton wool. In these it is sterilized in the hot-air oven at a temperature of 200° C. for a half hour, and can then be preserved indefinitely, ready for use at any time. Before using, the flasks containing the paraffin are heated in

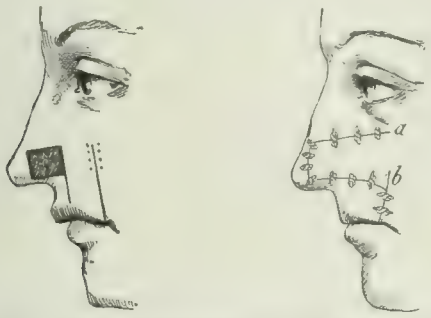

FIG. 4327.—Bonnet's Operation for Closing a Large Defect in One Ala of the Nose.

a water-bath to the melting point. The injection is made with a Pravaz syringe, wholly made of glass, holding about one gram. The object is to have a syringe devoid of all sharp corners and edges, so that the paraffin does not so easily congeal. Before injecting the paraffin, the filled syringe is again put into hot water and then the needle is screwed on. The injection is made by lifting up a fold of skin with the left hand and with the right inserting the needle and injecting slowly until the desired amount has been used. The needle is then withdrawn and a small piece of plaster fastened over the puncture. The paraffin is now moulded into the desired shape, while an assistant allows the ethyl chloride spray to play upon the part. Several injections may be made at different times, but care must be used not to insert the needle over the area previously injected, as it should be inserted to the side of it. According to Juckoff paraffin after its injection acts like any foreign body, and causes a reactionary inflammation with the formation of new tissue. Some of the paraffin is absorbed here and there, so that finally we have the mass pervaded by connective-tissue strands, which emanate from a fibrous capsule around the whole. This capsule is fused with the adjacent tissue.

This excellent method is not without a small amount of danger. The following unfortunate occurrences have taken place: Embolism of lung and intestinal organs from the accidental insertion of the needle and injection into a vein; infection from faulty asepsis; gangrene and sloughing from the introduction of too much paraffin, as a result of which obliteration of the blood-vessels has occurred.

The method is applicable to cases in which the normal contour of the body is lost. It has been used with distinct benefit in saddle nose following caries of nasal bones. In one case treated at von Bergmann's Klinik, the result was striking. Several injections were made at different places and the nose was thus gradually built up. The injection should be made with care so that none of the paraffin shall find its way into the orbit. Cleft palate may be treated by this method, which is chiefly applicable to those cases in which a small foramen has remained after staphylorrhaphy. The contour of the cheek might be reestablished after removal of the superior maxillary bone. The scrotum may be filled up after castration. The method is applicable to another class of cases, namely, those of urinary incontinence, especially in the female, in which condition a ring of paraffin is injected about the neck of the urethra so as to replace the sphincter. A cystocele has also been treated, with distinct benefit, by injections between the vagina and bladder wall. By establishing a paraffin depot around the rectum fecal incontinence has been cured. The most successful method of reforming the bridge of the nose is to reconstruct it with a piece of bone taken from the crust of the tibia, or from one of the costal cartilages. (See article, *Nose, Injuries and Deformities of the.*) JOSEPH RANSOHOFF.

Platter, Felix.—Born at Basel, Switzerland, in 1536, He received the degree of Doctor of Medicine in 1557, after spending three and one-half years (1553–1557) at the celebrated University of Montpellier, in the south of France. Six years later (1563) Basel was visited by an epidemic of the plague (known as the third plague and characterized by a great mortality). The devotion displayed by Platter throughout this epidemic obtained for him the universal gratitude of all classes of citizens. In 1571 he was given the Chair of the Practice of Medicine, left vacant by the death of Johann Huber. "As a professor," says Cumston (Johns Hopkins Hospital Bulletin, April, 1902), "he was in no way inferior to the practitioner. A rich experience, a clear, methodical and penetrating mind, combined with an elegance of elocution readily explains why Platter became an eminent teacher and that his disciples loved him for his affable and gentle character, likewise his untiring zeal and enthusiasm. Haller calls him the star of the University of Basel." He died July 28, 1614, at the age of seventy-eight, after winning the right to be esteemed one of the really great physicians of the sixteenth century.

The following are the titles of the three books published by Platter: "De corporis humani structura et usu," 1583; "Praxeos medicæ," 1602–1608; and "Observationum in hominis affectibus," published toward the end of his life. A. H. B.

Platyhelmia.—The phylum of animals which includes the flatworms: Turbellaria, free-living flatworms; Trematoda, flukes; Cestoidea, tapeworms. The last two classes are entirely parasitic. See *Trematoda, Cestoda, Parasites.* A. S. P.

Pleurisy (Pleuritis).—Inflammation of the pleura is a very frequent occurrence, some indication of it having been found in 74.4 per cent. of 215 autopsies at the Massachusetts General Hospital. A great many cases escape diagnosis either because of a lack of symptoms so that a physician is not consulted, or because of a lack of signs so that the disease is not discovered.

CLASSIFICATION.—A classification of the pleurisies according to their etiology must be incomplete since we are often unable to find a cause and yet the primary form is probably quite uncommon. The most satisfactory one is a clinical classification such as that proposed by Lord. Accordingly we will separate the forms of pleurisy into the following groups: (1) Acute fibrinous pleurisy. (2) Acute serofibrinous pleurisy. (3) Acute purulent pleurisy. (4) Diaphragmatic pleurisy. (5) Encysted empyema. (6) Actinomycosis and streptothricosis of the pleura. (7) Peripleuritis. (8) Syphilis of the pleura. (9) Chronic pleurisy.

In the presence of effusions the amount of fluid is

spoken of as small, medium, or large. An amount of fluid which does not reach above the angle of the scapula is spoken of as small. If the upper layer of the fluid is between the angle and the spine of the scapula it is called medium while anything larger than that is called a large effusion. With the development in our bacteriological investigations it has come to be believed that all cases of pleurisy are expressions of some infectious activity even though it may be impossible to demonstrate the guilty organism. The tubercle bacillus, the pneumococcus and the streptococcus are the bacteria most frequently found though any of the pathogenic microorganisms may produce the disease. The majority of cases occur in the colder months of the year and in males between the ages of twenty-one and thirty. Exposure to cold or wet is considered one of the important contributing causes of the development of a pleurisy. Pleurisy with effusion or even a purulent pleurisy may be produced by the injection of sterile irritants, such as chloride of zinc or aleuronat, into the pleural cavity but analogous processes must be very rare in man.

1. Acute Fibrinous Pleurisy (Dry Pleurisy, Plastic Pleuritis).—This is usually associated with the production of a small amount of fluid which is, however, so slight as to be neglected and this group may definitely be differentiated from the serofibrinous form.

Etiology.—In the apparently primary form of this condition the etiology is very difficult of discovery since it is a mild affection and the patients practically all recover, and moreover there is no fluid to be withdrawn for examination. A certain percentage of the patients develop tuberculosis and autopsy findings have strengthened the belief that a majority of these cases are tuberculous in nature. A fibrinous pleurisy may also be secondary to infective processes in any part of the body though, of course, diseases of the lung occupy the principal place. It is regularly a part of a lobar pneumonia and may be so prominent as to justify the term pleuropneumonia. Bronchitis is an important factor, while bronchopneumonia, abscess, gangrene, and bronchiectasis are less frequently found. Trauma usually acts by inducing infection from the lung. Infections in any part of the body, such as tonsillitis, pyorrhea, endocarditis, typhoid fever, may be accompanied by a fibrinous pleurisy and it is not infrequent in the terminal stages of chronic diseases. A dry pleurisy is very frequently the first symptom of pulmonary tuberculosis, another fact which strengthens the theory that the primary dry pleurisies are very often tuberculous.

Pathology.—The extent of the inflammatory process may be circumscribed and localized or it may extend over practically the whole pleura. The inflammation always extends to the portion of pleura opposite to it. In severe cases there may be extension along the interlobular septa. There is an acute hyperemia, followed by infiltration and exudation of blood cells and fibrin. There is practically always more than the normal amount of fluid present and this is usually cloudy. The pleura is dull, opaque, rough, and granular, and is somewhat thickened. The thickening is due partially to infiltration but chiefly to the fibrinous exudate present on the surface. When the exudate is very profuse the pleura may measure as much as a centimeter in thickness. On microscopic examination, desquamation and degeneration of the epithelial cells are found and the subserous tissue is edematous. The surface of the pleura is the site of a fibrinous layer containing numerous pus cells and serum. On subsidence of the process this exudate may undergo complete resolution leaving a normal pleura. If, however, the exudate is at all well marked this usually does not occur. The two layers of the pleura may adhere and organization and connective-tissue formation give rise to the formation of permanent adhesions or there may remain merely a thickening of a normally appearing pleura.

Symptoms.—The onset of acute dry pleurisy is usually characterized by the sudden appearance of a severe pain and the development of more or less fever. The pain is constant, sharp and stabbing in character and is aggravated by coughing or attempt at deep inspiration or anything which causes increase in the thoracic movement so that the patient often says that he cannot breathe. It is usually located between the mammary and the posterior axillary lines but may be felt in any part of the chest or upper abdomen. Not infrequently there is pain and more or less tenderness along the ridge of the trapezius muscle when it is believed that there is involvement of the pleura covering the central portion of the diaphragm or the pericardium (Capps). Pain in the abdomen may be so severe as to lead to a diagnosis of some inflammatory abdominal condition. At times the pain is slight or present only on deep breathing or coughing. There may be tenderness of the skin over the portion of the pleura which is inflamed. The fever usually varies between 99° and 101° rarely going to 103° or more in uncomplicated cases. It subsides in a few days. Quite characteristic is the suppressed cough which the patient attempts to check because of the pain. It is thought to be due to pleural irritation since it is generally relieved by strapping. The patient may hold his body in a fixed position in order to avoid movement of the affected side. There is rarely dyspnea. There is usually a definite leucocytosis the white cells rising to 12,000 or over in nearly half the cases.

Physical Signs.—There is diminished expansion of the affected side of the chest and a diminution in the intensity of the respiratory murmur. If the exudate is sufficiently thick there will be a dulness on percussion over the affected area and the act of percussion may cause pain. Vocal fremitus is usually unaffected. A friction rub can be heard and sometimes felt; it is produced by the rubbing together of the roughened layers of the pleura. It varies greatly in intensity, constancy, and character. It may be loud and resemble the creaking of leather or may consist merely of fine inspiratory crepitations. It may be very inconstant, being present with one inspiration and absent with the next, or even disappear altogether for a time. It may be so loud as to be felt with the hand or so soft that it can scarcely be made out. It should not be confused with crepitation produced in the shoulder-joint which is best heard over the scapulæ. A pleuropericardial friction sound may lead to a diagnosis of pericarditis. An inflammation of the pleura over the heart may be disturbed only by the movement of that organ so that the rub comes only with the heart beat. If produced within the pleura it should stop when the patient stops breathing. Such pleuropericardial sounds may occur in the absence of any lesion.

Diagnosis.—In typical cases the diagnosis is an easy one and the sudden onset of cough and pain in the side which is aggravated by respiration is usually due to pleurisy. In diaphragmatic pleurisy the diagnosis may remain in doubt for several days. Intercostal neuralgia is a dangerous diagnosis to make as a more serious condition might thus easily be overlooked. Muscular pains may simulate pleurisy but they are usually present in other parts of the body also. The pain may be the first symptom of a herpes zoster. Endeavor should be made to locate the cause of the pleurisy and a pulmonary embolism from an obscure phlebitis must always be considered. Syphilis and tumor, lead poisoning, aneurysm, periostitis, and spinal disease should all be excluded.

Prognosis.—The prognosis is favorable for the immediate attack. The ultimate prognosis depends upon the underlying cause. In the primary cases a certain number develop tuberculosis (thirty per cent. in Lord's series). In a small number of instances

a dry pleurisy develops into a pleurisy with effusion. The course is usually from a few days to about two weeks. If it lasts longer than this some persistent disease such as tuberculosis should be suspected.

Treatment.—Relief of the pain is obtained by the fixation of the chest involved. This is usually accomplished by application of adhesive plaster over the affected side. The strips should be applied during expiration and stretched forcibly over the ribs. The plaster should not remain in place for longer than a week or ten days and care should be taken not to injure the skin. The chest should be shaved, if necessary before its application. If the diaphragm is involved relief may be obtained by a similar strapping of the abdomen. An ice-bag or hot-water bottle may be of assistance and morphine should be given if necessary. In the presence of fever or severe pain the patient should be in bed. In all cases of primary dry pleurisy, tuberculosis should be suspected and the patient treated accordingly. Rest, fresh air, and extra feeding should be instituted and after recovery the patient should report at intervals for examination so that the onset of pulmonary disease may be detected, careful search must be made for any possible source of infection. In the secondary cases the treatment is largely that of the causative disease with such treatment directed to the relief of pain as may prove necessary.

2. Acute Serofibrinous Pleurisy (Pleurisy with Effusion).—This is a more serious affection than dry pleurisy, and is more often seen by the physician since many cases of fibrinous pleuritis are treated altogether at home. It is characterized by the excessive exudation of fluid into the pleural cavity.

Etiology.—It is being recognized more and more every day that a very large percentage of the cases of primary pleurisy with effusion are due to the tubercle bacillus. Many of them are unassociated with findings elsewhere in the body and yet the result of postmortem examinations, animal inoculation, *x*-ray examination, tuberculin injection and a study of the subsequent history will lead one to the belief that even if all of the above investigations yield negative results still the patient is probably tuberculous and should be treated as such. There is, however, a definite group of infectious, non-tuberculous pleurisy with effusion. It is not uncommon in lobar pneumonia though the amount of fluid is usually small and not recognized during life. A purulent fluid is, of course, not an infrequent complication of this disease. Pleurisy with effusion sometimes occurs coincidently with rheumatism, but even here tuberculosis should be suspected. It may complicate typhoid fever in which case the typhoid bacillus may be present in the fluid. It may be due to trauma or to infection in any part of the body. In some instances an inflammatory process may be superimposed upon an already existent transudate in which case it will be impossible to differentiate it from a process which has been an exudate from the onset.

Pathology.—In distinction to dry pleurisy, the serofibrinous form usually involves the entire pleura of one chest. Sometimes the extent of inflamed pleura is small and the fluid localized by adhesions when the condition is known as sacculated pleurisy. This occurs much more frequently when the fluid is purulent. Occasionally both pleuræ are involved in which case the pericardium is often affected or the pleural condition may be part of a polyserositis. The left side is rather more frequently involved than the right. The pleura presents much the same appearance that it does in a fibrinous pleuritis except that the infiltration is often not so marked. Bands of adhesions often unite the opposing surfaces of the pleura both above and below the surface of the fluid. Miliary tubercles may be found.

The fluid occupies the lower portion of the cavity, if it is free, and varies greatly in amount and character. It is generally more or less turbid from the admixture of cells and may contain fibrinous flocculi. A clot usually forms in the fluid in a short time after its withdrawal. Its color is most commonly yellow but may be red from the admixture of blood or chocolate colored if the blood has been present for a long period of time. In icteric patients the fluid contains bile pigments. It should be remembered that the cellular elements may sediment in the chest as well in a test-tube and the clarity of a fluid may vary depending upon the level at which it is withdrawn. The amount varies from any quantity which is more than normal up to a chest entirely full. Over 4,000 c.c. have been withdrawn at one tapping. The examination of a pleural fluid is often made difficult by the rapid formation of a clot within it which entangles cells and bacteria and alters its protein content. This can be avoided by drawing the fluid into a bottle containing sodium citrate. One cubic centimeter of a saturated solution is sufficient to keep 100 c.c. of fluid from clotting long enough to carry out a complete examination. If the citrate is sterilized it will not interfere with bacteriological tests or animal inoculations. The fluid is neutral or alkaline to litmus and generally has a specific gravity of 1,018 or over. A lower density than this indicates a transudate in the great majority of cases. The albumin content is high, often four per cent. or more. Fat, uric acid, cholesterin, glucose, biliary acids, and pigments are occasionally found. The sediment may contain all the varieties of cell which are found in the blood and in addition endothelial cells from the pleura. Tuberculous and idiopathic fluids show a predominance of the lymphocytes, while a fluid resulting from infection of the pleura with other organisms usually have a majority of polynuclear cells. One exception to this rule is seen in the early stages of a tuberculous infection in which the polynuclears may be present in excess. The fluid may contain tubercle bacilli which, however, are very difficult of demonstration in a majority of the cases. Other organisms are more easily detected when they bear an etiological relationship to the disease.

With the accumulation of the fluid there is progressive collapse of the lung until with large effusions it may become completely empty of air. With loss of the pulmonary elasticity there is a disappearance of the negative pressure in the pleural cavity. A relatively high pressure may be seen in small effusions where the retraction of the lung is prevented by the presence of adhesions. If the lung has been collapsed for a long time it may become so bound down by adhesions that it is incapable of re-expansion. The diaphragm is forced down on the side affected and the heart and the contents of the mediastinum are forced to the opposite side when the amount of fluid is sufficiently large. The intercostal spaces become flat or even convex. There may be pressure on the esophagus or upon the vagus from a dislocation of the mediastinum. The larger the effusion the less readily it is absorbed the difficulty being probably largely mechanical. Purulent fluids are not absorbed while those containing numerous flakes of fibrin often disappear very slowly, due to the fact, it is said, that the fibrin occludes the pleural stomata. The statement has been made that absorption is delayed by the production of artificial pneumothorax.

Symptoms.—The onset of a pleurisy with effusion may be sudden with chill and a high temperature simulating a pneumonia or it may be so insiduous that the patient does not realize that anything is the matter with him until the chest is nearly full of fluid. In the majority of cases, however, the onset is gradual and accompanied by pain, cough, fever, and malaise. If the pleurisy is secondary the symptoms of the

primary disease may so mask it that it will not be suspected or may be discovered only by careful and repeated examinations. The pain is one of the first symptoms and is like that present in dry pleurisy. It may be referred to the abdomen and lead to a diagnosis of appendicitis. As the fluid accumulates the severity of the pain is usually lessened and it may entirely disappear. Cough is quite frequent and may be accompanied by expectoration. The cough may often be due to pleural irritation. The absence of blood in the sputum is evidence against the presence of pneumonia in those cases which have a sudden onset. Fever is generally present. It reaches 100° to 102° in the afternoon, being higher than is usual in dry pleurisy. It may drop somewhat with the appearance of the effusion. The respirations are generally increased in frequency and with large effusions there is often well-marked dyspnea. Hoarseness and dysphagia may result from pressure upon the mediastinum. The urine is of the usual febrile type during the presence of the fever. While the fluid is accumulating the chlorides are diminished. During absorption the quantity is increased while the output of chlorides is markedly augmented.

Physical Signs.—Small amounts of fluid collect in the costophrenic sinus and yield no definite signs. In favorable cases 250 c.c. may be detected in an adult, while a smaller quantity should be discovered in an infant. The patient often is found lying on the affected side thus allowing the healthy chest free movement. There may be more or less dyspnea. There is generally diminished movement of the affected side in a well-developed case and the intercostal spaces may be flattened or bulging. The affected chest looks fuller than normally and may be found to measure more in circumference than the other side. Litten's sign is absent on the side of the effusion. A downward displacement of the liver or spleen, depending upon the side affected, may be made out. Tactile fremitus is practically always absent over the fluid. A localized area over which fremitus is present may denote the presence of adhesions. On percussion the note is flat over the fluid and immediately above it is dull but with a tympanitic quality (Skoda's resonance). With considerable fluid in the left pleura there may be obliteration of the tympany in Traube's semilunar space. The upper limit of flatness with the patient in the upright position is a curved line, lowest behind, advancing upward and forward to the axillary line and then sloping gradually downward. This is due to the elasticity of the lung which supports a certain volume of fluid. This curve cannot, of course, be demonstrated in sacculated effusions. The upper limit of dulness shifts on change in the position of the patient provided that the fluid is not limited by adhesions or is not so large in amount that there is no room for change in its position. It changes its position more slowly than does the dulness due to free fluid in the abdominal cavity. On auscultation one may hear a friction rub early in the disease. Later there is absence of breath sounds over the area of flatness in typical instances. The friction rub generally disappears with the collection of the fluid. Râles may be heard above the level of the fluid. Just above the level of the fluid the breath sounds are apt to be bronchial in character due to the compression of the lung at this point. The voice sounds are generally increased above, diminished or absent below the level of the fluid. The voice often has a peculiar nasal quality. Whisper is usually diminished or absent over the fluid. It must be remembered however that in some cases none of the auscultatory signs are typical. This is frequently due to the presence of adhesions which prevent the lung from retraction and so allow a transmission of sound below the level of the fluid.

The heart is generally displaced away from the affected side the extent of the displacement varying with the amount of the effusion and the side, it being more markedly affected by left-sided effusions than those on the right side. This displacement is due to the pull of the greater negative pressure of the healthy side rather than the push of the fluid. Occasionally, in a very old process, there is sufficient absorption on the diseased side to lower the pressure in that pleural cavity below that of the healthy one. In such a case the heart may be displaced toward the side of the effusion. A paravertebral triangle of dulness (Grocco) may be made out and is usually present. This is a triangular area over which the percussion note is dull. The apex is a point on the spine at approximately the level of the fluid. One side extends downward along the spine, the other downward and outward over the healthy side. The base is continuous with the lower limit of resonance on the healthy side. The length of the base increases with the amount of fluid present, varying from two to seven centimeters. There is generally a leucocytosis of from 12,000 to 15,000 with no characteristic alterations in the differential count. Not infrequently there is evidence of tuberculosis in the lung.

Diagnosis.—This is fairly easy in typical cases yet fluid may be discovered at autopsy without having been suspected, or it may be confused with a number of other conditions. A thickened pleura gives rise to dulness, not flatness, and there is no displacement of the heart and no paravertebral triangle of dulness. The absence of this triangle is also an important aid in the diagnosis of atypical pneumonia which may cause confusion. Empyema will give the same physical signs but the symptoms are those of a more severe infection. The leucocytosis is more marked and there is a polynucleosis. Exploratory puncture is of importance in making the diagnosis and should be done as soon as pus is suspected. Tumors of the lung should be differentiated in the same way. Pericarditis with effusion may be confused with an encapsulated pleurisy. The history is usually of rheumatism and the circulatory difficulty is greater than one would expect from a pleural effusion of that size. Subdiaphragmatic abscess may be very difficult of differentiation. The history of some abdominal disorder may be obtained, the paravertebral triangle is absent and the level of flatness is not the characteristic curved line of a pleural fluid. The most important evidence is furnished by the *x*-ray examination, and in most instances the diagnosis may be made if a good plate is obtained. The patient should hold his breath if possible. A free fluid occupies the lower portion of the chest and the upper level is slightly curved. Plates made with the patient in the vertical and horizontal positions will show a change in the position of the shadow. Exploratory puncture is of importance in the determination of the nature of the fluid. The technique is as follows: An aspirating syringe of 5 or 10 c.c. capacity is fitted with a fairly large needle and charged with 2 or 3 c.c. of a one per cent. solution of novocain. A point over the flat area and at the upper margin of a rib is frozen with ethyl chloride and the needle thrust in gradually, the novocain being distributed through the chest wall, some being reserved for anesthetization of the pleura. It may be impossible to aspirate thick pus through a small needle. Sometimes a piece of tissue caught in the needle may be sufficient to make a histological diagnosis of the process. The fluid obtained should be examined chemically and microscopically as already noted. It should also be cultivated and a portion injected into the peritoneal cavity of a guinea-pig. The amount injected will depend somewhat on the size of the animal, but should be as large as possible, usually 5 or 10 c.c. The pig may be examined at intervals for loss of weight and the development of enlarged lymph nodes but should not be killed, if it survives, for at least two months. Injections have been made into the liver,

the lactating breast, and into the thigh, but the intraperitoneal method has been preferred although it demands a longer time before a positive diagnosis can be made. If the pig fails to develop tuberculosis, it does not, of course, exclude the possibility of a tuberculous origin for the disease.

The detection of tubercle bacilli in the fluid is difficult but may be done occasionally. Fifty to one hundred cubic centimeters of the fluid are mixed with an equal quantity of fifty per cent. antiformin in a flask and heated to boiling. The mixture is cooled and 13 c.c. placed in a centrifuge tube. To this is added 2 c.c. of a mixture of nine parts alcohol and one part chloroform. The tube is shaken vigorously and then centrifuged at about 3,000 revolutions per minute for fifteen minutes. The supernatant fluid is poured off and the disc which has collected immediately above the chloroform is smeared on a slide with a drop of egg albumin. Staining is done in the usual manner.

Prognosis.—The immediate prognosis for a serofibrinous pleurisy is good. Rapidly accumulating pleurisies may be fatal unless promptly relieved by thoracentesis and sudden death may follow a pulmonary embolism. Small effusions may be absorbed within a few days while larger ones take a much longer time. The course is definitely shortened by early tapping. It is quite unusual for a fluid to reaccumulate after it has been completely removed. It is rare for a serous fluid to become purulent. Infection may, of course, occur from faulty technique during an aspiration. If a fluid has been present for a long period of time there is often a development of adhesions in the chest. The heart, as a rule, returns to its normal position after the removal or absorption of the fluid. Tuberculosis often develops as a late sequel of the primary form.

Treatment.—It is possible for spontaneous cure to take place but it is wrong to count on it. Every patient with a pleural effusion should be treated as if he were tuberculous whether or not it can be proven so. Rest, fresh air, and an abundant diet are the principles of such therapy. The patients should be kept under observation for as long a period of time as possible. Local applications of heat or cold may aid in the relief of pain but morphine may be necessary. Strapping is apt to be more of a hindrance than a help. The main and most important immediate treatment is the removal of the fluid from the chest. The indications for the operation of thoracentesis, or removal of fluid from the chest have increased in number as the knowledge of its results has become better known. In the presence of large collections of fluid, with pressure symptoms or without, tapping is generally done early. When the amount of fluid is moderate it has been the custom to wait for three weeks to see if the fluid would be absorbed spontaneously. At the present time physicians are advising earlier removal of fluid collections in the chest. Following such removal there is usually a drop in the temperature and a more rapid convalescence. The dangers of the operation are slight and the advantages of early removal many, so that it would seem best to advise immediate thoracentesis in all medium or large pleural effusions. A purulent fluid should of course be removed by thoracotomy.

Thoracentesis.—Many and complicated forms of apparatus have been devised for the performance of this operation but the best is the simplest. An aspirating needle seven to ten centimeters long with a bore of 1.5 to 2 millimeters is convenient and readily obtained. A very satisfactory cannula was used by Lord. It is fitted with a trocar and a lateral outlet protected by a stop-cock. The fluid may be removed either by aspiration or by siphonage. The Potain aspirating apparatus is well known but is needlessly complicated. The simplest arrangement and one that never gets out of order is the Connell bottle. A bottle with a narrow neck, of about two liters capacity is chosen. About half an ounce of ninety-five per cent. alcohol is poured into it and the inner surface thoroughly moistened. The excess is then drained off. A rubber stopper is provided fitted with a glass tube passed through it. To the glass tube is attached a fairly heavy rubber tube closed with an artery clamp. A lighted match is dropped into the bottle and the stopper quickly inserted. The ignition of the alcohol will produce sufficient vacuum to aspirate the chest. The bottle may be graduated and a smaller sterile bottle may be interposed between it and the chest for the collection of a sterile specimen. The operation itself should be carried out with all the sterile precautions of any surgical procedure. The site chosen is usually in the sixth or seventh space near the posterior axillary line when the amount of fluid is fairly large. If the fluid is encapsulated the site must of course correspond to the location of the fluid. The skin is prepared with tincture of iodine and the operator should disinfect his hands and wear sterile gloves. Instruments should be sterilized just before use. These include the trocar or needle, hypodermic syringe, scissors, hemostatic forceps, rubber tubing, and the stopper to the bottle. The patient is best placed in a sitting position with the arm on the side of the operation drawn across the chest so as to pull the scapula out of the way. Local anesthesia with cocaine or novocaine is produced as described in the technique of exploratory puncture. The needle is introduced close to the upper border of the rib and pushed slowly through the chest wall. Injury to the lung should be avoided. If the artery clamp is now removed from the rubber tubing the fluid will be aspirated. The lumen of the tubing should be so restricted that the fluid will not flow too rapidly. Withdrawal of the needle should be done quickly and a piece of sterile gauze immediately pressed over the puncture wound. The iodine is cleaned off with alcohol or aromatic spirits of ammonia and the wound closed with a drop of collodion.

Faintness often occurs during the operation. It demands no special treatment though it is usually relieved if the patient lies down. A slight cough frequently appears as the fluid is withdrawn. If it becomes severe it may be necessary to stop the operation. Dyspnea and discomfort may develop and be severe enough to warrant stopping the aspiration for the time. Sudden death may occur due, it is believed, to pleural shock. This may in a measure be obviated by a careful use of the local anesthetic beforehand. Other symptoms are due to the changes in intrathoracic pressure and can be guarded against in part at least by withdrawing the fluid very slowly and perhaps in small quantities. It has been suggested that these symptoms might be prevented by the introduction of a second needle above the first. The external opening of the second needle should be covered with a bit of sterile cotton to act as a filter. With this arrangement an artificial pneumothorax is produced at the same time that the fluid is being withdrawn and changes in intrathoracic pressure are slight. Artificial pneumothorax seems to present no special dangers and the air is gradually absorbed allowing the lung to expand. In cases seen at the New York Hospital the presence of air in the pleural cavity apparently did not delay absorption of the fluid or lengthen the patient's convalescence. Albuminous expectoration is rare and may prove serious. It has generally occurred in those instances in which very large amounts of fluid have been removed. The amount of fluid that should be withdrawn varies with the size of the effusion, but it is generally said that it should not exceed 1,500 c.c. at the first tapping.

Following thoracentesis there is usually prompt fall in the temperature, disappearance of the pressure signs, and a marked increase in the patient's comfort. Generally one operation is followed by the absorption of the remainder of the fluid in the chest even though

only a small amount has been removed. In a small percentage of cases the fluid recurs and it may be necessary to repeat the evacuation frequently. It is in such cases that artificial pneumothorax has proved at times of great value. After the operation the general treatment is continued. The patient may be up and around at the end of a week if everything goes well. Gilbert, Fede, and others have advised autoserotherapy, that is the subcutaneous injection of a small quantity of the fluid removed from the chest. Rather striking improvement has been described as resulting from this procedure though it has not been generally used. Lord has called attention to the possibility of the dissemination of tubercle bacilli by this procedure.

3. Acute Purulent Pleurisy (Empyema).—By this is understood the collection of pus in the pleural cavity.

Etiology.—When compared to the fibrinous or serofibrinous forms of pleurisy it is seen that the cases of primary empyema form a relatively small percentage of the total. The fact that primary empyema is more frequent in children is no doubt due to the fact that in them the detection of a pulmonary process may be very difficult. Empyema is secondary most frequently to disease of the lung, generally a pneumonia, either lobar or broncho-, and the pneumococcus is the most frequent infecting agent especially in children. In adults the streptococcus is often found while the tubercle bacillus causes a purulent effusion less frequently than it does a serofibrinous or fibrinous exudate. Mixed infections may occur and are usually present with putrid exudates.

Pathology.—The pleura is covered with a fibrinopurulent layer and is often greatly thickened. Sacculation of the exudate is not infrequent though generally there is a large amount of fluid lying free in the pleural cavity. Ulceration may occur and perforation of any of the boundaries of the pus collection. There is often the associated pathological condition in the lung and the findings of sepsis in the organs. Large soft spleen, cerebral abscess and endocarditis are other findings which may be met. If the process has been a long-standing one there is apt to be more or less amyloid degeneration of the viscera. Tuberculous lesions are found in some part of the body in about thirty per cent. of the cases. There is no sharp dividing line to be drawn between serous and purulent fluids. It must be remembered that pus may sediment within the chest and a turbid fluid may be withdrawn above a sediment of pus. An excess of polynuclear cells in the fluid should always excite suspicion. The pus may contain a variable amount of blood.

Symptoms.—The symptoms are often much the same as in pleurisy with effusion. The temperature is generally higher and there are more apt to be chills. If the temperature does not fall after an attack of pneumonia, or if after reaching normal or near normal it rises again, an empyema should be suspected. Toxic symptoms are fairly well marked and there may be loss of weight, pallor, and sweats. When due to the tubercle bacillus and uncomplicated, an empyema may exist for a long time without any very definite symptoms.

Physical Signs.—These are essentially the same as those described under pleurisy with effusion. The intercostal spaces may bulge noticeably and such a tumor may pulsate (empyema necessitatis). There may be edema of the superficial tissues. A disproportion between the amount of fluid and the severity of the symptoms is suggestive. The displacement of the heart and the liver is usually greater with pus. The blood shows a leucocytosis which may reach 50,000 together with an increase in the polynuclear count.

Complications.—The chief complications are sepsis and perforation of the limiting wall with escape of the pus into some other location. Metastatic cerebral abscess is the most dangerous complication. There may be perforation of the lung with escape of the pus into the bronchi or perforation of the thoracic wall with discharge externally. Perforation of the diaphragm results in peritonitis or subdiaphragmatic abscess.

Diagnosis.—The diagnosis is made usually by means of exploratory puncture when the condition is suspected from the presence of one or more of the above symptoms. If encapsulated it may be missed easily and one should always use a needle sufficiently large so that a thick pus will flow through it. *X*-ray examination is an important aid. Exploratory puncture should never be delayed once the condition is suspected. It is a comparatively safe procedure and an early diagnosis very important to the patient.

Prognosis.—Absorption almost never occurs. If untreated it would probably go on to sepsis and death from that cause. Peritonitis is a frequent coincident infection and may be fatal. Occasionally sudden death takes place without any ascertainable cause. After thorough drainage recurrence does not occur because of the obliteration of the pleural cavity. In infants the prognosis is uniformly bad. If the wound discharges for a long period of time the patient is apt to develop amyloid degeneration of the viscera.

The *treatment* is surgical. The operation of choice is resection of a portion of a rib and drainage. In cases where the character of the fluid makes the diagnosis doubtful, a thoracentesis is often all that is needed to bring about a recovery. If the amount of pus is large so that the heart is much displaced it may be wise to precede the thoracotomy by an aspiration of enough fluid to allow the organs to resume their normal position. The danger of a sudden release in the pressure is thus avoided. After operation, expansion of the lung may be aided by having the patient do breathing exercises or he may blow into James' bottles. If the sinus persists it may be of some advantage to administer autogenous vaccines. The technique of the operation and of the after-treatment of the sinus should be obtained from some surgical work.

4. Diaphragmatic Pleurisy.—When the pleuritis is limited to the diaphragmatic region the diagnosis may be difficult. Physical signs are often lacking. The pain is likely to be referred to the abdomen or to the lower chest. Strapping of the chest may aggravate the pain in which case relief is often obtained by strapping the abdomen thus obtaining a partial fixation of the diaphragm.

5. Encysted Empyema (Sacculated Empyema).—This may occur between the lobes of the lung or between the lung and the diaphragm or the chest wall. It occurs most frequently between the lung and the diaphragm where the fluid is at first free but accumulates very slowly and becomes walled off by adhesions. Dislocation of the heart and the liver may be the only sign. The symptoms are often those of a diaphragmatic pleurisy. There may be an area of dulness at the base of the lung and the voice sounds and fremitus may be suggestive of fluid. A friction rub may be present. Perforation of the diaphragm is a dangerous complication which may be the first symptom. When the collection of pus is situated between the lobes of the lung it is apt to be mistaken for a pulmonary abscess. The location of the process may be suggestive. *X*-ray examination may yield valuable information. The sudden expectoration of a large amount of pus occurs if the pus ruptures into the lung, a happening which may be the first symptom. If the empyema can be reached it should be evacuated. Rupture into the lung may result in a cure.

6. Actinomycosis and Streptothricosis of the Pleura.—The clinical pictures of these two condi-

tions are quite similar. The former is the more frequent. Actinomycosis of the pleura generally results from extension from the lung. Perforation of the chest wall is a characteristic feature. It should be suspected in empyema when associated with chronic pulmonary suppuration, interstitial pneumonia, abscess, or gangrene. The diagnosis can be made only by finding the characteristic fungus. The prognosis is bad. The treatment is surgical combined with the administration of large doses of potassium iodide. In streptothricosis the process is similar and the diagnosis is made by the identification of the streptothrix in the pus.

7. Peripleuritis.—A certain amount of peripleuritis is associated with all pleural infections. A primary form has been described in which there is inflammation and suppuration of the tissue between the pleura and the chest wall. Perforation of the chest wall is frequent. The symptoms are those of suppuration. The superficial tissues are swollen and tender. The affected region is dull and the breath sounds diminished or absent. There may be fluctuation. The absence of dislocation of the heart and of shifting dulness and the lack of signs at the bases of the lung are usually sufficient to differentiate this condition from an ordinary empyema. It may be impossible to distinguish it from an encysted empyema. The treatment is early operation.

8. Syphilis of the Pleura.—Cases of pleurisy with effusion in patients who have a positive Wassermann reaction, and in whom it is impossible to obtain any evidence of tuberculosis, have been classed as due to syphilis, but this classification has never been positively justified. The fact that the pleural fluid may yield a positive Wassermann reaction is of no weight since any of the body fluids may give this test when it is present in the blood serum.

9. Chronic Pleurisy.—Adhesions between the parietal and visceral layers of the pleura are a common sequel of all forms of pleuritis. These vary in character from delicate strands to heavy bands of connective tissue which may be so firm and numerous that at autopsy it may be impossible to remove the lung from the chest without injury to it. Adhesions at the apices may cause retraction above the clavicles and contraction of the apices with diminished breathing, voice and fremitus and dulness. Infrequently both layers of the pleura are tremendously thickened so that they measure a centimeter or more. Under these conditions there is more marked dulness or even flatness, and the signs in general approach those found in the presence of fluid except for the shifting line of dulness and the displacement of the heart. On thoracentesis it may be felt that the needle is traversing a thick resistant layer. There may be a small amount of fluid present. The symptoms are generally slight. There may be a low temperature, more or less cough and a varying amount of pain in the chest. The treatment is primarily that of tuberculosis which is the most frequent cause. Pulmonary gymnastics may aid in the expansion of the lungs. Otherwise the treatment is symptomatic.

Occasionally serofibrinous or purulent fluids tend to accumulate after removal. In these instances the lung generally has failed to expand properly, which is sometimes the result of delaying the removal of the fluid. Persistent reaccumulation of a serofibrinous fluid is often due to tuberculosis and it may be part of inflammation and fluid collection in all the serous sacs, the so-called polyserositis. Repeated tapping to keep the chest as dry as possible, with pulmonary exercises to expand the lung are the accepted forms of treatment. In a few cases the production of artificial pneumothorax has resulted in an improvement in the condition.

If the lung fails to expand after an empyema operation, the pus will reaccumulate as long as there is a cavity present. Cure can be obtained, as a rule, only by means of extensive operative measures, such as a resection of several ribs and a sinking in of a portion of the chest wall. In young individuals in whom the bony frame is not so rigid the chest wall is frequently drawn in and the cavity closed in that manner.

Ralph G. Stillman.

Pleurisy Root.—*Asclepias* (N. F.), *Butterfly Weed.*—The root of *Asclepias tuberosa* L. (fam. *Asclepiadaceæ*).

Asclepias L. is a genus of some sixty species, occurring chiefly in North America, a few in Central and South America, and in the tropics of the Old World. A number of these have been found to possess the composition and properties of the official one, and it is probable that the same properties are general in the genus.

The species in question is very abundant in sandy soil from New England southward and southwestward. It is a perennial, hairy herb, sending up a cluster of erect or ascending stems a foot or two long, as thick as a goose-quill, densely leafy, and bearing at the summit several branches terminating in handsome large umbels of orange-colored flowers. It is the only species of the northeastern United States with orange-colored flowers. The commercial root is irregularly or interruptedly fusiform, ten to twenty centimeters (4–8 in.) long, one to five centimeters ($\frac{1}{2}$–2 in.), rarely more, in thickness, usually cut transversely or longitudinally into irregular pieces; externally light orange-brown, becoming gray on keeping, coarsely annular at the crown, bearing numerous fine longitudinal and transverse furrows, imparting a finely tuberculate appearance and feeling; fracture tough, uneven, granular, whitish, the thin bark yellowish in the outer layer, the wood bundles pale yellow; almost inodorous, taste bitterish, slightly acrid, and nauseous. Pleurisy root was a food of the North American aborigines, who baked it long and thoroughly to destroy its noxious constituents.

Besides two resins, gum, and a large amount of starch, pleurisy root contains the bitter glucoside asclepiadin, to which its properties are chiefly due. Asclepiadin is a yellow amorphous substance, soluble, in alcohol, ether, and hot water, becoming of a deeper yellow, then green, with concentrated sulphuric acid.

Pleurisy root is diaphoretic and expectorant, and in domestic and country practice it has been used extensively in lung affections and catarrh of the air passages. In large doses it is emetico-cathartic. If desired, it can be given in decoction. Dose gr. xv. to xlv. (1.0–3.0). The fluid extract is official.

Henry H. Rusby.

Plombières.—This resort, one of the several spas in the Vosges, is situated southeast from Paris about six and a half hours' distant. It lies in an attractive narrow valley surrounded by forest-clad hills. The town itself, which has about 2,000 inhabitants, is clean and well built, and although hidden in a valley it is really 1,360 feet above sea-level.

From the charm of its situation and the attractiveness of its surroundings it is a favorite summer resort for many who do not come for a course of the waters. The climate is a wholesome one, though hot in summer, but cool in the morning and evening. The season extends from May or June to October, and the "cure" lasts the conventional twenty-one or twenty-five days. This popular resort has been called the "Queen of Watering Places of the Vosges" and is annually visited by 6,000 or more persons.

The springs, twenty-seven in number, were long ago discovered and used, and in one of them the remains of an old Roman piscine is still employed as a vapor bath (étuve). They are the property of the State, as

at Vichy, and are well equipped for the various applications of the thermal waters. There are hot vapor baths much like the common "Turkish baths;" hot and cold douches; the douche-massage; appliances for large intestinal "lavages;" vaginal irrigations; inhalations, etc.

The waters are feebly mineralized and of the class called "simple indeterminate waters;" their efficacy depending principally upon the method of application and the temperature which varies from 65° to 160° F. They are chiefly employed externally, only four out of the twenty-seven being employed for drinking and that only in a subordinate way. There is a cold ferruginous spring which is used as a table water and as an adjunct to bathing in cases of anemia and chlorosis. All the springs contain traces of arsenic, and some have a soft soapy feeling, said to be due to the presence of silicate of aluminum, and hence called "*sources savonneuses*," which are also used for drinking as well as bathing and are mildly laxative. Apart from the chalybeate and savonneuse the Plombières waters all belong to the same category called "indifferent." As at other spring resorts, exercise and diet are essential parts of the treatment.

The diseases and abnormal conditions which are treated at Plombières are many and various, for an abundant and frequent application of water, hot and cold, with skilful massage, is good for most anybody, and for a large variety of maladies. Chronic rheumatism—muscular and articular—sciatica, rheumatic neuralgia, and the many conditions dependent upon a rheumatic diathesis, are said to be much benefited by the hot baths, etc. Next in importance are various diseases of women, such as irregularities in menstruation, uterine complaints, sterility, for the cure of which the place has quite a reputation, leucorrhea, dysmenorrhea, and amenorrhea. Indeed, so many women come here for these various conditions that it is called a "ladies' station." The waters are also applicable to cases of gastralgia, dyspepsia, various gastrointestinal troubles, especially chronic diarrhea; to neurasthenia and other functional disorders of the nervous system. Habitual constipation is said to be successfully treated here by means of daily hot baths of half an hour to an hour and a half, followed by the rectal douche. Spinal irritation, nervous palpitations, neuralgias, certain forms of vertigo, and some skin diseases, such as eczema and psoriasis, are likewise said to be benefited by these waters. In pulmonary tuberculosis the place is said to be contraindicated.

The accommodations are good and abundant, and of all varieties and prices. There are as many as about a hundred private hotels, many of them with a regular table-d'hote. There are Protestant church services and English-speaking physicians. There is a fine casino, and the other usual forms of amusement. There are pleasant walks in the Park and on the Promenade des Dames, and interesting and pleasing excursions in the neighboring mountains.

Other resorts with waters of a similar nature and employed in a similar way are Teplitz, Wildbad, Gastein, Buxton, in Europe; and in this country, the hot springs of Arkansas and Virginia, those at Las Vegas, N. M., at Glenwood, Colorado, and at various places in California. EDWARD O. OTIS.

Plumbum.—*Lead.*—I. GENERAL MEDICINAL PROPERTIES OF COMPOUNDS OF LEAD.—Absorbed into the system, lead exerts a peculiar influence, developing a unique series of symptoms. The influence is wholly toward deterioration of tissue and perversion of function, and has no application in medicine. Locally, the effects differ among the compounds mainly according to solubility. The insoluble compounds are soothing and absorbent, like the insoluble salts of bismuth, while the soluble are decidedly astringent, but yet, in proportion to the astringency, are far less irritant than most other astringent metallic salts. The therapeutics of lead salts consist in the employment of the soluble salts as metallic astringents in catarrhs, or, in weak solution, as cooling lotions in inflammation or irritation of the skin. In these applications the following points need attention: 1. No lead compounds should be applied to the eye, for, though excellent for simple irritation or catarrh of the conjunctiva, yet there is the peculiar danger that if a loss of the epithelium of the cornea occur, whether by ulceration or by traumatic abrasion, application of a lead solution will produce an instant, indelible, opaque, white streak over the area of exposed underlying corneal tissue. 2. Lead salts should not be given internally for longer than a very few days, lest constitutional lead poisoning result.

II. THE COMPOUNDS OF LEAD USED IN MEDICINE.—These are the *oxide*, *iodide*, *acetate*, and *nitrate*.

Lead Oxide: PbO. Lead oxide is the compound so well known as *litharge*. It is official in the United States Pharmacopœia as *Plumbi Oxidum*, Lead Oxide. It is in the form of a heavy yellowish or reddish-yellow powder or minute scales, insoluble in water or alcohol and without smell or taste. It is not used medicinally under its own form, but is official as being the source, in pharmacy, of the solution of the lead subacetate.

Lead Iodide: PbI_2. This compound is official in the United States Pharmacopœia as *Plumbi Iodidum*, Lead Iodide. It is in the form of a heavy, bright yellow powder, without odor or taste, permanent in the air; slightly soluble in cold water and in alcohol, but more readily soluble in boiling water (1 to 200). The claim of lead iodide to medicinal recognition is based upon the theory that the salt will yield the peculiar effects of an iodide along with those of lead. But in practice the medicine seems to amount to little else than a very slightly soluble lead salt, and is little used. It has been given internally in doses of (gr. ss.–iij.). (0.03–0.2). Externally, it may be used in the form of an ointment.

Lead Acetate: $Pb(C_2H_3O_2)_2 + 3H_2O$. Lead acetate, the salt well known as *sugar of lead*, is official in the United States Pharmacopœia as *Plumbi Acetas*, Lead Acetate. The salt occurs in colorless, shining, transparent prisms or plates, or heavy, white crystalline masses, or granular crystals of a faint vinegar-like odor and a characteristic taste at first sweetish and astringent, and afterward metallic. Soluble in two parts of water, and in thirty parts of alcohol at 25° C. (77° F.); in 0.5 part of boiling water, and in one part of boiling alcohol. It effloresces and absorbs carbon dioxide from the air on exposure. The solutions commonly show a slight turbidity, which, however, is easily removed by the addition of a few drops of acetic acid. Commercial sugar of lead is apt to be contaminated with lead sulphate or carbonate, an impurity which may be suspected if a sample fail to dissolve wholly in water. The salt is decomposed by the alkalies, by acids, by soluble sulphates, chlorides, citrates, and tartrates, and by lime water.

Lead acetate is one of the most powerful of the lead salts. In rather weak solution it evinces the combined astringency and soothing influence characteristic of soluble lead compounds, but in strong solution is distinctly irritant, so that the salt is a possible severe irritant poison. Lead acetate may be used externally in solution as an astringent wash, with the caution already given about application to the eye. The strength of lead lotions commonly ranges from the one-half of one to one or two per cent. Internally the salt is a good deal given as an astringent in diarrheas, and has also an ancient reputation of being of avail for the arrest of hemorrhage in quarters inaccessible to local measures. This alleged hemostatic potency is held in high esteem by some, but by others is considered wholly imaginary. By the very condi-

tions of the case this virtue is one impossible to establish or disprove by methods of precision.

Lead acetate is administered in doses of gr. i.–iij. (0.06–0.2) every two hours or so, and, when given in diarrhea, is probably more often than not combined with an opiate.

When lead oxide (litharge) is boiled in a solution of lead acetate it dissolves with the formation of certain basic acetates, the composition of the resulting basic salt depending on the proportion of litharge to sugar of lead in the making. The United States Pharmacopœia avails itself of this reaction, and by taking the ingredients in the proportion of eleven of litharge to eighteen of acetate, obtains a solution of basic acetates of which the principal one is triplumbic acetate. This solution is proportioned so as to be about twenty-five per cent. strength of salts, and is officially entitled *Liquor Plumbi Subacetatis*, Solution of Lead Subacetate, called also *Goulard's Extract*. It is a clear, colorless liquid, of a sweetish, astringent taste, and an alkaline reaction. It is easily distinguishable from a solution of the normal acetate (sugar of lead) by the fact that it produces a dense, white precipitate with a solution of acacia. Solution of subacetate of lead is exceedingly easy of decomposition; even the carbon dioxide of the atmosphere will attack it and render it milky by the formation of the insoluble carbonate of lead. It must therefore be kept in well-stoppered bottles. It is decomposed also by so many other substances, organic and inorganic, that the practical rule is a good one, viz., to combine this solution, in extemporaneous prescribing, only with opiates.

Ceratum Plumbi Subacetatis, Cerate of Lead Subacetate; Goulard's Cerate. This cerate consists of twenty per cent. of the above solution mixed with camphor two, white petrolatum thirty-eight, paraffin twenty and wool-fat twenty. It is an astringent application.

Liquor Plumbi Subacetatis Dilutus, Dilute Solution of Lead Subacetate; Lead Water. This solution is simply four parts of the foregoing diluted with ninety-six of distilled water, previously boiled and cooled to deprive it of free carbonic acid. Lead water is of the average strength wanted for actual application of a subacetate of lead solution, and may therefore be prescribed for use without dilution.

These two preparations, derived from the parent solution of the subacetate, are much used as gently astringent, and at the same time soothing applications to sores, excoriations, or inflamed conditions of skin. Lead water is frequently combined with laudanum for the allaying of superficial pains, such as the pain of erysipelas, of a scald, or of a sprain.

Lead Nitrate: $Pb(NO_3)_2$. The salt is official in the United States Pharmacopœia as *Plumbi Nitras*, Lead Nitrate. It occurs in octahedral crystals, either colorless and transparent or white and opaque, according to the method of preparation. The crystals are permanent in the air, without odor but with the usual sweetish, astringent and metallic taste of the soluble lead salts. The salt dissolves in 1.85 parts of water at 25° C. (77° F.), and in 0.75 part of boiling water; almost insoluble in alcohol. Lead nitrate acts like the acetates, and is used only for external applications. A peculiar property of the salt is that it decomposes sulphuretted compounds, and thus proves deodorant to parts generating foul secretions, such as nasal surfaces in ozena. *Ledoyen's disinfecting fluid* is a twelve and a half per cent. aqueous solution of lead nitrate. Lotions of the nitrate average two per cent. in strength.

Lead Plaster. Under the title *Emplastrum Plumbi*, Lead Plaster, the United States Pharmacopœia recognizes a product containing sixty parts of lead acetate, and 100 parts of soap, each dissolved in hot water, and mixed. Lead plaster exerts but feebly the peculiar effects of lead compounds, though a case of lead colic has been recorded as resulting from long-continued application of the plaster as a dressing to an ulcerated surface. The main use of lead plaster is as a basis, non-specific, for medicated plasters.

Acute Poisoning.—Cases of acute poisoning by lead are uncommon, and are generally the result of accident. The acetate (including Goulard's extract) and the carbonate are the preparations usually responsible, the carbonate being occasionally employed as an abortifacient.

Symptoms.—At the time of ingestion the patient perceives a sweetish metallic taste. This is succeeded by a burning sensation in the throat and stomach, accompanied by nausea and persistent vomiting. There is intense thirst, and general prostration. Severe colicky pains in the abdomen are experienced, and constipation or diarrhea may be noticed. The stools are dark or black, owing to the formation of lead sulphide. Slow pulse, cold extremities, muscular cramps, headache, vertigo, and insomnia may follow, and in fatal cases there are usually convulsions and coma.

Treatment.—The stomach tube should be used, and the stomach washed out with a solution of some soluble sulphate such as magnesium sulphate (Epsom salt) or sodium sulphate (Glauber's salt), with the idea of forming an insoluble lead sulphate. An emetic may be administered if the stomach tube is not at hand. Emollient drinks, and opiates should be administered, and the patient's diet should be mild and unirritating (chiefly fluid) for some time.

Chronic Poisoning (Plumbism).—Cases of chronic poisoning by lead may be roughly classified under two heads: 1. Accidental. 2. Those which are incident to certain occupations. *Accidental* poisoning is generally due to presence of lead salts in food; cooking utensils, lined with an enamel containing lead, the use of canned goods (especially fruits), and the drinking of water or beer which has stood for some time in lead pipes are the main sources. Most of the cases of lead poisoning, however, are of occupational origin. (See *Occupational Diseases.*)

Symptoms.—These may be divided into three groups. 1. Lead cachexia. 2. Lead colic. 3. Lead paralysis.

1. *Lead Cachexia.*—The patient complains of failing health, loss of appetite, constipation, weariness, cramp-like pains in the muscles of the legs; and there may be observed coated tongue, foul breath, emaciation, pallor, and the characteristic blue line at the junction of the gums with the teeth. Many of these symptoms are similar to those enumerated under acute lead poisoning, the main difference being that in the acute condition the symptoms are more severe, while in the chronic condition they last through a much greater period of time.

The proper treatment is to remove the patient from danger of further poisoning. Warm baths, good food, tonics, potassium iodide, and mild purgation are all useful.

2. *Lead Colic* (*Painter's Colic*).—This generally comes on suddenly and is apt to be very severe, paroxysmal and accompanied by constipation. But in some cases there is a preliminary gastrointestinal discomfort, and the paroxysms of pain are sometimes associated with diarrhea. The pain is most severe around the umbilicus and may be slightly relieved by pressure. Epsom salts, to cause evacuation of the bowels, and morphine for the pain are both indicated. Mercurial purgatives should be avoided. The colic may last for two or three days and return again after an interval of a few weeks.

3. *Lead Paralysis.*—This is most commonly found in those whose occupation renders them liable to lead poisoning; but it has also been observed in cases due to the contamination of food and water and also to the use of various cosmetics, hair dyes, etc. Fortunately many workers in lead are never affected.

As a rule, the patient first suffers from the constipation, colic, blue line on the gums and other symptoms already described. Most commonly, several of the muscles of the upper extremities are affected, particularly those supplied by the musculospiral nerve. "Almost always the common extensors of the fingers are first affected, especially the extensors of the third and fourth fingers; then the extensors of the wrist, and ultimately the long thumb muscles. The extensors of the hand and fingers are in most cases exclusively involved. These different muscles are affected in varying degrees. The hands and fingers are held in the position of flexion, and drop as soon as they are placed in extension. On account of the lack of opposing force, the flexors are weakened in their action, but when support is given to the hand by passive extension they act normally. The paralysis of the extensor muscles of the wrist causes "*wrist-drop*," which produces the characteristic attitude of the hands commonly seen in these cases. In some instances the paralysis is not confined to the distribution of the musculospiral nerve, but all of the intrinsic muscles of the hand which are supplied by the ulnar and median nerves may also be involved. In the majority of cases, the triceps and supinators remain intact. It is only in the most severe forms that the latter muscles are involved. This condition is usually found associated with paralysis in the distribution of other branches of the brachial plexus and with pronounced symptoms of saturnism. Although lead has a strong predilection for the muscles already mentioned, these may escape. Lead palsy usually affects both upper extremities simultaneously, but it is not at all uncommon for it to attack only one arm. The right upper extremity is generally more paralyzed than the left in right-handed persons, and *vice versa*. It is quite uncommon, however, for both sides to be equally affected. Atypical cases occur in which the supinators, biceps, brachialis anticus and deltoid are the principal muscles affected (upper arm type of Remak). To this group is generally superadded paralysis of the supra- and infraspinati. This form of paralysis is usually bilateral and occurs in the most inveterate types of lead poisoning. When this group of muscles is affected, the patient is unable to lift his arm, and it hangs powerless by his side. Sometimes the deltoid is the only muscle involved. . . . The lower extremities are very rarely affected. When this does take place, the muscles involved are the long extensors of the toes and the peronei muscles. The tibialis anticus usually escapes. In fatal cases, the paralysis invades the muscles of respiration, *i.e.*, the intercostals, the diaphragm, and the muscles of the larynx. In some chronic cases the symptoms may closely resemble those of bulbar paralysis" (Leszynsky).

The *prognosis* is favorable, as to life; and, if not too extensive or of too long standing, recovery is the rule.

Treatment consists in removing the patient from the source of contamination, the regular administration of iodide of potassium (not exceeding five or ten grains a day), and the occasional administration of magnesium sulphate. Electricity, massage, and tonics have all been recommended. Workers in lead should keep themselves (particularly their hands) as clean as possible; they should be very careful to wash their hands thoroughly before eating, and not to eat in the work rooms.

EDWARD CURTIS.
R. J. E. SCOTT.

Pluto Water.—See *French Lick Springs*.

Pneumatic Cabinet.—The pneumatic cabinet is an apparatus designed for the therapeutic application of differential air pressures and consists of an air-tight chamber of sufficient size to contain a single patient. It is provided with means for rarefying the contained air and registering the degree of such rarefaction. In the glass front is fitted a stopcock through which, and an attached tube, the patients lungs may be instantly connected with, or shut off from, the outside air. With a patient sitting in the rarefied air of the cabinet and breathing through the tube outside air at barometric pressure there is developed a differential pressure between the entire cutaneous and pulmonary circulations.

The action of the cabinet in its application is two-fold: (1) upon the circulation, and (2) upon the lung and respiration.

PHYSICS.—All flow of liquids in a system of tubes like the vascular system depends upon differential pressures, and is from the higher to the lower. In such a system, with the liquid in stasis, flow of this liquid may be developed by either increasing the pressure behind or decreasing that in front, tension of the liquid being increased by the first and decreased by the second. Physiologically all increase of blood flow demands increase of vascular tension and corresponding increase of work on the part of the heart. As all cardiac failure depends, fundamentally, upon excess of work and lack of rest it is evident that any measure which maintains or increases blood flow under decreased tension is, *ipso facto*, an ideal therapeutic measure in all cases of deficient circulation or cardiac exhaustion The action of rarefied air in drawing blood to the area of its application has long been known, and is of daily application in the form of dry cups. As the action of a dry cup does not depend upon its size, the same suction effect is obtained in much greater degree when rarefied air is applied to the entire cutaneous surface. This condition is obtained by the cabinet when the patient sits in the rarefied air of the cabinet and breathes air at barometric pressure. This "dry cup" action with its obvious differential pressure is universally recognized. That the simultaneous application of rarefied air to both pulmonary and cutaneous circulations has a similar differential effect which is the equivalent of a dry cup applied to the lung, is less generally appreciated. The absolute reduction of pressure in this case is the same on the two circulations, yet such degree of rarefaction as is found at altitudes of 18,000 or 20,000 feet results in intense congestion of the lungs and respiratory mucous membranes, even, at times, to the point of causing hemorrhages. This different effect of the same rarefaction on the two circulations is due to the weaker anatomical support of the pulmonary vessels. Thus the mild general rarefaction of the cabinet acts as a gentle dry cup to the lungs.

APPLICATION.—With very rare exceptions these two forms of differentiation, the absolute and the relative, the cutaneous and the pulmonary dry cup, have been found to meet all therapeutic requirements. The former is termed "negative differentiation," the latter "negative pressure" and their combination, "alternating differentiation."

The absolute degree of differential pressure employed depends, of course, upon the condition under treatment and the effect desired. It runs from one-fourth to one and one-half inches of mercury.

Negative Differentiation.—In this motion respiration is carried on under a constant differential pressure, that upon the pulmonary circulation and the outside of the heart being barometric, and that upon the cutaneous and abdominal circulations being less by the amount of rarefaction in the cabinet which should not exceed one-half inch Hg.

The value of this form of pneumatic differentiation depends solely upon its action on the circulation. Respiration under negative differentiation results in:

1. Reduction of vascular tension in both the systemic and the pulmonary circulations.

2. Depletion of the pulmonary vessels with mild venous hyperemia of the systemic circulation.

3. Slowing of the entire circulation, both systemic and pulmonary.

4. Mild anemia of the cerebrospinal vessels.

The manner in which these conditions are developed is obvious. While the barometric pressure of the respired air offers no increased resistance to the pulmonary circulation, and hence no impediment to right heart action, the lower pressure on the cutaneous surface becomes a suction force influencing all the systemic circulation, save that of the brain and cord, which are protected by their bony envelope. As the result all the systemic vessels, and particularly the capillaries, are dilated, vascular tension is lowered, and for a moment the circulation is hastened as the blood is drawn from the lung. With the continuance of the differentiation the contracting arteries gradually force a relative excess of blood into the veins, from whence it passes more slowly to the pulmonic vessels which are under the higher barometric pressure. The degree of these results is easily controlled by varying the pressure differential.

The pathic conditions to which negative differentiation is applicable are: (*a*) pulmonary hemorrhage. There is no measure at our command which so quickly arrests bronchial hemorrhages. In these cases the application may be almost continuous with rarefactions of from one-fourth to one-half inch of Hg. With the slowing of circulation so controlled as not to affect respiration the depletion of pulmonary circulation under decreased tension is such that hemorrhages are quickly arrested and their recurrence usually prevented by further treatment. It affords immediate relief in (*b*) pulmonary congestion from any form of cardiac disease, and is the proper motion with which to begin treatment in all cases. With this condition, in which congestion is due to obstruction, the effect of this motion is to increase, instead of retard circulation, and the subjective relief of dyspnea is often immediate.

Negative Pressure.—The value of pulmonary hyperemia, to which this motion tends, is well known, but the degree of rarefaction which can be produced is not sufficient to give this motion value by itself.

Alternating Differentiation.—In this motion inspiration takes place under negative differentiation and expiration under negative pressure. Thus each respiration represents the alternate application of the cutaneous and pulmonary dry cup.

The effects are of two distinct forms, mechanical and circulatory. The pulmonary expansion, the opening and clearing of collapsed and plugged alveoli, and the stretching of pulmonary and pleuritic fibroses attained by means of the pneumatic cabinet do not differ in themselves from the corresponding effects of compressed air. The clinical results, however, are very greatly superior by reason of the coincident effect of the cabinet upon the attendant pathic processes through its control of the circulation. In this motion, during inspiration, which takes place under negative differentiation, the action upon the circulation is the same as with negative differentiation alone. It is greater in degree since a higher differentiation can be employed when the patient is to expire into rarefied air. With the decrease in cutaneous pressure the vessels are dilated and the blood is drawn from the lungs through the heart and arteries into the veins with a quickened flow and lowered tension. Before this action reaches the point of slowed circulation inspiration is ended and the differentiation instantly changed to negative pressure, under which, although the absolute pressure on the cutaneous and pulmonary circulations is the same, there is, nevertheless, a relative negative differentiation in favor of the pulmonary vessels due to their weaker anatomical protection and support. A pulmonary suction is thus developed which draws the blood from the hyperemic veins into the depleted pulmonary vessels, again with quickened flow and under lowered tension. Thus during each respiratory cycle a double negative differentiation is developed alternately in favor of the systemic and the pulmonary circulations.

Continuance of this process results in increase of both circulations with all which that implies of increased absorption and improved nutrition, and this, too, under decreased vascular strain.

It is this power of the cabinet to hasten circulation and diminish arterial strain which distinguishes it from all other forms of apparatus for the use of pneumatic differentiation, and which renders it the most potential measure for the relief of very varied conditions. All the mechanical effects of compressed air may be attained by forced inspiration, with the addition of improved tissue nutrition. This motion is valuable in all forms of inflammatory pulmonary disease after the acute stage. All pulmonary and pleuritic fibroses are loosened and absorbed much more quickly than by any other means. The effect of forced inspiration upon all forms or organic heart disease, with the exception noted under negative differentiation, is more immediate, satisfactory, and prolonged than that from any other method of treatment. Cardiac angina and dyspnea are speedily relieved, often within a few minutes, and in young subjects this relief often becomes permanent after a few treatments. Cases of aortic regurgitation give especially brilliant results.

In all conditions producing high arterial tension also this measure affords very marked relief, the extent and duration of which depend, of course, upon the nature and continuance of the primary cause. The treatment does not cure Bright's disease, but it does relieve and delay the secondary arterial and tissue changes.

CHARLES E. QUIMBY.

Pneumonia, Bronchial.—See *Bronchopneumonia.*

Pneumonia, Chronic.—*Synonyms:* Interstitial Cirrhosis of the Lungs, Chronic Interstitial Pneumonia, Pulmonary Fibrosis, Fibroid Phthisis.

Chronic pneumonia is not an independent morbid entity, but occurs as a sequel of one or more previous or coexisting pathological conditions of the lungs or pleura. It is a chronic productive inflammation which may occur wherever connective tissue is found. It is encountered in two chief forms, circumscribed and diffuse. The circumscribed form is associated with tuberculosis, gummata, tumors, infarctions, hemorrhages, abscesses, and every morbid growth, and really is the attempt of the part to wall off the pathological condition.

The diffuse variety is secondary to incompletely resolved lobar pneumonia or to acute or subacute bronchopneumonia and chronic bronchitis, spreading mostly from the bronchial walls. It may also be a result of pleurisy, or of any long-continued irritation, particularly, that of inhaled mineral particles. Miners, stone cutters, and workers in iron run the greatest risk of this.

In general arteriosclerosis, inflammation of the connective tissue of the arterial walls extends to that of the lung itself and results in a diffuse interstitial pneumonia. The distribution of the pathological connective tissue, of course, depends entirely upon that of its exciting cause.

In well-marked cases of the diffuse variety more or less of the pleura is adherent and greatly thickened, and the affected lung is smaller than normal and cannot be separated from the chest wall without tearing. The lung feels firm and leathery. The heart may be drawn to the affected side, and its right half may be hypertrophied.

On section the pleura is seen to be tough, fibrous, and of a grayish color. There is often a creaking

sound as the lung is cut. The cut surface is firm, shiny, and of a dull red or bluish color or marbled. Much pigment is often present throughout the lung tissue and in the bronchial nodes. The walls of the small bronchi are increased in thickness and in many places dilated. Some of the dilatations are large and often contain varying amounts of pus. The microscope shows the new tissue to be connective tissue of the small-celled variety; most of the cells are round, but some are fusiform. There are at first blood-vessels in this new tissue, but they tend to disappear later; there is, however, as before mentioned, but little tendency to tissue necrosis. The walls of the atria, air sacs, and air cells are infiltrated with the new connective-tissue cells, and the air cells may contain organized exudate.

In the unilateral cases the unaffected lung is enlarged because of the compensatory emphysema present.

Symptoms.—In looking for the symptoms of chronic pneumonia we first get a history of one or more of the diseases which it follows, especially chronic bronchitis or protracted bronchopneumonia. In the early stages the patient may feel fairly well, complaining only of cough with sero- or mucopurulent expectoration. The cough is worse in the morning, and is paroxysmal when there is an accumulation of secretion in the lower lobes. As the process advances there is dyspnea on exertion. Lying on the unaffected side may cause dyspnea, as it restricts the action of the functioning lung; consequently patients with unilateral chronic pneumonia lie on the affected side. With the onset of ulceration a new order of symptoms is noted, all of them being worse during the winter season. The sputum changes its character and becomes a thin mucopurulent fluid, of a gray or black color and is often fetid. On standing it separates into layers; the lowest contains solid particles and is yellowish in color; the next above is a greenish fluid; and the top layer is thin and frothy and contains mucus and fat. Cavities are formed, allowing of accumulations of pus, and these in some instances are emptied by change of position. Fever, of a hectic type, and night sweats may be looked for early, and small, frequent hemoptyses are common occurrences. With the conditions present giving such symptoms, it is no wonder that the patient's general condition becomes rapidly worse. The whole aspect of the case is that of chronic pulmonary tuberculosis, excepting that no tubercle bacilli can be found.

There is no elevation of temperature except during exacerbations of the bronchitis and after ulceration has begun, as noted above. Pain is by no means a constant symptom. It is present only when the pleura is involved, and then the diminution of respiratory movement on that side usually keeps it from being very severe.

For months we may be able to discover only the physical signs of previous or coexisting disease. Gradually there develop signs due to diminution of aërating surface, thickening of pleura, contraction of the new tissue giving lessened or absent respiratory movement, deformity of the chest, spinal curvature, and displacement of the heart. The cardiac pulsations are sometimes abnormally visible. The dilatations of the bronchi, with or without contained fluid, also give rise to special symptoms. In unilateral cases the unaffected side is increased in size, has increased respiratory movements, and shows the signs of compensatory emphysema.

Treatment.—In the management of these cases prophylaxis is of the utmost importance. All patients with persistent bronchitis, or with protracted or unresolved pneumonias, and those who have had several attacks of bronchopneumonia, should receive the very best tonic treatment with respiratory exercises; and above all, they should find the climate in which they do best and should, if possible, live there. When the trouble is due to the occupation, this must be abandoned. No treatment directly affects chronic pneumonia when once it is established. The therapeutic endeavor is then to control the cough, overcome the fetor of the sputum, and keep up the general tone of the individual. The patients must avoid exposure to cold and wet. They must spend their winters, at least, in the South, and are better for living the year around in a dry, warm, equable climate. Moderate daily outdoor exercise and the best of food are very important.

The quantity and odor of the sputum are often greatly reduced by inhaling the following mixture:

℞. Formalin ..... 1.0(℥xv.)
Chloroformi ..... 1.0(℥xv.)
Menthol ..... 0.33(gr.v.)
Olei anisi ..... 0.33(℥v.)
Spts. vini rect. q. s. ad..... 120.0 (℥iv.)
M. et Sig.—Gtt. x. q. 2. h. on respirator.

Ten drops are put on the sponge of a perforated zinc respirator (Wyeth), which is worn over the nose and mouth for at least half an hour. When possible this should be repeated every few hours.

When bronchiectasic or other cavities are present it is advisable to see if these can be emptied by having the patient assume for a few minutes as nearly as possible an inverted position. If it is found successful it should be made use of at least twice a day.

Diagnosis.—In aiming at a diagnosis of chronic pneumonia, we have to consider the possibility of pleurisy, pneumothorax, cancer of the lung, syphilis of the lung, and pulmonary tuberculosis.

Prognosis.—The outlook for the future comfort and happiness of these patients depends largely upon their dispositions and their ability to get to a suitable climate. No hope of cure can be held out to them. The disease, however, is seldom in itself a cause of death. Some intercurrent malady usually terminates the scene.

Henry E. Hale.

Pneumonia, Lobar.—Lobar pneumonia is an acute infectious disease in which there is exudative inflammation of more or less of the lung tissue.

Infective Organism.—As a rule the infective organism is the *Diplococcus pneumoniæ* (Weichselbaum[1]), which is more commonly called the pneumococcus (Fraenkel[2]). It is found in the consolidated areas, in the sputum and in the majority of the cases it can also be demonstrated in the blood and spinal fluids. The Friedlander bacillus also incites a small proportion of the cases of lobar pneumonia and mixed infections are also seen.

In cases in which the lobar pneumonia is a complication, the organism causing the primary disease may be found in pure culture or associated with one or more others. Pneumococci are present in from fifty to seventy-five per cent. of normal mouths and throats at all times. It has, however, been found by Dochez and Avery[3] that these mouth pneumococci always fall into group four (see below) and are responsible for only about twenty per cent. of the cases. The other eighty per cent. are of the more virulent strains and are found only in pneumonia patients and in the mouths of the attendants and in true "pneumonia carriers."

Predisposing Cause.—In reviewing cases it seems quite certain that exposure to weather and fatigue are contributing causes and the field is, as it were, prepared by irritation of a coryza or grip, real or so called. It appears, however, unusual for a frank bronchitis to develop into a lobar pneumonia.

Distribution.—Pneumonia is most prevalent in the temperate climates of the earth. It is almost unknown in the arctic regions and is rare in the tropics.

Cases developing in the tropics among the natives are most often the result of the contact with whites. The severity is very great, presumably because of no racial immunity.

Mortality.—The mortality differs greatly in different seasons and places. Sometimes it seems as though nearly all died, at others that nearly all got well. These variations are apparently the result of difference in virulence of the strain of pneumococcus and the resistance of the patients. Persons whose resistance is enfeebled by age, illness, or alcohol almost always die. No mortality percentage can be given as that of lobar pneumonia.

Anatomical Process.—The anatomical process is an oozing of a hemorrhagic, coagulable, fibrinous, that is, croupous, exudate into the alveoli and the smallest bronchi. This coagulates and fills the spaces, excluding air and fixing the portion of pulmonary tissue it occupies. The classical description divides this process into three stages as follows:

The *first stage* is that of inflammatory engorgement. The involved portion of the lung tissue is greatly congested and by reason of this is a dark red color. The alveoli contain much, as yet, uncoagulated exudate, which has excluded a considerable portion of the air.

The *second stage* is called that of *red hepatization* in which coagulation of the exudate has taken place. The involved areas are somewhat increased in volume and are as solid as liver, which they resemble. The cut surface is granular because of the alveoli crowded full or exudate. When the edge of the knife is drawn over the surface of the cut, it collects a creamy, grayish-red sticky fluid.

The *third stage* is called that of *yellow* or *gray hepatization*. This has gradually developed from the second. It may be mottled as the red blood cells decrease and the white ones increase. The fluid scraped off from the cut surface is more abundant and milky or purulent than in the second stage. As the liquefaction goes on, recovery takes place.

General Course of the Disease.—Though each case is individual and must be considered as such, there is much in common in the symptoms.

Onset.—The onset is almost always sudden. It is nearly always marked by a distinct shaking chill or a prolonged uncontrollable chilliness. Not infrequently the feeling that a serious condition has arisen seizes the patient.

Focal symptoms and physical signs do not, as a rule, develop until some hours later. Occasionally pain in the side is felt almost at once and the cough comes quickly and aggravates the pain. Because of the effort to keep from exciting the pain the respirations are shallow, more or less rapid and at times irregular. The chill is quickly followed by a sharp elevation of temperature to 104° F. (40° C.) or 105° F. (41° C.) or more, and quickening of the pulse and respiration rates. The proportionate increase of the respiration being greater than that of the pulse, disturbs the normal pulse-respiration ratio causing it to approach two to one. True dyspnea develops when large areas of the lungs are consolidated and when the heart has become inadequate for any reason.

During the first twenty-four hours there is usually no expectoration. On the second day the very sticky, ropy, red hemorrhagic sputum is usually seen. The sputum may, however, be only mucous or mucopurulent, or as yet there may be none at all. The cough is a most distressing symptom, greatly hastening exhaustion especially by preventing sleep. In rare instances there may be no cough and no sputum, particularly in the very infirm, whether aged or not and in drunkards where the pneumonia is complicated with delirium tremens.

Even without invasion of new lung areas the constitutional symptoms grow worse. These are great weakness, restlessness, and sleeplessness, in many instances mild delirium and in alcoholic subjects wild delirium. The occurrence of stupor or coma indicates an overwhelming amount of poison usually with great bacteremia, with or without renal inadequacy.

Defervescence and Recovery.—The serious symptoms and discomforts, as a rule, end as abruptly as they began, *i.e.* by crisis. The crisis comes most often on the fifth day, next most often on the seventh. When postponed more than a week it is due to new lung involvement, pleural, pericordial or other complication. In the crisis the temperature drops in a few hours to normal or below and never rises again more than a degree or two above normal. In a comparatively small number of cases the defervescence is by lysis and covers two or three days.

Death.—In the cases ending fatally, death may come suddenly at any time, most likely at the time of the crisis. If it comes slowly it is likely to come late.

Symptoms.—The *physical signs* are those of the chest condition. The toxic appearance of the patient in a way foretells what the blood culture will reveal as to the degree of bacteremia.

The physical signs of consolidation need not be discussed here. It will be wise, however, to consider certain things seen in a pneumonia patient. There is frequently herpes labialis and a flushed cheek or cheeks and in severe cases more or less marked cyanosis. The nostrils will often be seen to expand with each inspiration and the accessory muscles of respiration are called into action to do what they can to get more air into the lungs. The respiratory movements will be seen to be rapid, rarely under thirty-two and often sixty or more a minute. If only one side is affected it will be noticed that that side lags behind the other and has a smaller arc of motion in the respiratory excursion, and further, the patient will not lie on the unaffected side as it restricts too greatly the lung that is doing already more than its share of the work.

The signs of dry pleurisy need not be mentioned. However, those of a complicating effusion must be considered. Fluid may appear in the pleural cavity very early, so must be constantly borne in mind. Its presence can always be certainly determined by the use of the needle. In typical cases the superimposing of signs of fluid on those of consolidation are positive. Should the fluid become purulent, the temperature curve is disturbed and the expected recovery does not come. If an exploratory puncture has not already been made, it is now demanded. It is also demanded if at a previous time serous fluid was demonstrated.

The Circulation.—The pulse is quickened at the very beginning of the illness and continues fast until the defervescence. The degree of acceleration in a measure indicates the virulence of the infecting organism. A regular, full, strong pulse of not over 120 is not in itself alarming. However, irregular, feeble, or laboring action of the heart with a small pulse is a dangerous sign, especially if accompanied with cyanosis. It is interesting here to note that a systolic blood pressure in millimeters of mercury, above the pulse rate per minute, is a good prognostic sign and the reverse a danger signal.

If the defervescence be by crisis a sudden collapse of the circulation may occur, with a drop of temperature down even as low as 93° F. (34° C.). This condition is very dangerous. It must, if possible, be anticipated and met at once by appropriate treatment.

The infection may extend by contiguity to the pericardium or peritoneum. It may set up a fibrinous, a serous, a serofibrinous or purulent inflammation, adding a very serious burden, likely the one that will decide the issue. In some cases such a complication can be readily discerned on physical examination.

Temperature.—Excepting in asthenic persons lobar pneumonia always runs a high fever. It goes up very quickly after the invasion and with more or less variation stays high until the beginning of the defervescence. In a study of 145 cases, considering only the 8 A.M. and 8 P.M. temperatures, Rohdenburg and Vander Veer, Jr.[4] report that in the non-fatal cases the highest fever came most often on the third day and in the fatal ones on the fifth.

During the period of high temperature in New York during August, 1896, when insolation cases were being brought into the hospitals in large numbers, a patient evidently with very high fever came in with others and was put immediately into a tub of ice water. A thermometer was then in routine fashion inserted into the rectum and registered 108° F. (42.2° C.). As soon as the temperature was well started down the patient was sent to the ward and on physical examination was found to have a typical lobar pneumonia. He made a good recovery.

Leucocytosis.—In all cases in which the body offers effective resistance to the pneumococci there is a leucocytosis. It may go up to 40,000 or more per cubic millimeter with a sharp rise in the polymorphonuclear percentage as shown by Rohdenburg and Vander Veer, Jr.[4] In non-fatal cases the highest leucocyte count most often comes on the first day of the disease and the highest polymorphonuclear percentage on the third or fourth day; also in fatal cases the highest leucocyte count is most often on the third day and the highest polymorphonuclear percentage on the sixth day.

Meningeal Symptoms.—Symptoms of meningeal irritation are frequently observed especially in children. In such cases it is unusual to have a true meningitis without irregularity of the respirations and purulent spinal fluid.

Rohdenburg and Vander Veer examined the spinal fluid in sixteen cases and report that pneumococci were frequently found when no meningeal symptoms were present and that with them were always associated positive globulin and sugar reactions. The presence of the organism is an unfavorable sign.

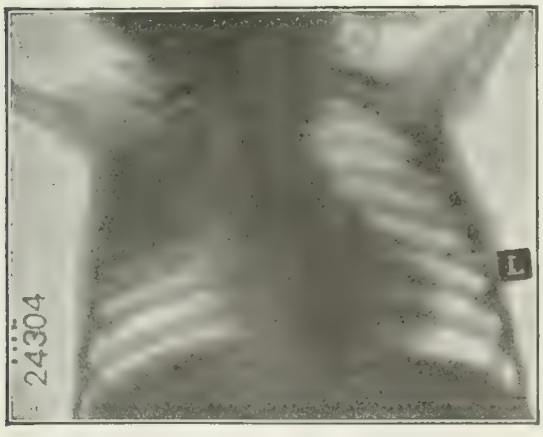

Fig. 4328.—Typical Roentgen Picture of Pneumonia.

The *digestive tract* presents no characteristic signs. Distention must be borne in mind and if persistent suggest peritonitis.

The *kidneys* may be acutely congested or an acute nephritis may develop. Such a complication, of course, influences the immediate prognosis somewhat, but in case the patient survives the pneumonia, the kidneys almost invariably return to normal. As in all cases where the intake of food and water falls off, the urine is dark and of high specific gravity. The diminished output of chlorides is of minor significance. The reappearance of normal amounts shows resolution.

Resolution.—As a usual thing the lungs are clear in from three to seven days after the crisis. However, this does not always occur. It may be delayed for weeks. Such delay may be due to some constitutional handicap as nephritis, anemia, or tuberculous disease, not necessarily of the lungs. In fact it may be due to the lighting up of an old tubercular process or to the engrafting of a new one. Delayed resolution must not

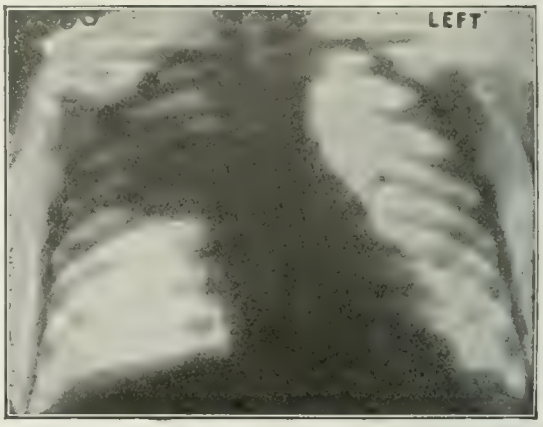

Fig. 4329.—Roentgen Picture of a Case of Pneumonia Giving No Signs of Consolidation.

be confounded with an empyema. A termination in chronic interstitial pneumonia or gangrene or abscess of the lung is unusual.

X-ray Diagnosis.—In hospitals or other institutions for the care of the sick an investigation of the chest by *x*-ray will often show that a "central pneumonia" exists and reveals consolidation in excess of the physical signs. Hartshorn[5] reports an interesting series of *x*-rays in chest conditions in children.

Treatment.—In the last few years there has been some progress made in the treatment of pneumonia and more is to be expected. The logical aim of treatment is first preventive and next curative. The curative aims are to kill the bacteria in the focus or foci and in the blood; and to secure good general oversight and to treat symptoms as they arise.

Preventive Treatment.—This resolves itself into three parts; first, the patient must not be allowed to be a source from which infection may spread; second, the patient's attendants must see to it that they do not themselves become infected or become carriers; third, general directions to be observed even in the absence of any known case or carrier.

The *first* of these aims is attained by seeing to it that all sputum, nasal discharges, or pus from complicating abscesses are caught and burned or thoroughly disinfected in phenol or lysol solution and that eating utensils, clothing, and bedding are boiled and that all bath waters are disinfected.

Second, the attendants of a pneumonia patient, be they rleatives or trained nurses, must be free from coryza or grip and so far as possible must not become overfatigued. It is further necessary that after each time in any way caring for the patient they must wash their hands and rinse in an antiseptic solution.

Third, the *general directions* in the very nature of the case cannot be explicit. However, avoid being chilled especially when fatigued or when already having an inflammation of the respiratory tract. These simple directions are of particular importance to persons who have once had pneumonia, as they are more susceptible than others.

Curative Treatment. — Bactericidal Measures. — Through all the years since it was proved that pneumonia was a bacterial disease, there has been a constant effort to find some way of killing the bacteria or failing in this, to make the blood serum a less fertile culture medium.

These aims are apparently partially realized by the use of a number of measures. I will mention in more or less detail the use of camphor, quinine and urea hydrochloride, creosote, ethylhydrocuprein, antiserum, and vaccine therapy.

Camphor.—For about ten years Dr. August Seibert[6] has been using with benefit subcutaneous injections of camphor in oil because of its pneumococcidal power. I have not used it in enough cases to express a conviction concerning it. The method is to inject 1 c.c. of twenty per cent. or thirty per cent. sterile camphor in olive oil, per every ten pounds of body weight. In very severe infections, especially where new areas are being involved, the injections are to be given every eight hours. When large injections such as these are given they should always be heated to a little above body temperature and the strictest asepsis observed.

Quinine and Urea Hydrochloride.—Solomon Solis-Cohen[7,8,9] has reported a long experience with intramuscular injections of quinine-urea hydrochloride solution. He calls it the "definite treatment." With it he greatly reduces mortality and greatly lessens the discomforts of the patient. In conjunction with it he uses some preparation of hypophysis cerebri, cocaine hydrochloride, and epinephrin with cocaine or camphor to maintain heart and vessel tone. I will quote from his article that appeared in the *New York Medical Times.* "In pneumonia the dose varies with the age and the vigor of the patient, the general severity of the case, and the time elapsing from the initial chill to the beginning of treatment. If the case is seen on the first day, and the patient is a vigorous adult under fifty years of age, the effort should be made to give as much quinine as possible within the first twenty-four hours. The initial injection may be twenty-five grains (1.6 gm.) and this, or a smaller dose, may be repeated in three or four hours, according to the effect produced. Aged persons, weak persons, and children receive proportionately small doses. Should the case be first seen on the third day, the initial dose should be governed somewhat by the height of the temperature and the severity of the general symptoms. If the temperature exceeds 104° F., and the patient markedly labors for breath, the first injection may be twenty-five grains; otherwise fifteen grains should be given and this dose repeated every third or fourth hour, according to circumstances, until the temperature falls and remains below 102.2° F.; to be repeated when the temperature again rises. While the object of the treatment is not antipyretic, the temperature line of 102° F. is taken as an approximate index of the severity of the infection, or rather of the toxemia, on the one hand, and on the other hand, of the adequacy of the patient's reaction. It is not desirable to reduce temperature abruptly below 102° F. by any form of treatment except, perhaps, the use of specific bacterin.

"Sometimes a single injection of fifteen to twenty-five grains (1 to 1.6 gram) suffices. Usually, however, from six to ten grams or more are given in the course of from forty-eight to seventy-two hours. The temperature quickly falls after the first injection, sometimes remaining down, but more frequently again ascending, and thus indicating the necessity of renewed injections. Pulse rate also falls, and with it, at first, blood pressure; but the latter, in cases of favorable prognosis, quickly regains its former level and even tends to go higher. In my more recent experience I have injected immediately after the quinine, or with it, about one-half grain (0.03 gram) of cocaine hydrochloride to keep up the vascular pressure; and this dose of cocaine is repeated as often as necessary, which may be several times a day, once or twice in an attack, or not at all. The indication is a tendency for the line representing systolic blood pressure measured in millimeters of mercury, and charted upon the same vertical as the line representing pulse frequency (in beats per minute) to fall below the latter.*

"To raise blood pressure and to stimulate and sustain the heart when necessary, the physician may employ, if he so prefers, epinephrin, pituitrin, camphor, musk, atropine, or strychnine, with, or instead of, cocaine. Digitalis is too slow and in the presence of fever, too uncertain. The adrenal principle is prompt but its action is fugacious. Its association with cocaine or camphor is usually efficacious; quick response coming from one agent, sustained effect from the other. To resume the statement of the effect of the quinine and urea injection, its most marked effect is upon the respiration, the rate of which falls proportionately lower than temperature or pulse frequency. Even when its rapidity is not markedly diminished, breathing becomes much less labored and distressful. The most significant fact of all is that cinchonism does not develop under these enormous doses of the most active quinine salt. Should it do so, it would be an indication for withdrawal of the drug, at least until the quinine symptoms had abated.

"The disadvantage of quinine and urea hydrochloride injections is, that *handled carelessly* they may excite cellulitis abscess or slough. Hence the following directions should be followed: All the instruments to be used are sterilized by boiling; the skin over the part into which the injection is to be made is cleansed with green soap and water, and then an area of some two inches in diameter is painted with tincture of iodine; a high pressure syringe is used and the long needle attached thereto is plunged deeply into the muscle; care is taken to expel all of the contents of the syringe, so that in its withdrawal, none of the solution shall be dropped in the surrounding tissue; the puncture is then sealed with iodoform collodion."

Creosote.—For administration by mouth I have depended mostly on creosote, administering it in enteric pills or a solution, two minims (0.13 c.c.) in ½ ounce (15 c.c.) of twelve per cent. alcohol in one-quarter glass or more of water every two or three hours or I have used it in an emulsion as recommended by Dr. W. H. Thomson.[10] His prescription is as follows:

℞. Creosoti carbonatis	9.
Mucil. acaciæ	90.
M. deinde adde:	
Glycerini	30.
Aq. menth. pip. q. s. ad	250.

M. et. S.: tablespoonful in water every 2 or 3 h.

Ethylhydrocuprein.—Quinine derivatives, especially ethylhydrocuprein, have been found to possess a strong antipneumococcal power. The latter is potent against all strains, as Morgenroth and Hallerstaedter[11] have shown. In watery solution it is absorbed too quickly. In oily suspension it is absorbed much more slowly with more bactericidal action. It was further discovered by Boehnicke[12] that its activity was enhanced by giving it with antipneumococcus serum. The great drawback concerning the use of this drug is that its therapeutic and toxic doses are so nearly the same that it is absolutely unsafe. However, it is of interest to note in passing that because of its great antipneumococcic power it is very valuable in corneal ulcers.

Serum Therapy. It has been shown that in cases of pneumococcus infection the serum contains no

* Dr. Solis-Cohen has written me that he has observed that the respiration curve in respirations per minute should be kept a considerable distance below the diastolic pressure curve in millimeters of mercury. The significance of this interrelation, he says has not the importance of that of the systolic pressure and pulse rate per minute.

true toxin, comparable to that of diphtheria (Cole[13]). However, from the time of defervescence for an unknown length of time there are present a variety of antibodies (Cole and Dochez[14]). By the use of various means, experimental protection can be established in some laboratory animals. The effect of these antibodies when injected in excess is to produce symptoms resembling anaphylaxis even to death. It may be that the beginning dissolution of the consolidation so deluges the system with antigen that the resulting antibodies bring about the crisis with its drop of temperature, perspiration, and possible heart failure and collapse.

Cole and Dochez[15] report some benefits from serum injection but state that it has not reached a practical stage.

Vaccine Therapy.—The status of vaccine therapy in treatment and prophylaxis is still undetermined. The course of lobar pneumonia is so short that autogenous vaccines are out of the question during the first few days of the disease. There are so many strains of pneumococci, each protecting only against itself, that the indiscriminate use of stock vaccines is absolutely useless. In an endeavor to overcome this, Dochez,[16] and Dochez and Gillespie,[17] as a working plan, have divided all pneumococci into four groups which are distinguished by their agglutinations. The first and second groups constitute the majority of cases and with each of these two it is possible to produce some degree of experimental immunity against itself. The third group is composed of the *Diplococcus mucosus* with which it has been impossible to make any immunizing serum. The fourth group is a heterogeneous one. It comprises all not in the other three. Adopting this grouping, it is seen that by having two stock vaccines on hand, one for group one and the other for group two, one or the other may be promptly and appropriately used just as soon as an agglutination test shows the case in hand belongs to either of these two groups. The pneumococci for this determination are obtained from blood or sputum by cultures.

Cold Fresh Air.—As soon as the diagnosis can be made the patient is to be put where he can have the freshest cold air to be had. By this means the work of the damaged lung is made as easy and as perfect as possible. Excepting in times of extreme cold, winter temperatures are no contraindication. The patient should be on a balcony or roof and kept there, excepting when it is necessary to uncover him. On these occasions he is rolled, bed and all, into a warm room. When no balcony or roof is at hand, the next best place is a corner room with windows on two sides and the windows kept open. Good as the latter way is, it is not as good as being actually out of doors. One indication of this is that there is not as great a resultant increase of blood pressure. Meara[18] gives this as his experience with regard to blood pressure in the open and in the ward.

These patients must be sufficiently covered to make them comfortable. In warm weather or while in a heated room a sheet may be enough. However, in winter it is often necessary for the patient to wear a thick hood and to keep a hot water bottle at the feet in addition to the usual thick coverings of blankets.

Oxygen.—If the patient is in the open air he is getting all the oxygen he can utilize without recourse to the oxygen cylinder. However, if he cannot be in the open air, the purest oxygen may be used to advantage when cyanosis begins. To be of service it must be used before the patient becomes moribund.

Ramond and Maissonet[19] have employed oxygen, run directly into the subcutaneous tissues by means of a needle. The gas must be free from chlorine and filtered through a little absorbent wool placed in a glass tube inserted in the rubber tubing. The gas is allowed to bubble under the skin for twenty minutes. It is to be repeated according to the necessities of the case. This method of administration is said to be better than the usual one.

Examination and Bathing.—The patient will assume the most comfortable position usually on his back or on the side most involved. Our aim must constantly be to prevent any and every unnecessary exertion on his part. This, of course, means that he must leave bed for absolutely nothing and that after the third day, the attending physician must move him little or not at all, for physical examinations. The nurse in bathing and changing the bed linen must also remember this. Warm sponging night and morning with careful drying and use of talcum powder add greatly to the patient's comfort. If profuse perspiration occurs, warm alcohol sponging followed by light friction will lessen it.

Temperature.—For the sake of accuracy all temperatures should be rectal.

Symptomatic Treatment.—The Chill. The initial chill is usually over before the physician arrives. However, if possible, the patient should be put at once into a warm bed and local heat applied by any means at hand, for example, hot blankets, hot water bottles, electric pads, hot non-alcoholic drinks and hot mustard foot and leg baths.

Headache.—The use of an ice cap is often all that is needed. Antipyretics should not be used to relieve this condition.

Delirium.—In the non-alcoholic this is rarely if ever difficult to handle, using only codeine, or morphine, or chloral. The last can be used in gr. 10 to 15 (gm. 0.66–1.0) doses. If the blood pressure is low it should not be used at all. Hyocin is used in doses of $\frac{1}{150}$ to $\frac{1}{100}$ (gm. 0.0004 to 0.0006) hypodermatically. If this is the drug needed, the first dose is pretty sure to demonstrate it. Great caution should be exercised in its use as a slight overdose may cause death.

In alcoholic cases moderate amounts of alcohol are needed and large doses of paraldehyde—as much as two teaspoonfuls (11.0 c.c.) at a time.

Cough and Pain.—These may be very distressing, preventing rest and sleep. As the pain is pleuritic, strapping with adhesive plaster is to be tried, but kept on no longer than absolutely necessary. If strapping fails to relieve, hot moist applications with or without counterirritants every few hours are often of great value. This may be used before strapping is tried. In certain instances the ice-bag to the painful areas is all that is needed. It can be used nicely over strapping. I have seen it prove too much for feeble patients, every application causing cyanosis. It should always be used with caution.

Acetylsalicylic acid (aspirin), gr. 10 (gm. 0.66) with codeine sulphate gr. $\frac{1}{2}$ (gm. 0.03), the latter by hypodermic, may be tried every two hours. If they prove unsatisfactory morphine should be used. As it will be needed at the longest for only a few days there is no danger of habit formation.

Circulation.—The treatment of circulatory disturbance may be either of two extremes or any point between them. It may, on the one hand, be unnecessary and the physician in charge must be wise enough to recognize this and bold enough to do nothing. On the other hand, it may require the most active treatment throughout. Between these extremes fall the vast majority of the cases, including those with sudden failure coming on at the time of the crisis.

The failure of circulation may be cardiac, *i.e.* myocardial insufficiency, or of vascular, *i.e.* vasomotor origin, or due to a combination of the two.

The obstruction to pulmonary circulation, the chemical changes in the blood, and the bacteremia throw an excessive load on the heart, which must be eased and never in any way further burdened. Such overburdening might come from overfeeding, especially of food causing gas and thus exerting pressure on the diaphragm, or from the taking of large amounts of fluid, which would quickly be thrown into the

blood stream giving the heart more to pump around, or by the changing of the patient's position. The latter, if the patient is raised, may do harm by making the heart work against gravity; if simply turned, by constriction of the chest acting directly on the heart, and indirectly through further embarrassment of the respiration.

The collapse may come on suddenly without warning, particularly during the crisis, or it may come slowly as is shown by the quality of the pulse, the heart sounds, and the falling of the blood pressure.

The first aim is to forestall any trouble by the treatment of the disease and by the judicious, *i.e.* ample and continuous, use of digitalis, having as a guide the blood pressure which must be kept up so that read in millimeters of mercury, it will be well above the pulse beats per minute.

When circulatory failure is once at hand there is no time to send out to get or to prepare restoratives. They must be on hand and ready to be used at once by the person who is at that time with the patient. It is always best, when possible, to have a physician constantly with a pneumonia patient during at least the most dangerous nights.

The usual nursing treatment of shock is at once started and the very efficient hypodermic administration of epinephrin (1 to 1,000) begun. From ten to thirty drops (0.6 to 2.0 c.c.) are given as often as needed. When given in conjunction with the hypodermic use of cocaine gr. ½ (gm. 0.03) it rarely has to be repeated under an hour. Infundibulum extract may be given in place of the epinephrin if a potent supply is at hand. Its action is less rapid but lasts longer than that of epinephrin. The blood pressure and heart action are to be kept up by repeated doses of these rapidly acting substances until digitalis can take hold and stability of the circulation once more be established. Transient glycosuria often develops after the use of epinephrin.

Caffeine was formerly largely used, but as it is almost solely a diuretic and cerebral stimulant, its use is really not appropriate. Its circulatory stimulation is so slight that it requires the hypodermic injection of gr. 5 (gm. 0.33) to make any appreciable rise in blood pressure. The use of strychnine has also been found of no service.

Urinary Condition.—The urine must be examined daily as to specific gravity and albumen and the specific gravity kept down, preferable below 1010 by the free giving of fluids in small amounts at a time.

Gastrointestinal Symptoms.—As in every infection, the gastrointestinal tract should be thoroughly emptied within a few hours. A grain and a half to two grains of calomel in divided doses at frequent intervals is in most instances the best drug to start with. This should be followed in from an hour and a half to two hours by a saline. The intestines and stomach must not at any time be allowed to balloon up with gas because of the consequent embarrassment of the respiration and heart action. This is prevented by careful diet and laxatives and enemata. If it does occur it is to be controlled by enemata, rectal tube, and the hypodermic use of eserine and pituitrin extract.

One of the prime factors of successful treatment is not to overfeed and still to supply supporting, easily assimilable food. Wolf and Lambert[20] have found that there is an excessive excretion of nitrogen, sulphur, and creatinin, roughly in proportion to the severity of the pneumonia. They report that "the daily loss of nitrogen on a diet adequate to protect a resting individual from nitrogen loss, may be twenty to twenty-five grams." This would lead us to advocate a high protein diet, if one can be found which the patient can readily digest. In giving milk it is necessary to begin it in small amounts as it at times forms large, tough, leathery curds which greatly annoy and even endanger the patient's life. Boiling of the milk helps do away with such curding, and buttermilk with or without the addition of milk sugar may be the very thing needed. One-half to one teaspoonful of dilute hydrochloric acid added to the quart of milk straight or diluted half with water and thoroughly stirred is often well borne. In order to get sufficient calories from a milk diet (1 quart equals about 700) approximately four quarts would be needed. This is out of the question, and cereals cooked three hours must be added. Custards and other soft forms of milk and eggs may be used. Purées of lima or kidney beans or lentils or dried peas have been found of great advantage. Any food or drink, including water, must be given in small amounts. The water must be urged frequently. When the circulation is unstable an extra half pound of water thrown quickly into the vessels, without time for the kidneys to eliminate an equal amount, may be enough to throw the balance the wrong way.

HENRY E. HALE.

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Pneumonoconiosis.—This generic name for the dust diseases of the lungs has to some extent become obsolete, and the literature tends to accumulate under individual forms of the disease, as encountered in special occupations. Indeed the word pneumonoconiosis has been actively repudiated by some clinicians. In the Surgeon-General's Catalogue it has been replaced by Dust Diseases of the Lungs. Nevertheless F. T. Lord, in his recent monograph "Diseases of the Bronchi, Lungs, and Pleura," not only retains the name but writes at great length on the subject. He asserts that dust diseases are in reality bacterial in origin, at least for the most part. Dust is an accompaniment but not a causal factor of disease, beyond the fact that it renders the pulmonary tissues more vulnerable to bacterial invasion. A doctrine of past years, recently revised, is that dust is not inhaled directly but swallowed and absorbed. That the lungs are ever reached in this manner seems very questionable.

The kinds of dust concerned in pneumonoconiosis comprise carbon (coal dust and soot), metal dust (chiefly of iron, steel, brass) and stone dust, all of which are inorganic in origin and nature, save charcoal and soot. The diseases produced by these three types of dust are known respectively as anthracosis, siderosis, and chalicosis or silicosis. These are separately considered in this HANDBOOK under the titles *Anthracosis*, *Siderosis*, and *Silicosis*. A fourth form of

dust is included by systematic writers, which consists of a purely organic débris given off in the manufacture of textiles, flour milling, the tobacco trades, etc. (See *Occupational Diseases.*) The medical control of the dust diseases is entirely prophylactic. Aside from well-marked occupational diseases, the public at large, notably in cities, is obliged to inhale a great amount and variety of dust—soft coal smoke, street and railway dust, and the accumulations in homes, factories, and public buildings. Fortunately much may be done in overcoming drawbacks of this sort by suitable legislation. EDWARD PREBLE.

Pneumothorax.—By this term is understood the presence of air or gas in the pleural cavity. Since there is generally also fluid present the terms hydropneumothorax when the fluid is serous, pyopneumothorax when it is purulent and hemopneumothorax when it is bloody, are the ones most frequently used. Pneumothorax may be spontaneous or artificial. The latter may be accidental as it occurs during the performance of a thoracentesis, or premeditated as when it is produced in the treatment of pulmonary tuberculosis or in operations involving the pleural cavity. Therapeutic pneumothorax will be discussed in detail in the article on pulmonary tuberculosis.

Spontaneous pneumothorax was recognized by Hippocrates who mentions succussion though he regarded it as an empyema. Because of their elasticity, the lungs tend constantly to collapse so that there exists in the pleural space a negative pressure. When, in any manner, air or gas is admitted to this cavity the lungs collapse to an extent depending upon the amount of gas admitted and there is then present a pneumothorax. The pressure in the pleural cavity when a gas is present depends upon the nature of the opening through which the gas entered. If the opening is a valvular one in the lung, air enters during inspiration and is unable to escape during expiration so that the pressure rises and may be very high while the lung is completely collapsed. If the opening is closed the pressure depends upon the amount of gas admitted. If the communication is freely open the pressure will be practically zero and air will pass in and out as the chest moves.

ETIOLOGY.—The most frequent cause is pulmonary tuberculosis in the active state, in which there has been a rupture of a subpleural tubercle or a tear of the lung by an adhesion during some violent effort such as lifting, coughing, or sneezing. Abscess, gangrene, or infarct of the lung and bronchiectasis are much less frequent causes. Perforating wounds of the chest wall often result in pneumothorax. A few cases have been described as occurring in apparently healthy individuals after violent exertion. In a few cases also a pneumothorax has been produced by the growth in the pleural fluid of a gas-producing organism.

PATHOLOGY.—If the pleura is free from adhesions and the opening is sufficiently large, the lung collapses and may be found shrunken against the vertebral column as a dense unaerated mass. It is generally the seat of advanced tuberculous changes and the perforation can be found leading to a cavity. Through the opening bacteria gain access to the pleural cavity and produce an infection that is accompanied by the formation of more or less exudate which may be serous or purulent. Blood is generally present in the traumatic cases. In the presence of adhesions the collapse of the lung is less complete. The contents of the mediastinum are pulled over to the unaffected side the degree depending upon the number and location of adhesions. The heart is displaced more in left- than in right-sided pneumothorax. The diaphragm is often depressed on the affected side.

SYMPTOMS.—The onset is generally gradual though in the absence of adhesions and the presence of a fairly large opening it may be sudden with severe pain and dyspnea. There is often an unproductive cough and always more or less pain in the chest. This may be very severe and the symptoms may simulate angina pectoris. The shock accompanying a sudden onset may be marked and if the air accumulates the patient may die in a short time. In the milder cases there is only an aggravation of the usual symptoms especially the pain and dyspnea.

Physical Signs.—There is enlargement and immobility of the affected side and a displacement of the cardiac impulse. Vocal fremitus is diminished or absent, depending on the presence of adhesions. The percussion note depends upon the presence of fluid in the pleural cavity and upon the degree of collapse of the lung. Over the contained air it is hyperresonant. The area of cardiac and liver dulness is displaced and usually diminished. There is dulness over the lung. There may be a cracked-pot sound or the percussion findings may be wholly irregular. Over any fluid that may be present there is flatness though the amount of fluid is generally underestimated. The upper level of flatness changes very rapidly on change in position of the patient and it is always a horizontal line. The breathing voice and whisper are much diminished or entirely absent. In some cases the breathing has an amphoric quality like that produced by blowing across the mouth of a bottle. Although an open fistula exists in the majority of the cases in which this amphoric quality of the breathing is heard, nevertheless it is probable that "the sound is due to the resonating properties of the pneumothorax cavity and is produced by the vibration of air within the cavity itself or by vibrations propagated from neighboring parts of the lung or bronchial tree" (Lord).

A metallic tinkling may be heard and is quite characteristic of the condition. Its cause has been ascribed to drops falling into the fluid from above, the washing of the fluid against the sides of the cavity or the bursting of bubbles at the surface of the fluid. It may be audible to the patient. The "Hippocratic succussion sound" is obtained by shaking the patient's body while the ear is held against the chest. If the amount of fluid is small the splash may not be obtained. This sign is usually positive before any of the other signs of fluid are obtainable. It should not be confused with the splashing sound originating in the stomach, but there may be difficulty in distinguishing it from the sound heard in a large cavity containing fluid. The coin sound is obtained by having an assistant tap one coin against another which is held against the chest wall while the examiner listens with the ear or stethoscope at a point directly opposite. A coin sound may be heard over a large cavity. It is a clear bell-like, echoing sound. The *x*-ray examination usually yields a picture that is easily recognized.

DIAGNOSIS.—Sudden pain in the side followed by severe dyspnea, generally following some slight exertion, and in the course of a pulmonary tuberculosis should cause a suspicion of a pneumothorax. The important signs are resonance on percussion with suppression of the voice and breathing together with succussion, coin sound, and metallic tinkle. It may be confused with a large pulmonary cavity which may or may not contain fluid. With a cavity however, the development of the symptoms is slower, and the heart and diaphragm are displaced toward the affected side rather than away from it. The *x*-ray examination is of great assistance in making the diagnosis. It may be very difficult to differentiate a pneumothorax from the so-called subphrenic pyopneumothorax. This is a collection of air and pus below the diaphragm and is due to a perforation of the intestine or an infection with the gas bacillus. All the physical

signs of a pneumothorax may be present. The history is very different, as a rule, and the *x*-ray examination furnishes valuable information. Diaphragmatic hernia may rarely cause confusion in the diagnosis. The history of trauma, the presence of gastrointestinal symptoms and changes in the signs following the filling of the stomach are all suggestive. Again the Röntgen ray should be appealed to for confirmatory evidence.

Prognosis.—When occurring in pulmonary tuberculosis the prognosis is uniformly bad. That this is not due entirely to the pneumothorax is evidenced by the success which has followed the production of artificial pneumothorax in the treatment of that disease. The conditions are of course different. The most rapidly fatal cases are those in which the opening is a valvular one and the amount of air in the chest accumulates rapidly and the patient may die in three hours. As a complication of abscess of the lung or bronchiectasis the prognosis is also very grave. In the traumatic cases, on the other hand, the prognosis is very favorable for if the patient escapes the sudden shock due to the change in pressure he almost invariably recovers.

Treatment.—In the suffocative form of pneumothorax, in which the air is rapidly increasing in amount it is necessary to relieve the pressure in the chest. This is readily done by inserting a needle into the pleural cavity and connecting it by means of rubber tubing to a wash bottle which will allow air to escape from but not to enter the chest. This apparatus will afford temporary relief of the urgent symptoms but will not effect a cure. The resection of a rib and the insertion of a drainage tube may be necessary to permit the tear in the lung to heal. The main indications in the less acute form are to allow the rupture of the lung to heal and to avoid infection. This is best accomplished by absolute rest and strapping the chest together with the use of morphine to quiet the cough if necessary. Aspiration should not be used. If there is a large collection of fluid in the pleural cavity it may be necessary to remove it, but this should be done without suction if possible. In the presence of an infected exudate a thoracotomy is necessary. The treatment of the pneumothorax, which occurs in the course of a thoracentesis, is merely rest and such symptomatic treatment as may be needed. This is usually some form of opiate to quiet the cough.

Ralph G. Stillman.

Podophyllum.—U. S., Mandrake, May-apple.—The dried rhizome of *Podophyllum peltatum* L. (fam. *Berberidaceæ*).

This striking and beautiful plant is found in the greatest abundance in rich soil throughout the eastern and central portions of North America, except the far north. The drug is mostly collected in the Ohio valley and the mountains southward. The very long and much branched rhizomes form a network a few inches beneath the surface of the soil, and produce large beds of the very peculiar foliage of the plant, which is herbaceous, about a foot high, and of the appearance shown in the accompanying illustration. The leaves are thin and somewhat shining, about a foot broad, the flower beautifully white and waxy, and about two inches broad. The sterile stems terminate in a circular, centrally attached leaf, which is similarly lobed, and presents the appearance of an umbrella, whence the plant is often called umbrella plant, whereas the forms of those of the flowering stems have given it the name of duck's foot. The fruit is a yellow, sweet, and edible berry, about as large as a pigeon's egg, and is known as May, hog, Devil's, or Indian apple, also as wild or ground lemon.

The younger portions of the rhizome, after being dried, are dark colored, thin, and shriveled, and are deficient in medicinal property. The drug is thus described:

Of horizontal growth and indefinite length, occurring in irregular pieces; cylindraceous, flattened from above, consisting of joints about five to ten centimeters (2–4 in.) long, the internodes two to eight millimeters ($\frac{1}{12}$–$\frac{1}{3}$ in.) thick, the nodes about twice as broad; yellowish brown to dark brown, the darker pieces usually longitudinally wrinkled, the lighter ones nearly smooth, the nodes marked above by broad cup-shaped scars and underneath by whitish, short stumps of the brittle roots; fracture short and sharp, whitish to pale brown, resinous in the best drug, marked by a loose circle of very short yellow wood wedges surrounding a large pith; nearly inodorous; taste sweetish and bitter, becoming acrid.

The active portion of the drug resides in its three to five per cent. of resinous matter, which is associated with much starch, a very little gallic acid, and small amounts of fixed oil, gum, etc. The resin is a somewhat complex mixture, and is very largely employed under the name *Podophyllin*. It is highly subject to adulteration, more than fifty per cent. of adulterant having been reported in it. It is prepared by exhausting the powdered drug with alcohol, concentrating the filtrate by evaporation, and pouring it into water acidulated with a little hydrochloric acid, when the resin is precipitated. It is afterward dried and powdered. The official *Resina Podophylli*, which is the practical equivalent of podophyllin, is thus described:

An amorphous powder, varying in color from grayish white to pale greenish yellow, turning darker when subjected to a heat exceeding 35° C. (95° F.) or when exposed to light. It has a slight, peculiar odor and a faintly bitter taste; very irritating to the mucous membrane, especially to that of the eyes.

Soluble in alcohol in all proportions; not less than seventy-five per cent. of resin of podophyllum should be soluble in ether, not less than sixty-five per cent. in chloroform, and not more than twenty-five per cent. in boiling water. A hot, aqueous solution deposits most of its contents on cooling, and if the cooled liquid be filtered, the filtrate has a bitter taste, and turns brown upon the addition of a few drops of ferric chloride T.S. Soluble in potassium or sodium hydroxide T.S., forming a deep yellow liquid, which gradually becomes darker on standing, and from which the resin is reprecipitated by acids.

Not less than ninety-nine per cent. of resin of podophyllum should be soluble in alcohol; the solution should be clear or, at most, slighly opalescent, and should have a faintly acid reaction.

Upon incineration, resin of podophyllum should yield not more than 0.7 per cent. of ash.

Resin of podophyllum has the following composition:

The most of it is resinous *Podophyllic acid*, which is brown, and soluble in alcohol and chloroform, not in water, ether, or petroleum ether, and is inert. Of *Podophyllotoxin* ($C_{23}H_{24}O_9+2H_2O$) there is apparently a very small amount (about one-fourth of one per cent. of the weight of the rhizome), the larger amounts reported by various observers being probably impure. It is best obtained by extracting the drug with pure chloroform, and this extract with pure ether, then precipitating with petroleum benzin. Pure podophyllotoxin usually occurs as a white, amorphous, bitter, slightly acid powder, or in crystals soluble in ether, chloroform, hot water, and diluted alcohol. This pure substance is very difficult to obtain, being usually contaminated with the isomeric *Picropodophyllin*, which is readily formed from podophyllotoxin by the action of alkalies, and is much less active than the latter. Picropodophyllin occurs in bitter crystals, soluble in alcohol, not in water. Podophyllotoxin is also very apt to be contaminated with podophyllic acid, with the yellow coloring matter *podophyllo-quercetin*, and with fat.

Action and Use.—Podophyllum or its resin is locally irritant, the dust occasioned by powdering the drug causing redness and smarting of the skin and inflammation of the conjunctivæ. It has also been known to produce, upon the perspiring skin, ulcers which have been mistaken for chancroids. It is an irritant cathartic, whether introduced into the bowels or stomach, given subcutaneously, or absorbed from a raw surface. It is a very slow-acting medicine, requiring from twelve to fifteen hours before its effects begin, but it is also rather persistent and thorough, and in full doses is followed by numerous watery stools. Griping pains are frequent accompaniments, and vomiting and persistent diarrhea may follow if the dose is very large. After poisonous amounts the above symptoms are exaggerated, and inflammation and ulceration of the intestines, bloody stools, great prostration, stupor, and death may follow. The action upon man and the lower animals is essentially the same. It is supposed to stimulate the liver, and is very extensively given with a view to this effect, but probably, as we now know of nearly all so-called cholagogues, it does not increase the production of bile, but merely favors its dejection.

Moderate doses of podophyllotoxin given to man produce the same effects as podophyllum itself, with perhaps less pain and less tendency to vomiting. Picropodophyllin acts like the above, but less violently in consequence, as is supposed, of its complete insolubility in water. Podophyllum and its preparations are, then, useful cathartics where action upon the whole intestine, or at least the small one, is desired, and when the expulsion of bile is desirable. They are frequent ingredients of "antibilious" pills, both of regular and irregular practice, and are frequently given, too, in small doses in "after-dinner" and other mildly laxative pills.

Administration.—The powdered crude drug may be given; dose, gr. x. ad xx. (0.6–1.2). But, in view of the great compactness of the precipitated resin this is to be preferred. The official fluid extract (*Extractum Podophylli Fluidum*) may be given in doses of ♏ viii. (0.5). *Podophyllotoxin* can be had in the larger cities, and should be more uniform than either of the above, though very commonly it is not.

The dose of the ordinary commercial article is about one-third that of the resin, but of the pure substance this would be about five times too much.

Poisoning.—The drug is a fatal poison in overdoses, the symptoms and treatment being those of an intense abdominal irritant.

"Mandrake" of the ancients was *Mandragora officinarum* L., a solanaceous plant, containing mydriatic alkaloids of the atropine type. It is now obsolete as a medicine. Henry H. Rusby.

Poisons.—To frame a complete and comprehensive definition of a poison which shall satisfy the popular, legal, and scientific acceptations is almost an impossibility. To the popular mind a poison is any substance which when given in small doses is capable of disturbing health or destroying life. This definition therefore excludes many well-recognized poisons which are deleterious only in large doses. From the legal standpoint a poison is any destructive or noxious substance whatever its nature or mode of action which produces injurious or fatal effects when introduced into the system. In this definition are included many substances which are not strictly poisonous, such as powdered glass, diamond dust, iron filings, and related compounds which may be regarded as mere mechanical irritants. From the viewpoint of the toxicologist a poison may be defined as a substance capable of being taken into any living organism which by its own inherent chemical nature causes impairment or destruction of function. This definition excludes mechanical agencies, direct thermal changes, electricity, bacteria, and protozoa.

Statistics.—A comparison of the number of deaths from poison, whether accidental, suicidal, or homicidal, and deaths from other violent causes as well as natural deaths is a matter of considerable interest. The great development of modern commercial industries particularly those necessitating the use or manufacture of powerful chemical agencies is conducive to increased death from accidental poisoning. The greater the mental development of a people the more likely are its homicides to be caused by the employment of the more subtle poisons—as by chloral, morphine, etc. Other influences which may operate in causing a diversity in the character of the toxic substances employed are those of age and sex, religion and the mental excitement attendant upon sudden political or social revolutions.

As an example of how the character of the poisons causing death may change with the advance of knowledge may be instanced the returns of death by poisons in England and Wales during the years 1863–67 and the years 1893–1903. During the former period opium and its derivatives were responsible for the largest number of deaths, with the following poisons in the given sequence: prussic acid, arsenic, mineral acids, oxalic acid, strychnine, mercury, phosphorus, and ammonia. During the later period mentioned above the numerical order of deaths occurred in the following order, carbolic acid, opium derivatives, lead, chloroform, mineral acids, prussic acid, strychnine, ammonia, arsenic, oxalic acid, phosphorus, mercury salts, chloral, belladonna preparations, alcohol, ether, chromic acid, aconite, paraffin, zinc salts, cocaine, nitrous oxide, acetic acid, soda, potash, and antimony. From these statistics it is interesting to note that more deaths are caused among women by the use of carbolic acid, phosphorus, and strychnine, whereas with all the other poisons the number of deaths among men is the greater.

Classification.—Every proposed system of classification of poisons has its defects and none is entirely satisfactory because of the diversity of action and the variety of chemical structures involved. In some of the older attempts at classification poisons were divided according to the nature of the poison as (a) animal, (b) mineral, (c) vegetable, or (a) organic, (b) inorganic, or (a) acids, (b) alkalies, (c) salts. Such a system is of little value since it conveys no idea concerning the properties of a poison or the manner in which it acts. On the other hand, Orfila's division of poisons into (a) irritants, (b) narcotics, (c) narcotico-irritants; Tardieu's classifications into (a) irritants and corrosives, (b) hyposthenients, (c) stupefacients, (d) narcotics, (e) tetanics, and Taylor's division into (a) irritants and (b) neurotics all have certain features that are good but each classification has its weak points. According to Taylor's classification the irritants are derived from the animal, vegetable, and mineral kingdoms, those from the latter being divisible into acid, alkaline, non-metallic, and metallic. Under neurotics are included (1) the cerebral, (2) spinal, (3) cerebrospinal, and (4) cerebrocardiac.

Kobert has classified poisons according to the following scheme:

I. *Poisons which cause coarse anatomical changes of the organs.*

A. Those which especially irritate the part to which they are applied.

1. Acids.
2. Caustic alkalies.
3. Caustic salts, especially those of the heavy metals.
4. Locally irritating substances which do not fall within the above three groups, as, cantharidine, phrynine, croton oil, savin, etc.

5. Gases and vapors which cause local irritation when breathed, as ammonia, chlorine, iodine, bromine, sulphur dioxide, etc.

B. Those which have little effect locally, but change anatomically other parts of the body as lead, phosphorus, etc.

II. *Blood Poisons.*

1. Blood poisons interfering with the circulation in a purely physical manner, as hydrogen peroxide, ricine, abrine, etc.

2. Poisons which have the property of dissolving red blood corpuscles, as saponin.

3. Poisons which, with or without primary solution of the red blood corpuscles, produce methemoglobin in the blood, as potassium chlorate, hydrazine, nitrobenzene, aniline picric acid, carbon disulphide, etc.

4. Poisons having a peculiar action upon the coloring matter of the blood, or on its decomposition products, as hydrogen sulphide, the cyanides and carbon monoxide.

III. *Poisons which kill without the production of coarse anatomical change.*

1. Poisons affecting the cerebrospinal system—as chloroform, ether, alcohol, atropine, morphine, nicotine, strychnine, carari, etc.

2. Heart poisons, as digitalis, muscarine, etc.

IV. *Poisonous products of tissue change.*

1. Poisonous protein.

2. Poisons developed in food.

3. Autopoisoning—as uremia, glycosuria, etc.

4. The more important products of tissue change as fatty acids, oxyacids, amino acids, amines, diamines, and ptomaines.

A classification proposed by Blythe[1] has many excellent features and is as follows:

A. Poisons causing death immediately or in a few minutes. There are few poisons which destroy life in a few minutes. Excluding the strong mineral acids, carbon monoxide, and carbon dioxide with the irrespirable gases, the chief poisons coming under this head are hydrocyanic acid, the cyanides, oxalic acid, and strychnine.

B. Irritant poisons (symptoms mainly pain, vomiting, and purging). Arsenic, antimony, phosphorus, cantharides, savin, ergot, digitalis, colchicum, zinc, mercury, lead, copper, silver, iron, barium, chromium, yew, laburnum, and putrid animal substances.

C. Irritant and narcotic poisons (symptoms those of an irritant nature, with the addition of more or less pronounced cerebral indications). To this class belong more especially oxalic acid and the oxalates, with several poisons belonging to the purely narcotic class, but which produce occasionally irritant effects.

D. Poisons more especially affecting the nervous system.

1. Narcotics (chief symptom insensibility, which may be preceded by more or less cerebral excitement) opium, chloral, chloroform.

2. Deliriants (delirium a prominent symptom) belladonna, hyocyamus, stramonium, poisonous fungi, Indian hemp, camphor, etc.

3. Convulsives—almost every poison has been known to produce convulsive effects, but the only true convulsive poisons are the alkaloids of the strychnine class.

4. Complex nervous phenomena—aconite, digitalis, hemlock, calabar bean, tobacco, curari, etc.

Relation Between Toxic Action and Chemical Structure.[2]—The advance of synthetic chemistry has brought to light many interesting and important facts concerning the influence upon toxic action when certain groups of a poison are replaced by other groups. It must be admitted, however, that at present this knowledge at best is but fragmentary and no broad generalizations can be drawn.

The presence of the hydroxyl group (OH) usually endows a substance with toxic properties, as, for example, in the alcohols and in hydroxylamine. Moreover, the toxic action usually is increased by an increase in the number of hydroxyl groups present; thus phenol has one hydroxyl group, resorcin two, and phoroglucin three, and the poisonous action is in the same order.

If hydrogen is replaced by a halogen, especially chlorine, in the fatty acids, substances are produced having narcotic properties, for instance monochloracetic acid. In sulphur compounds the introduction of chlorine changes the physiological action and increases the poisonous properties, thus ethyl sulphide is a weak poison, monochlorethyl sulphide is a strong poison and dichlorethyl sulphide is a very toxic compound. The weight of the molecule may also exert a significant influence in the alcohols and acids of the fatty acid series. Thus there is a regular progressive increase in toxicity in ethyl, propyl, butyl, and amyl alcohols as the carbon content increases. The narcotic action of sodium propionate, butyrate, and valerianate increases with the augmenting carbon content. When nitrogen exists with a valence of three in the amines these compounds are less toxic than when nitrogen is present in the pentad condition.

Replacing hydrogen by alkyls (for example ethyl and methyl) in aromatic compounds causes usually the formation of a body having more or less pronounced narcotic properties. Generally methyl is stronger than ethyl in this respect but the rule does not necessarily hold. The introduction of a methyl group into an alkaloidal molecule may yield a compound with entirely different properties from the original substance. Thus methyl strychnine and methyl brucine instead of causing tetanus have an influence upon striated muscle tissue very much like that of curare. The effect of introduction of an alkyl into a substance is not constant, for sometimes the action of the poison is increased and again it may be diminished. In some cases the introduction of CO groups into the molecule of a substance decreases toxic action. Loew has put forward a theory to explain the action of poisons which admits of general application. According to this idea it is assumed that living and dead protoplasm are entirely different substances. The albumin of dead protoplasm has a definite composition and is a very stable body, whereas that of living protoplasm is not stable but is of an ever-changing character, that is, is a labile molecule. "If the old idea is accepted that living albumin is chemically the same substance as that which is dead, numerous toxic phenomena are inexplicable. It is impossible for instance, to explain how it is that diamide N_2H_2 and hydroxylamine NH_2OH are toxic even with great dilution, on all living animals; while neither of these substances has the smallest action on dead plasma or the ordinary dissolved passive albumin, there must therefore be present in the albumin of the living plasma a grouping of atoms in a "labile"condition (atomgruppirungen labiler art) which are capable of entering into reactions; such, according to our present knowledge, can only be the aldehyde and the ketone groups. The first-mentioned groups are more labile and react in far greater dilution than the latter groups." According to this conception all substances which enter into combination with aldehyde or ketone groups in general must be poisonous to life. For example, hydroxylamine, diamide and its derivatives, phenylhydrazine, free ammonia, phenol, hydrocyanic acid, hydrogen sulphide, sulphur dioxide, and the acid sulphites all form combinations with aldehyde.

The formation of imide groups in the aromatic ring increases any poisonous properties the original substance possesses, because the imide group readily forms a combination with the aldehyde group, thus, piperidine $(CH_2)_5NH$ is more poisonous than pyridine $(CH)_5N$, conine $NH(CH_2)_4CH-CH_2.CH_2CH_3$ is

more toxic than collidine $N(CH)_4C-CH-(CH_3)_2$, pyrrol $(CH)_4NH$ than pyridine $(CH_5)N$. If the theory is correct, then substances with "labile" amino groups, on the one hand, must increase in toxic activity if a second amino group is introduced; and in the other hand, there will be a diminution in toxic action if an amino group is changed into an imino group by the substitution of an atom of hydrogen for an alkyl group. In many instances both of these requirements are met for phenylenediamine is more poisonous than aniline and toluylenediamine is more toxic than toluidine.

From his investigations Loew has drawn the following generalizations.

1. Entrance of the carboxyl or sulpho groups weakens toxic action. 2. Entrance of a chlorine atom exalts the toxic character of the catalytic poisons (Loew's catalytic poisons are alcohols, ether, chloroform, chloral, carbon tetrachloride, methylal, carbon disulphide, and volatile hydrocarbons). 3. Entrance of hydroxyl groups in the catalytic poisons of the fatty acid series weakens toxic character; on the other hand, it exalts the toxicity of the substituting poisons. (Examples of Loew's class of "substituting" poisons are hydroxylamine, phenylhydrazine, hydrocyanic acid, hydrogen sulphide, aldehyde, and the phenols.) 4. A substance increases in poisonous character through every influence which increases its power of reaction with aldehyde or amino groups. If, for instance, an amino or imino group in the poison molecule be made more "labile," or if thrice-linked nitrogen is converted into nitrogen connected by two bands, whether through addition of water or transposition (umlagerung), or if a second amino group enters, the poisonous quality is increased. Presence of a negative group may modify the action. 5. Entrance of a nitro group strengthens the poisonous character. If a carboxyl or a sulpho group is present in the molecule, or if, in passing through the animal body, negative groups combine with the poison molecule, or carboxyl groups are formed in this molecule; in such instances the poisonous character of the nitro group may not be apparent. 6. Substances with double carbon linkings are more toxic than the corresponding saturated compounds. For example, neurine with the double linking of the carbon of CH_2 is more poisonous than choline.

Action of Poisons.—The action of poisons may be local, remote, or both. Local action is physical and chemical, and is manifested by inflammation, corrosion, and direct effect upon the nerves, whereby the functions of organs are impaired or destroyed. If the chemical affinity of the poison for the tissues at the point of application be not great, the result is irritation and inflammation; if, however, the affinity be great, the action is most intense, and we have actual corrosion. Remote action depends upon absorption into, and transportation by, the blood to the various organs which may be affected. Thus, for instance, digitalis affects the heart, strychnine the cord, and opium the brain. In any case of acute fatal poisoning, death is the result of the remote action of the poison, which may or may not have a local action.

The ordinary action of poisons may be modified by the size of the dose, by the chemical combination of the substance, by the state of aggregation or admixture, by the condition or absorptive power of the part or membrane to which it is applied, by the condition of the patient, by habit, and by idiosyncrasy. The young and old are more susceptible, as a rule, than the middle-aged; women more than men; and fasting more than well-fed persons. Disease also may render the subject less susceptible, or, on the other hand, may facilitate the action of the poison. Habit diminishes the effect of many poisons, so that a much larger dose is required for the manifestation of symptoms than would be for persons not so habituated. Idiosyncrasy is a peculiar condition of the system which enables harmless substances to produce violent symptoms similar to those of irritant poisons. Thus many persons are unable to eat certain articles of food, even unknowingly—such as shell-fish, fish, strawberries, some kinds of meat, butter, honey, and other things. In the same way, many persons are seriously affected by small medicinal doses of opium, strychnine, arsenic, and other pharmaceutical preparations. A second form of idiosyncrasy is a tolerance for exceptionally large doses of poison by persons in no way protected by the influence of habit.

Absorption of Poisons and Circumstances which May Modify Absorption.—All poisons are absorbed. In order to produce poisonous symptoms the presence of a certain amount of poison in the blood is usually necessary and the amount required depends upon rapidity of absorption and of elimination. A certain quantity of any poison in the blood is incapable of producing any symptoms. Beyond this is that amount which is capable of producing characteristic symptoms, *i.e.* the poisonous dose, then that amount capable of destroying life—the minimal fatal dose and beyond this up to a certain point, the action is increased in violence and rapidity. The poisonous and minimum fatal doses are relatively large if absorption is slow and elimination is rapid, and small if the latter conditions are reversed. Toxic action therefore is directly dependent on the absorption of the poison, and the extent of action is in direct proportion to the rate of absorption. A substance in itself insoluble and indiffusible, or incapable of being rendered soluble and diffusible by the secretions of the body, is incapable of being absorbed, and hence cannot be a poison.

Poisons may be taken into the system directly through the blood, as in absorption through wounds or injection into blood-vessels; they may be absorbed through the skin or from the cellular membranes, from inflamed serous surfaces, and from all mucous membranes. Absorption directly into the blood from wounds occurs with great rapidity. Through the healthy intact skin absorption is very slow and small in amount although it may be somewhat increased by rubbing and the addition of fatty substances or solvents of the poisons. Gases are more easily absorbed than aqueous solutions especially if the latter are warm or hot. On the other hand, absorption from a diseased skin is very rapid, and many fatal cases have been recorded from the application of washes, ointments, and dressings to diseased surfaces.

Mucous surfaces absorb poisons in the following order, lungs, stomach, intestines, mouth, nose, eyes, tear passages, rectum, vagina, uterus, bladder, prepuce. Poisons, particularly those in the form of gas or dust, are absorbed with great rapidity by the mucous surfaces of the lungs and air passages. In ordinary cases of poisoning the mucous membrane of the stomach and intestines is usually the absorbent surface. Everything else being equal, the greater the solubility and diffusibility of a poison, the more rapid its absorption, and hence the more rapid its manifestation of toxic action. As a rule, the salts of the alkaloids are more soluble than the alkaloids themselves, and hence the toxic action of the former is more rapid than that of the latter. Arsenite of potash is more rapid in its action than arsenious acid; and this is due in great measure to the rapid absorption of the more soluble compound. The action of many chemical antidotes is confined wholly to the conversion of the easily soluble form of the poison into a compound either wholly insoluble, or insoluble to such an extent as to delay its absorption, and thus admit of its removal from the body before it has been absorbed in sufficient amount to lead to a fatal result. Thus, in poisoning with oxalic acid the administration of lime water in large quantities leads to the formation of calcium oxalate, a com-

pound comparatively insoluble and hence limited in its toxic action.

Again, the absorption of a poison naturally soluble is increased by introducing it in the form of a solution. Thus arsenous oxide introduced into the stomach dissolved in water, is more rapidly absorbed than when introduced in the form of powder. Further, when dissolved in dilute alkalies, thereby being converted into a new body, it is still more rapidly absorbed, thus introducing another feature into the problem, viz., that of diffusibility. It is here much the same as it is with certain foods: in order to have absorption we must have not only solubility, but also diffusibility. Thus raw egg albumen, while readily soluble, is of little use as food until by the action of the digestive juices it is converted into *diffusible* products. Arsenous oxide, then, when dissolved in a given volume of water, is rapidly absorbed; but the same equivalent of arsenic introduced in a similar manner, in the form of an alkali arsenite, is still more rapidly absorbed by virtue of its greater diffusibility. Hence, everything else being equal, the more soluble and diffusible the form of the poison, the more rapid is its absorption, and consequently the more vigorous its toxic action.

Again, the nature of the surface to which the poison is applied modifies materially the rate of absorption. This depends mainly on vascularity; the greater the supply of blood, the more rapidly does absorption go on. Hence the introduction of a poison in the form of vapor into the lungs leads to more rapid absorption than does injection into the intestine; and similarly, the injection of a soluble poison into the intestines or vagina is ordinarily followed by more rapid absorption than when it is introduced into the stomach. While, then, the natural vascularity of an organ or tissue has some modifying influence on the absorption of a poison, the condition of the blood-vessels also exerts some influence. Fulness of the blood-vessels opposes a mechanical obstacle to absorption and this no doubt explains, in part, why it is that poisons taken on retiring at night are sometimes delayed in their action until the morning, since during sleep the withdrawal of blood from the brain leads to an accumulation in the abdominal organs, and hence retards absorption from the alimentary canal. For a similar reason, poisons taken on a full stomach are much less rapidly absorbed than when the stomach is in a comparatively empty condition. The delayed absorption incident to the former state is, of course, due in part also to the mechanical obstacle afforded by the food itself, the latter keeping the poison for a time away from the stomach walls. Hence absorption, and consequently toxic action, is most rapid when the poison is taken into an empty stomach, less rapid when taken with food, and still less rapid when taken after a hearty meal.

In considering absorption from the alimentary canal, we have to notice, further, the modifying action of the digestive juices. Insoluble substances are not directly absorbed, but many compounds, by the action of the digestive juices, are so altered that their solubility is either increased or diminished, thus modifying their absorption and hence their toxic action. As examples of the former there are many metallic carbonates, as lead, copper, zinc, and manganese which, when taken into the stomach, may be changed by the acid of the gastric juice into soluble chlorides, so that what was in itself an insoluble and non-poisonous substance may be converted into a vigorous poison.

Disposition of the Poison after Absorption.—Once entered into the circulation, there is a twofold disposition of the poison possible. Either it is deposited for a time in the various tissues and organs of the body, or else it is at once eliminated through some one or more of the various emunctories. Ordinarily, if sufficient time intervenes between the taking of the poison and death, there is a temporary deposition of the poison throughout the body—after which, however, the deposited poison is gradually redissolved and eliminated. Careful study of collected facts further shows that, as a rule, the poison is deposited in the largest amounts in the liver, kidneys, spleen, heart, lungs, muscles, brain, and bones. In other words, these organs and tissues have the power of absorbing and retaining poisons, and furthermore, this absorbing power is not the same for the different organs. Chemical analysis in poison cases, and in experiments on animals where the conditions are known with much more definiteness, clearly testifies to the accuracy of this statement. Further, variation in the conditions under which the poison is taken modifies not only absorption as a whole, as already indicated, but also the absorption by individual organs and tissues. The form of the poison; the character of the dosage, whether small and oft-repeated, or a single large one; the mode of administration, etc., all are liable to exert their own modifying influence on the absorption of the poison by the different organs. A knowledge of such modifying influence must then necessarily be of great value, especially in medicolegal cases; for in time the accumulated facts will serve as data on which to found definite conclusions concerning the form of the poison, the mode of administration, the length of time intervening before death, and many other points of a similar nature, so important in criminal cases.

In this connection, therefore, the results of the quantitative analysis of the various organs and tissues of the body in poison cases are of great importance, for, as they show the distribution of the poison under known conditions, the time may come when it will be possible to draw deductions in unknown cases from the analytical results.

During the past few years many data have been collected in this direction, a few of which may be advantageously mentioned.

Carbolic Acid.—A man swallowed 15 c.c. of an official preparation of carbolic acid (100 parts phenol + 10 parts of water), and died in fifteen minutes. With the internal organs Dr. Bischoff[3] obtained the following results:

112 gm. of blood.....	contained 0.0259 gm. phenol	= 0.0231 %
1,480 gm. of liver.....	contained 0.6370 gm. phenol	= 0.0430 %
322 gm. of kidney.....	contained 0.2010 gm. phenol	= 0.0620 %
508 gm. of heart muscle	contained 0.1866 gm. phenol	= 0.0367 %
1,445 gm. of brain.....	contained 0.3140 gm. phenol	= 0.0217 %
12.5 gm. of urine.....	contained 0.0014 gm. phenol	= 0.0112 %

This case is particularly interesting as showing how rapidly a readily soluble and diffusible substance may be absorbed, and how quickly it may be distributed throughout the body. Further, it is to be seen that the poison was, at the time of death, in position to be eliminated, having entered into the urine.

Oxalic Acid.—An unknown dose of oxalic acid, followed by death in fifteen minutes. The amounts of oxalic acid found by Dr. Bischoff were as follows:

In 2,240 gm. stomach, intestines, etc . .	2.280 gm.	oxalic acid.
In 770 gm. liver.....	0.285 gm.	oxalic acid.
In 180 gm. heart blood.....	0.043 gm.	oxalic acid.
In 350 gm. heart.....	0.020 gm.	oxalic acid.
In 290 gm. kidney	0.014 gm.	oxalic acid.
In 40 gm. urine.....	0.007 gm.	oxalic acid.

Potassium Cyanide.—An unknown case of potassium cyanide. The analysis made three days after death.[4]

223 gm. stomach and contents . . .	contained 0.0692 gm. HCN.
595 gm. intestines.....	contained 0.0186 gm. HCN.
122 gm. intestines.....	contained 0.0031 gm. HCN.
505 gm. liver.....	contained 0.0170 gm. HCN.
138 gm. heart.....	contained 0.0025 gm. HCN.
352 gm. brain.....	contained 0.0144 gm. HCN.

Arsenic.—The case of an adult female who lived two days after taking a fatal dose, furnishes the following results reported by Dr. E. S. Wood.[5]

179 gm.	stomach	contained 0.0442 gm. arsenic.
6 gm.	stomach contents	contained 0.0097 gm. arsenic.
490 gm.	intestines	contained 0.0638 gm. arsenic.
62 gm.	intestines contents	contained 0.0205 gm. arsenic.
1,227 gm.	liver	contained 0.0497 gm. arsenic.
149 gm.	left kidney	contained 0.0043 gm. arsenic.
125 gm.	right kidney	contained 0.0026 gm. arsenic.
318 gm.	uterus	contained 0.0065 gm. arsenic.
521 gm.	brain	contained 0.0088 gm. arsenic.

In all these cases of poisoning the order of distribution of the poison is much the same as that previously stated, the liver standing first, then the kidneys, heart, lungs, etc. In experimenting on animals, however, where the poison can be variously introduced, it has been noticed that the distribution of the absorbed poison is not always the same. It is easy to see how there might be a decided difference in an acute and chronic case of poisoning, for if elimination of the poison commences at once, it follows that the relative amount of poison contained in the liver and kidneys must necessarily be different in a chronic case than where a single large dose of the poison is taken. Again, it is not difficult to see how the *form* of the poison might modify the rate of absorption and the order of distribution. This latter fact has been clearly indicated by results obtained with arsenic, both in experiments on animals and in poison cases. Thus Scolossuboff,[6] under the impression that the muscular paralysis noticed in the extremities of animals poisoned with arsenic was accompanied by a localization of the poison in the muscles, subjected his hypothesis to the test of experiment, feeding the animals experimented on with a solution of sodium arsenite. The results obtained in this manner were all of a like nature, and in several respects different from all preconceived ideas. Thus, in one experiment with a bulldog, which had been fed for thirty-four days with the arsenite, the following amounts of absorbed arsenic were found:

100 gm. of muscle	contained 0.25 mgm. of arsenic (As).
100 gm. of liver	contained 2.71 mgm. of arsenic (As).
100 gm. of brain	contained 8.85 mgm. of arsenic (As).
100 gm. of spinal cord	contained 9.33 mgm. of arsenic (As).

It is to be noticed in this experiment that the amount of arsenic in the brain is three times as great as in the liver. In another experiment, with a griffin dog, the brain contained per 100 grams of tissue double the amount of arsenic contained in the muscles. In every experiment, comparatively large amounts of arsenic were found in the brain, thus giving evidence of a special localization of arsenic in nerve tissue; but this result was contrary to the experience of all toxicologists in arsenic cases. Scolossuboff gave his results to the world as characteristic of arsenic poisoning in general, without apparently considering that he was experimenting with a *form* of arsenic seldom used as a poison, and with which toxicologists had had little practical experience.

In the white oxide of arsenic, (As_2O_3), the arsenic of commerce, and the form most commonly used as a poison, we have to deal with a substance but slowly soluble, while in sodium arsenite we have one of the most readily soluble and one of the most easily diffusible of the solid compounds of arsenic. If the amount of arsenic in the brain could be taken as an index of the *form* in which the poison was taken, whether as a soluble or as a comparatively insoluble compound, it would in many cases of poisoning be a point of great importance. But in order to have the point in question of any practical value, we must be certain, on the one hand, that under no circumstances can the taking of the white oxide of arsenic, either in the form of powder or dissolved in water or other neutral fluids, be attended with accumulation of arsenic in the brain other than in the merest trace; while, on the other hand, the taking of a soluble arsenite should be attended with a proportionally large amount in the brain. It might be argued that in chronic cases of poisoning with arsenous oxide, where the person has for weeks or months been taking small or gradually increasing doses of the oxide, the poison might then accumulate in the brain. Such arguments have been made, but the facts at our disposal tend to show the incorrectness of such a theory. Nevertheless, it seems probable that more cases must be studied before the above conclusion can be accepted in its entirety for there has recently come under the writer's observation a case in which the amount of arsenic in the brain was relatively large and yet the evidence pointed definitely to chronic poisoning with arsenous oxide.

The history of the case indicated chronic arsenic poisoning. The individual had been ill for a period of approximately six weeks presenting symptoms typical of arsenic poisoning, such as loss of appetite, malaise, nausea, pain in abdomen, vomiting, diarrhea, peripheral neuritis, motor paralysis of the extremities and, finally, convulsions and death. After being buried for a period of three months the body was exhumed. The box, casket and clothing were only slightly damp and were not discolored. The body, that of a woman apparently twenty years of age, was in a remarkable state of preservation, the tissues being firm, normal in color and without odor other than that of formalin, the preservative employed. The only organ presenting an abnormal appearance was the liver which was pale yellow, resembling strongly the liver of "fatty degeneration." The bladder was empty. Upon opening the gastroenteric tract, which presented no perforations throughout, the only abnormality to be observed was a small hemorrhagic area in the antrum of the pylorus. The intestines contained a quantity of a semi-liquid material. About 30 c.c. of a black gritty mixture was obtained from the rectum. From the stomach were taken 200 grams of fluid containing little or no food residues, but exhibiting the presence of a considerable quantity of arsenous oxide in a crystalline form, thus revealing the form of the ingested arsenic and indicating the administration of a dose of the toxic substance a short time previous to death.

The distribution of the arsenic follows.

Organ.	Weight of organ, grams.	As_2O_3, milligrams.	As_2O_3, milligrams per 100 grams of tissue.
Liver	1,105	184.6	16.7
Stomach (tissue)	290	23.8	8.2
Intestines (tissue)	700	41.6	5.9
Kidneys	200	8.5	4.2
Spinal cord	25	0.9	3.6
Lungs	645	19.4	3.0
Brain	1,190	17.4	1.4
Spleen	135	1.9	1.4
Pancreas	80	0.9	1.1
Muscles (thigh)	600	3.3	0.5
Heart	300	1.1	0.3
Uterus and appendages	85	Present.	Present.
Bone (femur)	100	Present.	Present.
Hair	15	Present.	Present.
Portion of absorbed arsenic as As_2O_3			303.4 mgm.
Stomach contents		200	15.8
Intestinal contents		200	4.0
Rectal contents		30	7.7
Unabsorbed arsenic as As_2O_3			27.5 mgm.

From this case therefore it is apparent that at times at least the repeated ingestion of arsenous oxide may lead to the deposition of significant quantities of arsenic in the brain and spinal cord.

Data concerning the deposition of arsenic in the brain are supplied by E. Ludwig,[7] of Vienna, who writing from a large experience on the distribution of arsenic in the organs and tissues of suicides poisoned with arsenious oxide, and likewise in the organs of dogs poisoned with the same form of arsenic, both in acute and in chronic cases, says: "In all experiments it was invariably found that most arsenic was collected in the liver, that in acute cases the kidneys also contained considerable arsenic, while the bones and brain showed but very small quantities of the poison." Ludwig, moreover, states that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." Quoting one of his cases, that of a suicide, an acute case of poisoning with arsenous oxide, the following results are worthy of notice:

1,480 gm. of liver.....contained 51.90 mgm. of arsenic (As).
144 gm. of kidney.....contained 7.69 mgm. of arsenic (As).
600 gm. of muscle.....contained 0.78 mgm. of arsenic (As).
1,461 gm. of brain.....contained 0.59 mgm. of arsenic (As).
bones.....contained only a trace.

In 1880, Chittenden,[8] in conjunction with Professor Johnson, reported on two cases of poisoning with arsenous oxide, in which the poison was detected and determined in all parts of the body. In one case there was no question whatever as to the form in which the poison was taken, for a mass of the white oxide was found undissolved in the stomach itself. Here there was present in the stomach, liver, and other internal organs, 83.2 grains of the poison, while the brain contained a hardly perceptible trace of arsenic. It would thus appear that the *amount* of the poison taken has little influence on the amount absorbed by the brain. In this particular instance there was as large an amount to draw upon as is often found in cases of poisoning, yet the quantity contained in the brain could not have been much smaller and been recognizable. The length of time, however, intervening between the taking of the poison and death was probably not long, although there had been time for decided absorption by the liver and other organs. In the second case referred to, where there was decided evidence of chronic poisoning, a somewhat similar result was obtained. In this case there was present in the entire body 5.22 grains of arsenous oxide, most thoroughly and evenly distributed, even to the bones, and yet the brain contained only an unweighable trace of the poison. Again, experiments carried on in Chittenden's laboratory, on animals have led to the same result; whenever the animals have been fed with arsenous oxide, the amount of arsenic found in the brain has been extremely minute, while in poisoning with a soluble arsenite a much larger amount has been found in the brain. At one time it was considered that the presence of arsenic in the brain was proof positive of the antemortem character of the poison; that in no case would the poison, introduced into the stomach or rectum after death, find its way by osmosis to so remote a part as the brain. Sutton,[9] however, by experiments conducted on dead animals, finds that arsenic may pass by diffusion quite rapidly even to the brain. Such being the case, the only way to distinguish between ante- and postmortem introduction of arsenic would be to determine the amount of poison contained, for example, in the outer portions of the liver, as compared with the percentage amount in the center of the organ. Guareschi[10] has also reported on the distribution of arsenic in a case of poisoning with arsenous oxide, and he likewise found only traces of the poison in the brain. Many other cases of poisoning with the more insoluble forms of arsenic, in which the distribution of the poison has been studied, lend favor to this view, that arsenic is to be found in the brain in any quantity only when the poison has been taken in a readily soluble form. One case studied by Chittenden is particularly important in this connection. A laboring man ate for his dinner a quantity of bean soup; almost immediately after he was seized with the ordinary symptoms of acute arsenic poisoning, and died in nine hours. The autopsy showed a marked condition of inflammation of the alimentary tract, and a chemical analysis showed 76 milligrams of arsenic in the liver, 0.6 milligram in the kidney, while one-half of the entire brain contained only a recognizable trace of the poison. A portion of the soup (125 c.c.) yielded 314.6 milligrams of arsenous sulphide, while the fact that the arsenic was introduced in the form of arsenous oxide was proved by finding in the sediment from the soup an abundance of the octahedral crystals of the oxide. Such a case as this must necessarily carry considerable weight with it. Everything favored the absorption of the arsenic, yet the brain contained only the merest trace. The same investigator obtained like results in an acute case of poisoning with Paris green, or acetoarsenite of copper, in which the liver (2,984 grams) was found to contain 12.7 milligrams of arsenic; the kidneys (515 grams), 3.4 milligrams; 735 grams of muscle, 0.9 milligram, and the brain (1,179 grams) only a slight trace. These results certainly indicate that the relative distribution of the poison may offer some suggestion as to the form in which the poison was administered, and that, with arsenic at least, a comparatively large amount in the brain may be indicative of a readily soluble form of the poison. In this connection, however, there are always other facts to be learned in the distribution of the poison, which may substantiate the indications obtained by analysis of the brain, and at the same time, perhaps, enable us to distinguish between an acute and a chronic case of poisoning.

It is a favorite defense in poison cases, particularly with arsenic, morphine, and some other poisons, to claim that the poison found in the body of the deceased came from some hypothetical medicine containing the poison, and which the deceased had long taken, or that the person was habituated to the daily use of the toxic agent. A study of the distribution of arsenic in acute and chronic cases of poisoning shows plainly that many times, with this poison at least, it is quite possible to decide definitely whether the poison has been for a long time in the body, taken in oft-repeated doses, or whether it has been introduced in one or two large doses.

As preliminary to a discussion of this point two cases may be quoted from the experience of Chittenden.

(*a*) In this case there was every reason to suppose a case of chronic poisoning with arsenous oxide. The following results were obtained by analysis of the parts a year and a half after burial:

	Weight of organs, grams.	Weight of arsenic, grams.	Per cent.
Stomach and spleen	514	0.05359	0.01040
Kidneys	80	0.00660	0.00825
Liver	590	0.04788	0.00811
One lung and heart	441	0.01454	0.00329
Intestines and uterus	978	0.02582	0.00260
One lung and liquid from thorax	402	0.00583	0.00140
Bladder	73	Trace.	
Brain	477	Trace.	
Upper arm (left)	665	0.00542	0.00081
Forearm (left)	288	0.00158	0.00055
Hand (left)	150	0.00019	0.00012
Lower leg (right)	1,323	0.00864	0.00065
Thigh (right)	3,160	0.01685	0.00051
Foot (right)	468	0.00105	0.00022
Thigh bone (right)	615	0.00040	0.00006
Transverse section of body above pelvis	1,920	0.03011	0.00156
Muscle and ribs from left breast	406	0.00371	0.00091
Abdominal muscle, right side	615	0.00358	0.00058

(*b*) In this case the evidence pointed to acute poisoning with some readily soluble form of arsenic. Following are the results obtained by analysis:

	Arsenic as As_2O_3. Grain.
Stomach and esophagus*	0.158
Large and small intestines	0.314
Liver (one-half)	0.109
Kidneys	0.029
Heart (one-fourth)	0.028
Lungs and spleen (two-thirds)	0.114
Brain (one-third)	0.025
Diaphragm	0.010
Trachea, larynx, and tongue	0.081

	Weight of tissue, grams.	Weight of arsenic, grams.	Per cent.
Left arm	1,230	0.00609	0.000495
Right leg	4,650	0.00764	0.000164
Thigh bone	216	...	...
Transverse section of body at pelvis	4,060	0.01205	0.000296
Muscle from breast (right)	510	0.00635	0.00124
Muscle from back (left)	620	0.02306	0.00371

In (*a*) the total amount of arsenic was 5.26 grains, in (*b*) 3.119 grains; yet it is to be noticed in (*b*) that the brain contained a comparatively large amount of arsenic, while in (*a*) there was found only a trace. This fact, if our theories concerning absorption by the brain are correct, would imply the administration of a soluble form of the poison. Further comparison of the two series of analyses shows other noticeable points of difference which point to the same conclusion, and also throw some light on the character (acute or chronic) of the poisoning.

When there has been time for even distribution of the poison, as in chronic cases, there would seem to be no reason why one set of muscles should contain more arsenic than another, aside from such differences as might arise from differences in vascularity, etc. On the other hand, there is every reason for supposing that when death ensues only a few hours or less after the poison has been taken, the distribution might be quite irregular.

The following table shows the distribution of the arsenic through the muscle tissue in the two cases, calculated to *grains of* As_2O_3 *per pound* of tissue:

	(*a*)	(*b*)
Thigh bone	0.004	...
Leg	0.033	0.011
Transverse section	0.109	0.021
Arm	0.046	0.034
Muscle from breast	0.063	0.087
Muscle from back	.....	0.260
Muscle from abdomen	0.040	.....

In (*a*) the results, with the exception of the transverse section, show a fairly close agreement. There is not that gradual increase from nothing in the bone up to a fourth of a grain per pound as seen in (*b*). The irregular distribution of the poison in tissue of the same kind, noticed in (*b*), is certainly indicative of the arsenic having been taken but a short time before death, particularly as there was none whatever found in the bones, which fact would certainly exclude the possibility of chronic poisoning.

Again, in (*b*) the two kidneys yielded only 1.5 milligrams of metallic arsenic, while the tongue and adjacent parts (175 grams) gave 4 milligrams, and a portion of the muscles (200 grams) gave 5.65 milligrams of metallic arsenic.

Assuming the usual order of distribution, the amount of arsenic in the kidneys in (*b*) would suggest only a proportionally smaller amount in the muscles; and yet in this particular instance the amount of arsenic contained in 620 grams of muscle tissue is greater than the amount contained in the entire liver and kidneys together. The kidneys, however, are the organs above all others concerned in the elimination of arsenic. Elimination usually commences almost immediately, and yet in this particular case there is but 0.029 of a grain of arsenic in the kidneys, while in less than three pounds of muscle tissue there is contained half a grain of the poison. This fact would necessarily imply that elimination had but just commenced, and that consequently the poison had not been long taken. It might, perhaps, be argued that the proportionally large amount of poison contained in the muscles, as compared with the liver and kidneys, might imply chronic poisoning, but coupled with the peculiar distribution is the entire absence of arsenic from the bones. Ludwig, moreover, states that in "both acute and chronic poisoning with arsenous oxide, most arsenic is invariably found collected in the liver," and that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." It is impossible, therefore, to make the results obtained in (*b*) accord with a case of chronic poisoning with arsenous oxide; and further, the amount of poison found in the brain, and the proportionally large amount in certain muscles, would apparently indicate an extremely soluble and diffusible form of arsenic as the toxic agent.

Such results as these certainly favor the belief that it is quite possible to draw definite conclusions as to whether we are dealing with an acute or a chronic case of poisoning. Further than that, it is possible, in some cases, to decide even more definitely regarding the time at which the poison was taken prior to death. In this connection, the fact to be considered most closely is the amount of poison contained in the liver, as compared with the amount present in the alimentary canal and in the different organs of the body. When arsenic, for example, is taken into the stomach, absorption by the liver through the portal circulation commences almost immediately; and, as Dr. Geoghegan[11] has plainly demonstrated, deposition of arsenic in the liver continues to increase up to about fifteen hours after the poison has been taken, after which it commences to diminish. Dogiel,[12] who has confirmed Geoghegan's results as to the time required for maximum saturation of the liver, says, "a maximum of arsenic in the liver kills the animal." The absolute amount of arsenic involved in maximum saturation of the liver must necessarily vary somewhat in different cases. Barker,[13] from his analysis of portions of the liver of Horatio Sherman, concluded that the entire liver contained nearly five grains of arsenic. In the case of Dennis Hurlbut, also analyzed by Professor Barker, the liver contained over seven grains of arsenic, and it would seem as if these amounts must approach near to the maximum. When such large amounts of the poison are found in the liver, it is safe to assume that the poison must have been taken at least fifteen hours before death.

In some cases of administration of arsenic, it has been claimed by Taylor[14] that the poison may be found in the stomach and intestines, and not in the liver or other organs. This can hardly be correct under ordinary circumstances, since death seldom results so quickly from arsenical poisoning as to prevent the

*The internal organs were preserved separately in alcohol, hence the weights of tissue analyzed are not given.

absorption of at least a small trace of the poison by the liver. Dogiel,[15] who has experimented somewhat on the rapidity of absorption by the liver, found that on forcing 500 milligrams of arsenous oxide dissolved in water, into the stomach of a dog, death resulted in one hour and five minutes. In a second experiment, conducted in the same manner, death resulted in one hour and thirty-eight minutes. In the first case the liver was found to contain 94.5 milligrams of arsenious oxide; in the second case, 137.8 milligrams. Thus, judging from the amount in the liver at the end of an hour, certainly but a few minutes would have been required for the absorption of a detectable quantity of arsenic.

Arsenic having been deposited in the liver or elsewhere, gradually diminishes, and if the person should survive, entirely disappears in from two to three weeks. An entire family were taken sick, directly after eating, with all the symptoms of arsenic poisoning; all of them recovered except one, a middle-aged man, who died just two weeks after partaking of the poisoned food. An autopsy was made, the internal organs, together with the various articles of food partaken of by the family at the time of their sickness were analyzed. A portion of the bread (786 grams) contained 32.7 grains of arsenous oxide, while a piece of cake (166 grams) was found to contain 55.5 grains of arsenous oxide, thus proving the character of the poison.

Analysis of the internal organs gave the following results, showing that at the time of death elimination was nearly, but not quite, complete:

Stomach (365 gm.).....contained 0.10 mgm. arsenic (As).
One-third liver (428 gm.).....contained 0.20 mgm. arsenic (As).
One kidney (283 gm.).....contained 0.15 mgm. arsenic (As).
One-half intestine (487 gm.).....contained 0.20 mgm. arsenic (As).
Thigh muscle (389 gm.).....contained 0.25 mgm. arsenic (As).
One-half brain (390 gm.).....contained trace mgm. arsenic (As).

Concise experiments on animals, carried out quantitatively, are capable of yielding many instructive results in reference to the relative distribution of a poison under different conditions. From experiments by Chittenden and Blake[15] a few of the results may be advantageously given, as confirmatory of some of the preceding statements.

(*a*) *Hypodermic Injection of a Solution of Tartar Emetic.*—0.120 gram of tartar emetic was introduced under the skin (right thigh) of a cat weighing 1,262 grams. The animal died in two hours. Following is the distribution of the poison:

	Total weight, grams.	Weight of Sb, milligrams	Sb per 100 grams of tissue, milligrams.
Liver	52.0	6.35	12.21
Brain	27.5	0.60	2.18
Heart and lungs	32.0	0.70	2.18
Kidney	12.0	0.15	1.25
Stomach and intestines	74.0	0.80	1.08
Muscle from back	138.0	1.25	0.90
	335.5	9.85	.....

In a second experiment a smaller amount of tartar emetic (0.082 gram) was injected hypodermatically, and instead of being introduced in a single dose, it was divided into three, and injected separately, several hours apart. As a result, the animal lived twenty-two hours after the first dose. The following results show the distribution of the poison:

	Total weight, grams.	Weight of Sb, milligrams	Sb per 100 grams of tissue, milligrams.
Kidneys	11.5	0.60	5.21
Liver	63.0	1.50	2.38
Brain	9.0	0.20	2.22
Stomach and intestines	98.0	2.00	2.04
Heart and lungs	17.0	0.25	1.47
Muscle from back	106.0	0.70	0.66
	304.5	5.25	.....

The only difference of importance between these two cases is the element of time. As might naturally be expected, therefore, there is a more even distribution of the poison in the second case than in the first. Further, in the second case the kidneys stand first in their content of antimony, the liver contains a proportionally smaller amount—much smaller proportionally than was found in the first case. This is, of course, due to the fact that in the second case the animal had lived long enough to admit of extensive elimination, and, consequently, those parts which had originally contained the most, particularly the liver, had been drawn on to the greatest extent; so that at the time of death the excretory organs, notably the kidneys, were the richest in poison. Quite noticeable in both of these cases is the comparatively large amount of antimony in the brain—which fact would agree with the previous statements regarding absorption by the brain when a readily soluble and diffusible form of poison is used.

(*b*) *Injection of a Solution of Tartar Emetic per Rectum.*—0.24 grain of tartar emetic, dissoived in a little water, was injected into the rectum of a rabbit, in two doses. Death resulted in about twelve hours. Following was the distribution of the poison:

	Total weight, grams.	Weight of Sb, milligrams	Sb per 100 grams of tissue, milligrams.
Stomach and small intestines	172	8.89	15.30
Brain	9	0.40	4.40
Rectum and adjoining intestines	18	0.55	3 05
Liver	54	1.60	2 96
Kidneys	13	0.25	1 92
Muscle	100	1.10	1 11
Urine	20	0.20	1.10
Heart and lungs	17	Trace.	.....
	403	12 99	.....

Perhaps the most noticeable feature of these results is the comparatively large amount of antimony contained in the stomach and small intestines; a result which, taken in conjunction with other similar ones, would appear to indicate special absorptive action on the part of the epithelial cells of these parts. The amount of antimony in the kidneys, and particularly the amount in the urine, indicates plainly that at the time of death elimination was going on rapidly; but the fact that the percentage content of antimony in the liver was greater than in the kidneys, might perhaps be taken as an indication that absorption was not completed.

(*c*) *Experiment on a Dog with Antimonious Oxide.*—A dog weighing 14.2 kilograms received, with his food, 2.073 grams of antimonious oxide, during a period of seventeen days, in doses of from 0.032 to 0.125 gram per day. The dog was then killed by chloroform eighteen hours after the last dose of antimony had been given. The following results show the distribution of the poison:

	Total weight, grams.	Weight of Sb, milligrams.	Sb per 100 grams of tissue, milligrams.
Liver	452	23.7	5.24
Lungs	140	1.8	1.28
Muscle (fore-leg)	157	1.2	0.76
Brain	79	0.4	0.50
Muscle (thigh)	200	0.9	0.45
Kidneys	82	0.1	0.12
Heart	117	Trace	
Blood	440	Trace.	
	1,667	28 10	

In this experiment, which may be termed a chronic case of poisoning with an insoluble form of antimony, the relative distribution of the poison is seen to be somewhat different from what it was in the preceding cases. First, the brain contains relatively less antimony than in the preceding; secondly, the liver contains a noticeably large amount of the poison, while the kidneys contain only a trace. This latter result would seem to indicate that elimination was going on quite slowly; but analysis of the twenty-four hours' urine showed that the amount eliminated by the kidneys in an entire day was considerable. Thus on one day, the entire twenty-four hours' urine contained 13.5 milligrams of metallic antimony; on another day, 22.5 milligrams.

With copper, Ellenburger and Hofmeister have found, by experiments on sheep,[16] that the liver contains the most copper when small doses have been regularly administered, and, further, that this organ retains the metal with the greatest tenacity, they having found it there forty-one days after the last dose. The pancreas was also found to retain the copper with nearly equal tenacity; the kidneys do not contain so much of the poison. Elimination is mainly by the bile or through the intestine. Deposition of copper in the nerve tissue is quite small, but still smaller in the muscles, though copper is to be found in the muscles after administration of copper salts. Ellenburger and Hofmeister also state that the deposition of copper is proportionally much greater if it is administered in numerous small doses, the cells then having time to absorb it.

With lead, Victor Lehmann[17] has obtained some interesting results. In his experiments the lead was introduced by hypodermic injection in the form of nitrate, the animals used being rabbits. Two of his series of results are given in full.

(*a*) 0.5 gram of lead nitrate introduced at one dose.

(*b*) 0.01 gram of lead nitrate introduced daily, until finally a total of 0.21 gram of the lead salt had been injected.

Distribution of Lead in (*a*).

	Weight of the organ, grams.	Content of lead, milligrams.	Lead per 100 grams of tissue, milligrams.
Liver	40	0.250	0.625
Kidneys	13	0.625	4.807
Heart	3	0.125	4.166
Lungs	6	0.125	2.083
Intestine	16	0.312	1.953
Muscle	30	0.187	0.625
Bones	7	0.187	2.678
Brain	8	0.062	0.781
Bile	3	0.125	4.166

Very noticeable in both series is the small content of lead in the liver, an organ which, as a rule, contains the largest amount of absorbed poison. The relatively large amount of lead in the bile naturally suggests that the elimination of the metal takes place mainly through this channel, which would account for the small content of metal in the liver. Further, experiments conducted on rabbits show plainly that more lead is excreted in the feces than in the urine, the lead in the former doubtless coming from the bile poured into the intestines. Quite noticeable also is the large amount of lead in the bones, which amount probably grows larger the longer the lead has time to act.

Distribution of Lead in (*b*).

	Weight of the organ, grams.	Content of lead, milligrams.	Lead per 100 grams of tissue, milligrams.
Liver	25	0.062	0.250
Kidneys	4	0.125	3.120
Heart	5	0.187	3.750
Lungs	2	0.062	3.125
Intestine	7	0.125	1.785
Muscle	10	0.031	0.312
Bones	3	0.125	4.166
Brain	3	0.125	4.166
Bile	2	0.125	6.250

Mercury can exist in the body for some time in an inactive state, and then, from some change, it may be thrown into the circulation and show its effects. Ullmann[18] found mercury in the organs in the following order, kidneys, liver, spleen, stomach, none in small intestine, present in large intestine, in the heart, skeletal muscles, and the lungs. When the dose was small no mercury was found in the brain, salivary glands, abdominal glands, thyroid, bile, or bones. The main channel by which absorbed mercury is eliminated is by the kidneys, whereas mercurial compounds of small solubility are in great measure excreted by the bowel.

From the body of a dog that had been given 2.789 grams calomel in the course of thirty-one days about ninety-four per cent. was recovered. The distribution follows:

	Mercurous sulphide, grams.
Feces	2.1175
Urine	0.0550
Brain, heart, lungs, spleen, pancreas, kidneys, scrotum, and penis	0.0090
Liver	0.0140
Muscles	0.0114
	2.2069

In a recent fatal case of mercuric chloride poisoning in which 15 grams of the poison were taken with suicidal intent, the distribution of the toxic substance in the body was studied by Rosenbloom. The results obtained follow:

	Mercury in mgm. per 100 gram of organ	Mercury in mgm. in whole organ
Kidney	2.80	5.80
Spleen	1.20	1.70
Liver	3.62	39.82
Brain	0.14	1.68
Stomach	0.50	1.50
Small intestine	1.60	4.80
Large intestine	1.82	7.28
Heart	1.92	5.81
Lungs	trace	trace
Blood	1.20	52.0[a]
Muscle	0.06	25.8[b]
Bile	trace	trace
Stomach contents		12.20
Intestinal contents		8.60
Rectal Contents		8.40
Total		175.39

[a] Calculated on the basis of the blood constituting $\frac{1}{13}$ of the body weight

[b] Calculated on the basis of the muscle constituting $\frac{2}{5}$ of the body weight.

With zinc, Matzkewitsch found the following distribution in the body of a dog poisoned with 100 parts of zinc as the acetate—muscles, 60.5; bones, 24.4; stomach and intestines, 4.63; skin, 3.7; site of injection, 2.19; liver, 1.75; lungs and heart, 1.68; kidneys, bladder, and urine, 1.14.

Neumann has demonstrated that after repeated injection of insoluble barium sulphate into the veins of rabbits, barium is to be found in the liver, spleen, kidneys, and spinal cord, but not in the muscles, thymus, or brain. Linossier experimenting with barium carbonate found that all the organs contained some barium, the lungs, muscles, and heart contained traces only, the liver contained more, and still more was present in the kidneys, brain, and spinal cord, and the bones also contained significant amounts.

Naturally, such systematic work as has been done in studying the relative distribution of poisons has been confined mainly to mineral substances, but it is to be hoped that the time will come when there will be a collection of data embracing all poisons capable of detection by chemical means. When such a time does come, it will doubtless be found that we cannot establish any general laws regarding the relative absorption and distribution of poisons as a class, but rather that each individual poison or group of poisons will show some peculiarity characteristic of itself—which possibility, or rather probability, makes it all the more needful for us to acquire, as speedily as possible, accurate knowledge of the relative absorption and distribution of the individual poisons.

Postmortem Imbibition of Poisons.—Antemortem distribution of poisons is, as we have seen, due to the carrying power of the blood and lymph. Poisons are absorbed, distributed, and temporarily deposited. Poisons may, however, travel through the *dead* body, after circulation has ceased, by a process of imbibition or diffusion, by the same method as that by which salt works its way gradually through a barrel of fresh pork when placed on the upper layers. The rate of imbibition of poisons depends in large measure upon the interval elapsing between the death of the body and the introduction of the poison. Arsenic, for example, introduced into the rectum shortly after death, before the tissues have become rigid, travels with a fair degree of rapidity and in time may be found in distinct traces even in the brain and spinal cord, while in the abdominal organs the amount present may be quite large. Where a long interval elapses after death, the poison introduced postmortem travels more slowly, but even in this case it gradually penetrates to remote parts. In view of these facts, it is obvious that in cases of poisoning where a surplus of the poison remains in the gastrointestinal tract after death, and the body is buried for some time prior to the autopsy, the apparent antemortem distribution of the poison is liable to modification by postmortem imbibition. This is an important fact to be kept in mind in drawing conclusions from the analytical data, especially in cases in which a large surplus of the poison is unabsorbed. With metallic poisons, however, putrefaction may quickly put a stop to postmortem distribution, since the formation of hydrogen sulphide from the decomposing proteid material is very liable to transform the metallic salts into insoluble sulphides, thereby preventing further migration.

Elimination.—As soon as absorption begins, the substance is duffused through the whole body by the circulation, and at the same time the process of elimination is begun. Coincident with this is still a third process, that of deposition in the various tissues of the body, from which, however, the poison is eventually eliminated, unless death intervenes. Deposition goes on chiefly in the liver, kidneys, spleen, brain, and heart. The effect of a poison depends upon the relative rapidity of absorption and elimination, and these processes go on with greater or lesser rapidity according to the nature of the substance. If elimination proceeds as rapidly as absorption, fatal results do not occur; but with a slower elimination the poison accumulates in the system, and, provided a sufficiently large amount has been administered, destroys life. Elimination is influenced by the chemical affinity of the poison for the constituents of the blood or of the tissues of the affected organs. If this affinity is great, the process is slow; if weak, the process is very rapid.

Gaseous and volatile poisons are excreted chiefly by the lungs; others chiefly by the kidneys, though all secretions of the body play a more or less important part in the process. Certain poisons appear to elect particular secretions, though the kidneys act in most cases as the most important organ of elimination. Thus mercury elects the salivary glands, iron and barium the intestines, arsenic and antimony the mucous and serous membranes, and many metallic poisons the liver.

Diagnosis of Poisoning.—The diagnosis of the administration of a poison is based on the symptoms and their course, the detection of poison in articles of food and drink or in the ejecta and excreta, on the postmortem appearances, and on the detection of the suspected substance in the organs of the deceased. The symptoms are usually of sudden onset, in a person previously in good health, soon after eating or drinking. If several persons are affected at the same time, there is commonly a marked similarity in the symptoms. Where the poison is administered to a sick person, the diagnosis is rendered more difficult on account of symptoms already present, which may appear to be modified or exaggerated, and the phenomena of poisoning may seem to be only the natural course of the disease. Too much importance should not be attached to the fact of recent eating or drinking, since a poison may be inhaled, injected, or applied externally. The diagnosis of the particular kind of poison involved is of great importance for the determination of the treatment to be pursued, and it is therefore essential that the medical attendant should know, if possible, the exact course of the symptoms from their first appearance, the previous history of the patient, and the exact nature of any medicines which may have been administered. Owing to the similarity of symptoms of particular diseases to those produced by certain poisons, one must often exercise great care in making a differential diagnosis. The physician is often aided in forming an opinion by the moral aspect of the case.

Acute irritant poisoning may be suspected when violent purging and vomiting, accompanied by pain in the region of the stomach or complete prostration, occur in a person without some assignable natural cause. Acute poisoning may also manifest itself by more or less sudden symptoms referable to the nervous system, such as stupor, insensibility, delirium, or convulsions. Chronic poisoning is more difficult of diagnosis than acute or subacute, on account of the less marked character of the symptoms, which are often, or indeed usually, ascribable to natural causes.

In making a diagnosis in a case of suspected poisoning, it is to be borne in mind that symptoms may be delayed by fulness of the stomach, sleep, or intoxication, or may be modified or intensified by disease or debility. Among the diseases which may be confounded with irritant poisoning may be mentioned cholera asiatica, cholera morbus, gastritis, enteritis, gastroenteritis, colic, peritonitis, intussusception, and dysentery; among those which may simulate poisoning affecting the nervous system are apoplexy, sunstroke, uremia, septicemia, epilepsy, tetanus, diseases of the brain and of the heart, pulmonary embolism, cerebrospinal meningitis, rupture of the stomach or gallbladder, typhoid fever, and coma of various origin.

Of very great importance in the diagnosis and subsequent treatment of poisoning is the detection of the substance in the remains of food or drink, or in the

vomitus; but as it is possible, in any case of criminal poisoning, that these substances may have been removed and others substituted, or in cases of feigned poisoning that a poison may be introduced into the food remains or vomited matters, reliance cannot always be placed upon this evidence. But the detection of the poison in the urine of the patient establishes the diagnosis beyond any doubt. Yet, at the same time, it should be remembered that the non-detection in that fluid does not by any means prove its non-existence in the body.

The TREATMENT in cases of poisoning depends altogether upon the nature of the particular substance involved. The first indication, except when corrosives or poisons administered otherwise than by the mouth are involved, is evacuation of the stomach and administration of antidotes, stimulants, etc. (See special poisons under their appropriate heads.)

POSTMORTEM INDICATIONS.—It frequently happens, in cases of suspected poisoning, that an autopsy is all that is necessary clearly to establish the cause of death, particularly in cases of sudden death, which to the uneducated mind are associated usually with suspicious circumstances. The popular belief in poison as an agent of sudden death is doubtless, in great part, due to works of fiction and the stage, where the interval occurring between the swallowing of the poison and the termination of life is so short that the two events are almost simultaneous. As a matter of fact, sudden death is much more likely to be due to disease than to poison, and, indeed, the only poison which approaches heart disease and apoplexy in rapidity of fatal effect is anhydrous prussic acid, a poison not easily obtainable. But, in consequence of the popular tendency to associate the two ideas, innocent persons frequently are suspected or accused of a heinous crime, which may be easily disproved by the appearances on section. On the other hand, with perhaps equal or greater frequency, the autopsy serves to direct suspicion or to strengthen it in cases of poisoning which have resembled disease. But it not seldom fails to throw any light whatever upon the question of the cause of death, and then a chemical examination may be required.

The external appearances indicative of poison are very few, and of no great value. Evidence of corrosive action is sometimes furnished by the skin and clothing. The presence of certain poisons may be betrayed by their odors, and of others by stains. There is nothing characteristic to be observed from the attitude of the body, rate of cooling or of decomposition, or expression of the countenance. Rigidity is usually more marked and longer continued in death from strychnine, and is often diagnostic of this poison; in other cases, no great difference is to be observed. Internal appearances vary according to the poison; they may be absent, or so slight as not to attract attention in cases of death by poisons acting upon the nervous system, or they may be very marked and characteristic where irritants, and particularly corrosives, have been employed. The chemical and physical properties of the blood sometimes undergo marked changes; it is darkened by chloroform, ether, carbonic acid, sulphide, hydrogen, and other gases, and by prussic acid and cyanides, oxalic acid, etc.; by morphine, strychnine, and some others, it is both darkened and rendered more fluid. The greater number of mineral poisons have no effect on the blood. The blood-vessels of the brain are sometimes observed to be engorged in narcotic poisoning, but this appearance may be very slight or entirely wanting. The principal postmortem appearances due to poison are to be found in the alimentary canal and abdominal viscera. Corrosion of any part of the alimentary canal, softening of the mucous membrane, which is changed in color and easily detached, and evidence of intense inflammation or perforation, are diagnostic of corrosive acids or alkalies, etc. In irritant poisoning, the stomach and intestines show signs of inflammation of a more or less intense character, and sometimes ulceration and perforation, thickening of the walls, or even thickening and softening. The changes produced in other organs are chiefly engorgement and fatty degeneration: the latter occurs sometimes with surprising rapidity in the liver in poisoning by arsenic and phosphorus.

The postmortem appearances in any case of suspected poisoning will be but imperfect evidence of the presence or results of poison, unless it is possible to distinguish them without doubt from analogous appearances which may be the result of disease. Otherwise the proof of poisoning must rest on the detection of the poison in the body, or on outside evidence. The changes which may be referable to disease or to the action of irritant poisons as well, are softening, thickening, reddening, ulceration, and perforation. Softening of the walls of the stomach may be due to poison, to disease, or to postmortem change. If it is due to poison, similar changes are usually to be found in the mouth and esophagus; if to disease or postmortem digestion, these additional changes are wanting. Reddening may be due to poisoning or to gastritis, gastroenteritis, gravitation, or to contact with the liver or spleen. But these appearances are not likely to be mistaken by one accustomed to postmortem examinations; the redness of poisoning is usually accompanied by some peculiarity of appearance which renders it readily distinguishable. Ulceration is more commonly referable to disease than to poison. When it is due to the former, the accompanying redness is confined to the immediate locality, whereas in poisoning it is more or less widely diffused. There is also a considerable difference in the symptoms. Care should be taken not to confound ulceration, which is a vital process, with corrosion, which is chemical. Perforation of any part of the alimentary canal is, like ulceration, of more common occurrence in disease than in poisoning. When due to disease perforation of the stomach is accompanied by little if any vomiting and no purging, and death is due to peritonitis. The aperture, if due to ulceration and not to corrosion, is usually small in size, and with smooth, regular edges, instead of large, rough, and irregular. Perforation from postmortem digestion is very rare; it may be suspected from the fact that there has been no peritonitis, nor any symptom before death, to indicate such a severe process. Perforations of the esophagus and intestines are commonly due to ulceration from the presence of a foreign body, and in such cases the latter is usually discoverable. The intestinal wall is perforated frequently in disease, as, for instance, in typhoid fever.

CHEMICAL EXAMINATION.—When a chemical analysis of the body is deemed necessary, the greatest precautions should be observed in performing the autopsy, and in the preservation of organs and fluids. The stomach should be ligatured at both ends before removal. On its being opened the contents should be received in a clean glass or porcelain vessel, and their quantity, color, odor, reaction, and consistency, and the presence of any unusual substances should be noted; the intestines should be treated in like manner. Each organ, on removal, should be placed in a clean vessel by itself, sealed with a private seal, and labelled Any suspicious vials or powders, and all remnants of food, vomitus, urine, or other substances connected with the case should be sealed at the same time and delivered to the chemist, who should be present at the autopsy. In case of exhumed bodies, where decomposition has proceeded so far that the coffin is no longer entire, it is often advisable to take, in addition, a sample of earth from above and below the receptacle. The chemist should be given a complete history of the case in order that he may have a definite idea regard-

ing the nature of the suspected poison. From the symptoms and postmortem appearances, it is frequently possible to cut the work of chemical analysis down to a minimum. Failure to detect a poison in the body is by no means conclusive that death has been caused naturally, for there are many poisons which cannot be isolated. The fatal dose of many is so very small that, even if not eliminated in great part before death, its distribution over the system renders it impossible, with our as yet imperfect means, to be isolated. In such cases the proof depends on symptoms and other attendant circumstances. Nor is the presence of poison in the dead body proof that it has caused death, for it is conceivable that poisonous substances may be introduced into the body after death has already occurred, or may have been used in the process of embalming. But the discovery of the poison in the liver and other viscera, and particularly in the urine, usually indicates antemortem administration. In many cases in which death is the result of chronic poisoning, it may be impossible to detect any of the substance, which, having performed its work, has been eliminated from the system. Volatile poisons also may be lost within a very short interval after death, and others may be decomposed or oxidized in the living body. In most cases, the ability to detect the poison depends upon the length of time which has elapsed after death, upon the interval between the first manifestation of symptoms and dissolution, upon the amount taken, and upon the amount remaining in the stomach and other organs when death occurs, for reasons which have been given.

Before proceeding to a chemical analysis, a careful examination of the stomach with the aid of a magnifying glass should be made. Such inspection may reveal crystals or powders admitting of ready examination, or particles of vegetable matter may be detected which may be identified from their botanical characteristics with the aid of the microscope. The organs subjected to analysis should be accurately weighed, and any peculiarities observed should be noted. It is best to divide the organs into several portions: one for preservation; one for volatile substances; one for alkaloids, etc.; one for metallic substances; and one for special poisons. The reagents and chemical apparatus used in an investigation must be free from any impurities. The work should be carried on with great precautions, and without assistance except such as is absolutely necessary; for the chemist must be prepared to swear to the identity of the organs, and to the impossibility of any tampering with his work on the part of others.

The methods of analysis to be pursued vary with the nature of the poison. Many substances require special processes for themselves alone, while others may be grouped together under a single process. It is best to look first for volatile substances which are easily lost with keeping, such as chloroform, ammonia, volatile acids, alcohol, ethereal oils, etc. The substance suspected of containing a volatile poison is rubbed up with sufficient distilled water, made acid or alkaline according to the substance sought for, and distilled; the distillate is then further examined by special tests.

The analysis for metallic compounds requires that the organic matter of the examined substances shall be destroyed, since otherwise it interferes with the characteristic reactions. For this purpose the substance is heated in an open dish, or glass flask, with chemically pure hydrochloric acid and potassic chlorate, the latter being added a little at a time until the color of the resulting liquid remains straw yellow for half an hour after the last addition. The excess of chlorine is then driven off by prolonged heating over the water-bath, or by the passage of a stream of carbonic acid through the liquid, which is then filtered and subjected to the regular process of qualitative analysis.

The analysis for alkaloids, glucosides, etc., is one which requires great care and delicacy of manipulation. The amount present in any one case is usually very small and widely distributed, and it is, therefore, not at all surprising that an analysis for this class of poisons often yields negative results even in the best of hands, when the administration of the poison may be proved absolutely. The method of Dragendorff for this class is the one most favorably regarded, and consists in extraction of the various poisons by particular solvents and then the separation of individual poisons by differing solubilities.

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Poke Root and Berry.—See *Phytolacca.*

Poland Springs.—Androscoggin County, Maine.

POST-OFFICE.—South Poland. Poland Spring House, Mansion House, and Riccar Inn.

This resort is located in the town of Poland, twenty-five miles north of Portland and ten miles west of Lewiston, at an elevation of about 800 feet above the sea-level. Poland is reached from Boston by the Boston and Maine and Maine Central Railroads to Danville Junction, thence by automobiles and carriages five miles to hotels. There is through Pullman service from New York, Boston, and Portland. The spring boils up from a fissure near the crest of a magnificent mound of the oldest rocks at the rate of about eight gallons of water per minute. The bed of the spring is composed of gneiss, scarcely distinguishable from the original granite, this gneiss being, as the geologists inform us, the oldest of the sedimentary rocks. The unvarying temperature of the water throughout the year, as well as its freedom from organic matter, would indicate a very deep origin. The surroundings of the spring have been extensively improved since 1859, in which year, it is said, the water was first described by a physician. The Poland Spring property covers an area of over 4,000 acres of lawns, groves, farms, meadows, lakes, and forest. The most detailed attention has been given to the drainage system, the electric-lighting system, and the water-supply system.

The harmonious group of buildings is most attractive. The Poland Spring House, the Mansion House, the Maine State Building—Library and Art Gallery—the new Chapel, and the Riccar Inn are set on a gently rounding elevated plateau, while beyond stretch miles of beautiful country with the western background formed by the White Mountains fifty miles distant.

In the neighborhood of Poland are many ponds and lakes, the nearest of importance, being the three Range Lakes nestling at the foot of Ricker Hill, less

than a mile from the hotels. These waters afford excellent fishing. Arrangements can be made to occupy the Poland Spring Camp on Mooselookmeguntic for short periods if guests so desire. Canoeing, boating, and swimming can be enjoyed in the Range Lakes.

Art exhibitions and fine concerts are features at this resort.

The foundations of Poland Spring House were laid in 1876, but such varied and extensive improvements have been made since that time that but little of the original structure remains. The season extends from the first of June to the middle of October. The Mansion House is open all the year round. This hotel was originally called the Wentworth Ricker Inn, and since first erected in 1794, has never closed its doors to guests. The winter sports at Poland are noted.

The Spring House is of Spanish design, built of mottled brick with Italian Pavonazzo marble interior. The floors are mosaic and the spring is inclosed in plate glass within a bronze grille. In the process of bottling, the water is never exposed to the air. The entire process may be observed through plate-glass walls.

The following analysis of the water was made by Professor C. F. Chandler of Columbia College:

One United States Gallon (231 Cubic Inches)

Contains:	Grains.
Potassium sulphate	0.1562
Sodium chloride	0.2636
Sodium carbonate	0.1333
Calcium carbonate	1.2287
Magnesium carbonate	0.5112
Oxide of iron and alumina	Traces.
Silica	1.1197
Organic and volatile matter	0.2332
	3.6759

The results of various analyses made by different chemists at widely different periods, "indicate not only the great purity of Poland water, but its constancy of composition during long periods."

This may be classed as a mild alkaline-calcic water, with very slight ferruginous properties. It has long had an extensive reputation in the treatment of rheumatism, gout, and dyspepsia, and in renal and hepatic disorders. It is best known, however, as a table water, for which purpose it has an extensive sale throughout the United States.

The early history of Poland Spring is most unique and interesting, and its reputation is now world wide.

Emma E. Walker.

Polarimetry.—Polarimetry is the measurement of the angle of rotation of a ray of polarized light, and instruments adapted to the purpose are termed polarimeters. Polarized light is light which (as explained by the accepted theory) has been changed so that vibrations transverse to the path of propagation have been reduced to a single plane. By this change the rays become much more susceptible to interference and may be used for detecting difference of structure not appreciable to ordinary light. Polarization may be brought about by reflexion or refraction of ordinary light, and also by direct transmission through some substances, such as tourmaline, Iceland spar, and quinine iodosulphate. Of these, Iceland spar is the only practicable material, and all laboratory instruments employ it. The crystal in its natural state, composed of pure calcium carbonate, is rhombohedral and double-refracting, that is, a ray passing into the crystal is split into two rays, both of which are polarized. For the best results in polarimeters the crystal is cut in an oblique direction and the pieces are recemented in their original position with Canada balsam. By this means one of the polarized rays is prevented from passing through, while the other is transmitted. A crystal so prepared is called a Nicol's prism. When a ray of light, white or of any color, passes through this prism, it will not be completely transmitted through a second similar prism unless the latter is placed in the same relative position, or 180 degrees of arc from it. At any intermediate position, more or less of the polarized ray will be intercepted, and at a 90-degree position—technically termed "crossed nicols"—only traces of the light pass. Many substances possess power to affect the ray in such a way that when they are placed between the nicols, these must be turned slightly from the above angles to get the maximum effect of transmission or obstruction, and such an effect is believed to be due to the fact that the intervening body twists the plane of vibration of the polarized ray, and the second nicol has to be twisted to compensate for this. Any substance which possesses this twisting (rotating) power is termed "optically active." The degree of rotation is fairly constant for any given substance under definite conditions, and hence the amount of an optically active substance may be measured by measuring the extent to which the nicols have to be adjusted in order to correct the rotation produced.

In the actual construction of polarimeters many details have to be regarded in order to secure delicacy and accuracy. Many forms have been devised, but only a few are now employed. In all these a beam of light passes through a Nicol's prism, called the "polarizer," then through the substance to be tested, then through another Nicol's prism, called the "analyzer," and then to the eye. As the mind cannot carry a recollection of the exact brightness of a field of light, some comparison is provided as a zero point, and the degree of alteration of the analyzer required to bring the whole field to uniformity is the measure of rotation. Substances differ as to the direction in which the light is rotated. When this rotation is such that the analyzer has to be moved to the right in order to compensate, the substance is termed dextrorotatory and designated + or *d*; when the opposite effect is produced the substance is termed levorotatory and designated − or *l*.

The adjustment of the analyzer to restore the zero may be made by the direct rotation of it, and the extent measured in degrees of arc; but in the instruments now usually employed the compensation is made by means of superposed wedges of quartz, which are shifted horizontally to the right or left as required and the amount of shifting indicated on an arbitrary scale termed the "sugar scale." This is graduated and adjusted so that if a solution containing twenty-six grams of pure cane sugar dissolved in sufficient water to make a volume of 100 c.c. at 20° C., is examined in the instrument, the rotation will correspond to 100. This scale has been introduced because the principal use of the polarimeter is the determination of the amount of cane sugar in raw sugar and syrups. It enables the analyst to read directly the percentage, but this applies to cane sugar only. For some purposes, monochromatic light must be used, for which a non-luminous gas flame charged with some sodium salt is the best. This gives a pure strong yellow light. The common polarimeters are now constructed to use white light from any ordinary source.

Fig. 4330 shows a form that is now extensively used as made by Schmidt & Haensch, of Berlin. *K* is a lens and mirror for illumination and reading the scale. *JJ* is the analyzer with the compensating quartz wedges. The details of the optical train are also shown in outline. At the polarizing end, also shown in detail, a large Nicol's prism, which receives and polarizes the light from the lamp, bears in front two small similar prisms, so arranged that the central rays are unaffected by them. By this means is obtained a field uniformly illuminated when the adjustment is at zero; but when any rotating body is introduced,

the central segment becomes darker or lighter than the side segments. In a cheaper form of the instrument only one accessory prism is used, and a "double field" instead of "triple field" is obtained. The material to be examined is dissolved in a suitable solvent, clarified if necessary, and a portion placed in a tube of known length closed by glass caps. On now viewing the field, any rotation of the ray will be marked by a contrast in illumination, and to restore the uniformity the quartz wedges must be shifted more or less. A given substance has usually constant rotating power under given conditions, but temperature, density of solution, nature of solvent, and many other factors produce variations. Some bodies have a high rotation when freshly dissolved, but fall off much when allowed to stand or when heated to boiling. This abnormal effect is termed "multirotation." Milk sugar shows it to a high degree. In order to make comparisons between different bodies, a factor termed specific rotatory power, indicated by $[a]$, is calculated by the formula $\frac{100a}{cl}$ in which a is the angular deviation observed; c the number of grams of the substance in 100 c.c. of solution; and l the length, in decimeters, of column of liquid examined. As the rotation differs somewhat with light of different colors, the specific rotatory power is now usually given for yellow light corresponding to the D line of the solar spectrum (see *Spectroscope*), and the symbol is written $[a]^D$. In practice certain weights, termed "normal weights," of material are employed. Rotation is influenced by temperature, hence a standard temperature is designated. This is 20° C. (68° F.). Though the principle of the operation of these instruments is simple, yet accurate results are obtained only by much care and experience.

The expense of the standard form of polarimeter has led to efforts to construct cheaper forms for clinical purposes, but these lack accuracy and do not involve any principles essentially different from those presented above. The extensive application of the polarimeter to the examination of food stuffs has led to many investigations as to the accuracy of the instrument, and it is evident that it has many sources of error, so that trustworthy results can only be obtained by attention to many details.

Clinical Applications.—Polarimeters are of but limited application in clinical diagnosis. Practically, the determination of sugar in urine is the only medical use made of them. Proteins rotate polarized light, but the fact has no diagnostic value. Diabetic urine is apt to contain several optically active bodies, not all of which are dextrorotatory; hence the observed reading will be a resultant. The polarimeter may be of use in making routine tests in a given case to determine the effects of treatment; but even then it will be necessary to check occasionally by the chemical tests which can now be performed with ease and celerity, and with sufficient accuracy for clinical purposes.

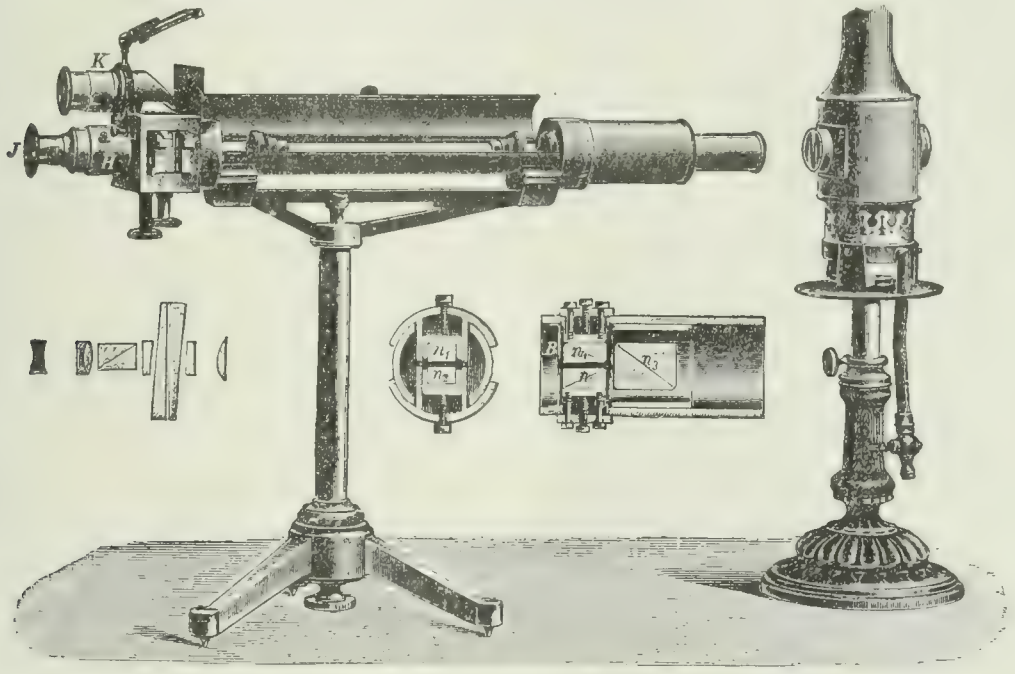

Fig. 4330.—Triple Field Polarimeter with Details of Polarizing and Analyzing Apparatus. (With permission of Eimer & Amend, New York.)

Urine, as a rule, will require clarification and decolorization for examination in the polarimeter. A solution of lead subacetate is commonly employed; 50 c.c. of the sample are added to 5 c.c. of the official solution, the liquids well mixed and filtered through a dry filter. The first 10 c.c. are rejected and the examination is made on the next portions. The dilution must of course be allowed for by increasing the reading ten per cent. Henry Leffmann.

Poliomyelitis Anterior.—Under this name we recognize a form of paralysis which occurs, as the name implies, most frequently in young children, especially during the period of first dentition. It is by far the most common form of paralysis to which children are subject and presents a well-marked clinical picture. A healthy child is suddenly found to have lost the use of one or more extremities, or of some individual muscle of an extremity. This loss of power may or may not have been preceded or accompanied by febrile disturbance; occasionally convulsions have ushered in the paralysis, but never is the latter accompanied by loss of sensibility,

Any of the voluntary muscles of the limbs or trunk may be affected, but the functions of the bladder and rectum are left undisturbed. Such is a general description of the onset of the disease. Soon, however, many of the affected muscles begin to recover their power; this recovery may be almost complete, the paralysis being finally limited to a few individual muscles; or, on the other hand, the greater part of the muscles originally affected may remain paralyzed, and later on undergo atrophy and degeneration. In this atrophy and retardation of growth the bones take part, giving rise to shortening of the affected extremity, while other deformities occur as a result of the unopposed action of the healthy antagonists of the disabled muscles.

Strümpell[55] in 1884 first recognized positively the infectious character of the disease, and also that such infections frequently produced cases in which the lesion was not limited to the spinal cord but accompanied lesions of the type of acute encephalitis. These latter cases are apt to occur in epidemics of the disease and the recognition of the infectious character of the affection was very much strengthened by the occurrence of many epidemics in various parts of the world. Such epidemic cases differ markedly in their pathology and clinically from cases of the endemic type.

Synonyms are numerous, and owe their variety to the views held by different observers as to the nature of the disease, before its pathology has been established. They are: Infantile spinal paralysis; Spinale Kinderlähmung (Jacob von Heine); Paralysie spinale; Paralysis infantilis spinalis; Infantile paralysis; Kinderlähmung; Paralysie infantile; Paralysie des petits enfants; Essential idiopathic or functional paralysis of children; Paralysie essentielle de l'enfance (Rilliet and Barthez); Essentielle Kinderlähmung; Dental paralysis (Underwood, 1784); Poliomyelitis anterior acuta; Acute inflammation of the anterior gray horns of the spinal cord (Kussmaul); Tephromyélite antérieure aiguë (Charcot); Acute atrophic spinal paralysis; Paralysie atrophique graisseuse de l'enfance (Duchenne); Regressive paralysis (Barlow); Myelitis of the anterior horns (E. C. Seguin); Epidemic infantile paralysis. These various terms were intended by their originators to indicate what appeared to be prominent clinical or pathological characteristics of the disease. Without entering upon the question as to the relative value of a clinical, as compared with a pathological, designation of diseases, there is no doubt that, of all the terms applied to the affection, the best of the first class is that adopted by Heine (Spinale Kinderlähmung, or infantile spinal paralysis). It is true that here even the word spinal would indicate, in a general way, the anatomical location of the lesion which is the cause of the clinical manifestations; but, inasmuch as it serves to distinguish this form of paralysis from other paralyses of cerebral origin, we can pardon this slight offence against unity in terminology in consideration of the completeness with which it serves to distinguish the disease. Of the purely pathological terms we should prefer poliomyelitis anterior acuta, as indicating the seat of the lesion, the term acute being especially applicable to the disease as it occurs in children. Seguin's myelitis of the anterior horns purposely omits the term "acute," in order to include the subacute and chronic cases of the disease which sometimes occur in adults. A more accurate pathological designation of the epidemic form of the disease as observed in recent epidemics is acute epidemic poliomyelitis with meningoencephalitis. The designation essential or idiopathic paralysis can certainly no longer be applied to a condition which has so well defined a pathology as poliomyelitis anterior.

Historical Account.—This disease has in all probability affected children for hundreds of years, without being differentiated by medical writers from other forms of paralysis. As early as 1784, however, Michael Underwood[1] described a form of paraplegia which occurred in teething children, and especially in those suffering from bowel troubles, which in its clinical history resembles the disease now known as infantile spinal paralysis. In 1836 John Badham,[2] of London, described a similar affection occurring in children, which he considered cerebral in origin. Notwithstanding these publications, the condition did not receive general clinical recognition until, in the publication of J. von Heine's[3] great monograph, in 1840, the symptom group of the affection was clearly defined and this form of paralysis distinguished from other forms of paralysis occurring in children. The picture of the affection in question, which Heine gives us in the very first edition of his work, is so accurate in detail that later clinicians had but little to add to the symptomatology of the disease. But, although no objective or subjective manifestation of the disease escaped the notice of this accurate observer, yet he remained ignorant as to the true pathogenesis of the affection. So logical a mind, however, could not but suspect that the disease was the result of an actual lesion of the nervous system, and accordingly we find him indicating the spinal cord as the most probable seat of the lesion. In the second revised edition of his work[4] he terms the disease Spinale Kinderlähmung, or infantile spinal paralysis. Duchenne, de Boulogne,[5] in 1855, besides accurately describing the affection, took a great stride in the direction of precision in diagnosis as to the character and extent of the paralysis, by discovering the relation which the faradic current bears to muscles which are the seat of this paralysis. Here, then, the first stage in the history of the disease may be said to have been completed. But, although clinically the affection was established upon a firm basis, its pathology was yet unknown. Rilliet[6] and Barthez,[7] basing their statement upon negative findings in cases of this disease upon the autopsy table, considered the affection primarily a muscular one, and hence termed it essential paralysis of children, the term essential referring to the idiopathic or non-organic nature of the paralysis. Although this view gained many followers, and some of eminence, yet it was not long before positive findings upon the autopsy table exploded this theory as to the pathogenesis of the disease. In 1863 von Reinecker and von Recklinghausen[8] published the autopsy of a case in which both lower extremities had been the seat of infantile spinal paralysis. Upon a macroscopic and minute examination of the cord it was found that the ganglion cells of the anterior gray horns and the nerve fibers of the anterolateral columns of that portion of the cord which gave origin to the nerve fibers supplying the paralyzed extremities had undergone atrophy and degeneration. The accuracy of these pathological data was confirmed by similar findings by Cornil,[9] Bouvier and Laborde,[10] Prevost,[11] Lockhart Clarke,[12] and later on by Charcot[13] and Joffroy,[14] Vulpian,[15] Roger and Damaschino,[16] and others.

Before we close this brief historical account of the affection we must refer to the studies of Erb,[17] as to the reactions produced by the galvanic current upon the muscles which are the seat of this spinal paralysis. Finally, we should refer to the identity of this affection, as far as the pathology is concerned, to a similar but more chronic affection, occurring in adults, which was first mentioned by Duchenne fils[5] in 1872, but not thoroughly studied until E. C. Seguin,[18] in 1877, devoted an admirable monograph to the subject.

In the last few years many writers have sought to ascribe an infectious character to this disease. This has been based not so much upon bacteriological or pathological findings, but upon the fact that the disease has been found to occur in occasional epi-

demics, one specially reported by Medin. Other observers, like Marie, Strümpell, Seligmüller, have reported smaller epidemics. Some have reported the occurrence of the disease in several members of the same family.

Strümpell probably deserved the credit of having determined that certain cases of acute encephalitis sometimes accompanied by spastic paralysis, together with the usual symptoms of infantile paralysis, occurred in epidemics of poliomyelitis and proposed the conception that the disease in this form was due to an infectious cause. Medin[296] studied epidemics occurring in Sweden and gave a good clinical and pathological description of the disease in its various forms including the recognized forms of cases of the older writers as well as those with spastic and bulbar symptoms, due to more or less extensive acute encephalitis in addition to the pathological involvement of the spinal cord.

Pathology.—The *endemic type* of cases which come to autopsy long after the incidence of the paralysis, the condition rarely proving fatal in such cases, show that the anatomical seat of the primary lesion of this form of paralysis is the spinal cord. This has been positively determined by numerous autopsies. It consists of an inflammatory process, acute in character, affecting in the first instance the anterior horns of gray matter. The lesion is at first diffuse, but as soon as the acuteness of the inflammatory process subsides it becomes limited in its longitudinal extent to circumscribed portions of the cord, in which even at the outset the inflammation had been most intense; this is most apt to be about the cervical and lumbar enlargements. At these points further changes soon occur, the most important of which are destruction and atrophy of the large multipolar ganglion cells situated in the anterior cornua.

This destruction and atrophy are not limited to the cells, but involve the nerve fibers in this region, and even the cells and nerve fibers of the posterior horns may become involved; sometimes the lesion extends into the white substance of the anterolateral columns. As a result of the primary lesion in the ganglionic cells of the anterior gray cornua, we have secondary changes taking place in the nerves which take their origin from the affected portion of the cord, and in the muscles to which these nerves are distributed. These changes are atrophic and degenerative in character.

Spinal Cord.—In epidemic cases, then, this disease is first an acute parenchymatous inflammation affecting chiefly the ganglion cells of the anterior horns of gray matter in the cord (Charcot).[19] When the autopsy has been made within two years after the onset of the disease, but slight changes can be observed in the cord by the naked eye, although the microscope reveals decided and constant alterations. These changes are typically shown in a case examined by Dr. Fred. Taylor, the particulars of which were presented to the London Pathological Society. It was that of a girl, three years of age, who suddenly became paralyzed, at the age of fifteen months, in the left leg. The paralysis was supposed by the friends to be the result of a blow; the principal symptoms observed at the time of the onset were fever and pain in the left lower extremity, followed by paralysis, and, later on, the development in the paralyzed member of the ordinary clinical phenomena of infantile spinal paralysis. The child was treated by galvanism for five or six months, and the paralysis somewhat improved; but at the age of three years death resulted from bronchopneumonia. Postmortem examination of the spinal cord showed a diminution in the size of the transverse section of the left half of the lumbar region of the cord. This diminution was most marked anteriorly, although also observable in the left posterior horn of gray matter. The anterior roots of the spinal nerves at this level were smaller than the corresponding roots on the right side. The posterior nerve roots were unaffected. On microscopical examination of a section taken from this portion of the cord it was found that there were but few ganglion cells in the left anterior cornu, and even those remaining were ill-defined and smaller in size, paler in color, and possessing fewer and shorter processes than those of the right side. The absence of these cells was most marked in the external and median groups of ganglion cells.

The nerve fibers passing from the anterior root to the cornu of the affected side were diminished in number and size. The main substance of the anterior horn consisted of a very dense and felt-like tissue, made up of matted fibers, "an increase and condensation of the normally open and spongy basis-structure of the part." In this felt-like structure the remaining nerve cells were embedded; no granular corpuscles were visible. The white matter of the left anterolateral column was found denser, the connective tissue being increased; while the nerve tubules were smaller than usual and deficient in axis cylinders.

This case shows the most prominent changes found in the cord in cases in which the autopsy has been made comparatively early. Occasionally areas of softening are found, more or less well defined, in different portions of the anterior horns, and at such places there is generally a total absence of proper nerve tissue, ganglion cells, and nerve fibers; but instead there is a low form of connective tissue, filled with large numbers of leucocytes and simple nuclei. In these recent cases the blood-vessels are found dilated. The cord may be affected at any level, although the cervical and lumbar regions are most frequently the seat of permanent lesion. The severity of the inflammatory process varies greatly, so that in some situations there is almost complete recovery, while in other places there is utter destruction, degeneration, and atrophy of nerve cells and fibers. The ganglion cells have been found in all stages of various forms of degeneration; many of them are entirely destroyed, and those that remain are found in a condition of extreme atrophy, having suffered great contraction and diminution in size, the cell processes, and frequently their nuclei, being destroyed. Sometimes the atrophy is of the pigmentary variety. In a case reported by Dr. Humphreys,[20] of Manchester, the number of the polar cells remaining in the affected portion of the anterior horns was compared with the number in the corresponding healthy portion of the cord, and it was found that while on the healthy side there were fifty-two ganglion cells, on the diseased side there were but thirteen.

Epidemic Type.—We come now to the consideration of autopsy findings upon cases of poliomyelitis anterior acuta epidemica. The material we have to select from is considerable, for epidemic infantile paralysis, so called, is frequently fatal, differing in this respect, as I have already noted, from sporadic poliomyelitis anterior. The best studied and most recent autopsies of this type of the disease are those of Harbitz and Scheel.[36] The study includes nineteen cases at necropsy, of which thirteen were cases of acute poliomyelitis, including acute bulbar paralysis, seven children and six adults. These cases died after two, three, four, and five days, one of each, and eight in from seven to ten days. The authors state that in the nervous system the following changes were found: In the spinal cord, a diffuse infiltrating inflammatory process, closely related to the blood-vessels, chiefly in the anterior horns, but involving to a less extent the whole gray matter more or less extensively longitudinally through the whole cord. Inflammation could also be traced in the white matter and in the pia mater with its prolongations; this, however, was demonstrable only by microscopic examination. There was also a cellular infiltration consisting partly of small and large mono-

nuclear lymphocyte-like cells, especially in the pia and white substance, while in the gray substance the cellular infiltration consisted partly of polymorphonuclear leucocytes. There was marked degeneration of the ganglion cells over large areas of the cord. They also state that the inflammation in the cord was more extensive than might be expected from the clinical symptoms, and in cases suffering only from symptoms of acute bulbar paralysis there was found extensive inflammation all along the cord. Occasionally the inflammation was hemorrhagic with small hemorrhagic cavities in the anterior gray cornua.

The inflammation of the pia mater on the cord and in the fissure was demonstrated opposite sections of cord, where the cord itself was not involved, which Harbitz believes shows that the inflammation begins in the pia and extends to the cord along the vessels. The inflammation is most intense in the anterior gray horns because these are supplied by the largest vessels. There is, therefore, a meningitis which precedes the inflammation in the anterior gray horns. Indeed, the pia mater is inflamed around the medulla and pons, about the cerebellum, along the base of the brain and cranial nerves, and particularly along the Sylvian fossa, exceptionally even over the hemispheres. There was also in many of these cases inflammation of the brain substance, including the medulla and pons, the fourth ventricle and nearly all the cranial nerve nuclei. The white matter, however, was but very slightly or often not at all involved. In nearly all the cases examined, even those giving no bulbar symptoms, all the cranial nerve nuclei were attacked by the inflammation. As a rule the gray matter around the aqueduct of Sylvius with the third and fourth nerve nuclei were involved. The inflammation, however, was more intense in the cord than in the brain. There were even infiltrations in the cortex in some cases, particularly around the central convolutions. These were the severe cases ending fatally; but even the milder cases which recovered but died of subsequent intercurrent disease, when examined showed (four such were examined) degenerated nerve tissue to a much greater extent than had been expected; changes were found in these cases not only in the cord, but in the medulla, basal ganglia, and in a few places in the cortex of the brain. The process even in the milder cases is therefore a general inflammatory one throughout the brain and spinal cord, and the pia mater of the brain and spinal cord.

It is obvious that the bulbar cases correspond closely in their symptom complex to cases of acute ascending paralysis, or what has been described as Landry's paralysis, as shown by Basoe.[42] Such bulbar cases have been quite frequent in our recent epidemic. They differ only in degree from the milder cases; the simple inflammatory changes in these go on to destruction and hemorrhagic infiltration of basic ganglia and bulbar nuclei in the severe bulbar cases. So that epidemic so-called poliomyelitis is in reality a general cerebrospinal leptomeningitis with anterior poliomyeloencephalitis. How different this from sporadic poliomyelitis anterior, which is exactly what the name indicates.

Harbitz and Scheel,[36] whose great work is the leader and teacher of the modern knowledge of the pathology of this disease, Wickman,[52] Römer,[49] the studies of Flexner[50] in experimental poliomyelitis, and the work of many other recent pathologists have further taught us the lesions occurring in acute epidemic cases of this disease. They find that the meninges as well as the brain and cord substances are swollen and edematous. Sections of the spinal cord show the gray matter, particularly the anterior horns, projecting above the white matter. The color of the gray matter is darker than usual, being purplish, almost red in color. Wickman[52,53] found that both in children and adults acute epidemic poliomyelitis involves pathologically not only the spinal cord, but the pathological findings were disseminated as a meningomyeloencephalitis. The lesion involves the medulla, pons, cerebrum, and cerebellum and their meninges as well as the spinal cord and its meninges, and while in the cord the anterior gray horns are most severely and frequently affected by the inflammatory and degenerative changes, yet the white matter and the rest of the gray matter, as well as the pia mater, are quite generally affected. The disease most commonly affects the cervical and lumbar portions of the cord. In these affected areas of the cerebrospinal tract the pathological changes are parenchymatous and interstitial; especially the latter, for never, says Roemer and Wickman, does one see changes in the ganglion cells without interstitial lesions. The process is preëminently an interstitial process of an infiltrative character of a lymphocytic type. The infiltrations are closly connected with the blood-vessels and follow the vascular distribution. The infiltrated areas are almost always accompanied by an inflammatory edema. The extension of the inflammation through the nerve centers occurs through the lymph channels of the blood-vessels, while the transportation of the morbus vivum of the disease from the site of the infection to the spinal cord is probably by way of the perineural lymph channels. Wickman believes that the point of entry of the causative agent is the gastrointestinal canal. Flexner believes that it is probably the nasopharynx and mouth. His experience in the production of experimental poliomyelitis in monkeys certainly warrants that conclusion. The work of Wickman, Harbitz, and Scheel, and others would lead to the conclusion that the pathological findings in acute epidemic poliomyelitis would include the pathological findings in Landry's paralysis as well as other types of acute myelitis hitherto looked upon as clinical and pathological entities.

Harbitz and Scheel consider that the disease process is spread not only through lymphatic but vascular channels affecting first the vessels of the meninges, and secondarily those of the spinal cord. Forssner and Sjövall[56] believed that the destruction of the ganglion cells is accomplished in part by a phagocytic-like activity of the leucocytes and Wickman has come later to be also of their opinion. The two former observers were furthermore the first to call attention to the fact that the intervertebral ganglia are also affected in poliomyelitis anterior.

In these cases of the epidemic types of the disease pathological changes were also found in other organs and parenchymatous structures not directly connected with the nerve centers. Particularly have there been found changes in the liver of an inflammatory and degenerative character. The lesions are not extensive but are quite generally found. So that acute epidemic poliomyelitis is a constitutional disease which, while preëminently and primarily affecting the structure of the spinal cord and brain, also produces pathological changes of a widespread character in other portions of the body. Whether these latter toxic affects are the result of the action of the specific virus of poliomyelitis or the result of a mixed infection acting with the specific virus is not yet determined. The method by which the virus is disseminated through the system from the site of infection and particularly how and why it reaches the nervous system has been well summarized by Paul H. Roemer.[49] The virus of this disease enters the organism by way of the nasopharynx or gastrointestinal mucous membranes or both. It disseminates itself through the lymph channels in the interstitial nerve tissue and neural sheathes of the peripheral nerves to the spinal cord. On reaching the cord it produces a slight infiltrative inflammation of the pia mater and thence spreads to the nerve tissue proper and the lymph channels of the nerve centers and those of the larger veins. This virus has a selective action for the lymph apparatus so that in these lymph channels it reaches

its highest development in those parts of the cord, which like the anterior gray horns are prolific in lymphatics and where the connective-tissue elements are extremely cellular and loose. The virus produces an infiltrative inflammation of the lymphocytic type which not only directly involves the ganglion cells in the inflammation and thus causes their destruction, but also secondarily causes degenerative changes in these cells by interfering in the nutrition of these cells. In some very severe cases the virus thus carried to the cord, involves the ganglion cells, previously leading to destruction of these cells through a process of lymphocytic phagocytosis.

Should the autopsy be made, as more frequently happens, many years after the original lesion has taken place, we would find changes similar in character to those described in endemic cases, but further advanced in a retrograde direction. The changes can be admirably studied in a collection of autopsies reported by Seguin in his work, and quoted and amplified by Seligmüller in his article on this subject in Gerhard's large work on "Diseases of Children." These changes are now readily appreciated by the unaided eye. The affected portion of the gray anterior horn is apt to be markedly shrunken and atrophied; sometimes even the posterior gray horns will be found slightly smaller than on the opposite side. The white columns, and especially the anterolateral columns, are found atrophied and sclerosed, sometimes to a limited extent on a level with the lesion, at other times to some distance above and below the lesion; indeed, the transverse section of the cord on the affected side will show a general diminution in size as compared with that of the healthy side. The anterior nerve roots at the level of the lesion are apt to present a grayish, translucent appearance and a diminution in size.

The microscope also shows the more complete atrophic changes which the nerve tissue has undergone; the diseased portion of the atrophied anterior horn is found to contain but few or no multipolar ganglion cells, and even those remaining are shrunken, with their processes atrophied, and found to have undergone various stages of granular and pigmentary degeneration. These cells have been replaced by connective tissue which has become contracted and hardened.

The changes in the white columns are apt to be less marked, although, as already stated, there is some diminution in the size of the anterolateral column, to a greater or less extent, above and below the lesion. These changes can scarcely be termed sclerosis. They consist of a certain degree of hyperplasia and contraction of the connective tissue, and an increase of the nuclei of the neuroglia. Amyloid corpuscles are also found. The anterior nerve roots undergo a more decided atrophy than the anterolateral columns; the number of their medullated nerve fibers is decidedly diminished. Many of them have lost their myelin, leaving only the axis cylinders, and, as a whole, the nerve root has become thinner and of a grayish and translucent appearance. The diseased foci in the gray matter are apt to be quite sharply defined, although at the onset of the disease large portions of the cord, above and below the areas of softening, are found congested; these portions, however, are not the seat of destructive changes, and they recover as soon as the inflammatory process subsides. This probably corresponds to the regression which occurs in the symptoms, thus leaving only those muscles paralyzed which derive their nerve supply from the softened areas.

It was formerly believed that all of these degenerative changes in the cord which I have described as characteristic of poliomyelitis anterior acuta take their origin in an inflammatory process in the vascular (arterial) system of the spinal cord. Such inflammatory changes are found even in the large blood-vessels of the cord, even in the walls of the arteria spinalis anterior and its branches (Socki). Manfredi, Widal and Besançon, and others have produced degenerative changes in the anterior horns of the spinal cord of animals by injections of pure cultures of various microbes. Widal was successful in producing the lesion in seven out of 117 rabbits which he had inoculated with streptococci. Thonot and Masselin believe that the coli bacilli can produce the lesion.

Schultz (1901), in a recent case of this disease in which the onset resembled meningitis, but the subsequent history and, months later, autopsy showed it to be a case of poliomyelitis anterior acuta, obtained by lumbar puncture the spinal fluid and isolated therefrom the meningococcus of Weichselbaum-Jaeger. The occurrence of this disease as a complication or sequel of the acute infectious diseases, such as measles and scarlet fever, would lead one to suspect that this form of inflammation of the cord, like the types of cerebrospinal meningitis, may be the result of a mixed infection of the primary disease infection and the various pus organisms. Some observers have been led to believe that the toxins of various infections in distant parts of the body may be carried to the cord, and set in motion the inflammatory changes in the blood-vessels which result in the degenerative changes in the anterior horns of the cord.

Changes in the Paralyzed Muscles.—Within a few weeks after the paralysis has taken place the paralyzed muscles become the seat of characteristic pathological alterations; not only do they become atrophied and smaller in size, owing to disuse, but they undergo active degeneration. Portions of such muscles can be obtained for examination by means of an apparatus like Duchenne's trocar, so that the various stages of degeneration can be studied. The first stage in the degeneration is, undoubtedly, ordinary atrophy of the muscle fibers. The fibers are narrower and diminished in diameter, the transverse as well as the longitudinal striations are finer and apparently more numerous. This apparent increase in the number of the transverse striations is due to the diminished thickness of the contractile discs. These phenomena are seen in muscles that have become atrophied from disuse, and are not distinctive of atrophy due to spinal-cord lesions.

In infantile spinal paralysis, however, the muscles soon begin to show further changes. Certain portions of the degenerating muscles begin to lose their striations entirely; here and there we find contractile discs replaced by granular matter, until the whole fiber has become to a great extent granular. This granular matter is probably protein in character, being at first soluble in acetic acid and insoluble in ether; later on, however, the granules are found to be insoluble in acetic acid and soluble in ether which shows that the protein granules have been replaced by fatty matter. Here and there will be found pigment granules. The muscle corpuscles are found to have increased in number, and in fibers which have undergone a complete granular fatty degeneration we shall find no trace of proper muscular tissue, the fibers being replaced by these muscle corpuscles embedded in a mass of fat granules surrounded by the sarcolemma. This may be termed complete muscular degeneration, and is the inevitable fate of muscles which have not recovered in the earlier stages of ordinary atrophy. Some of the muscles thus degenerated become the seat of further changes. The connective-tissue corpuscles found in the endomysium and perimysium increase largely in number, and form themselves into fibrous connective-tissue bands, which compress the degenerated muscular fibers; gradually the fat is absorbed, and what was formerly muscular tissue has become a firm fibrous cord. This change is known as cirrhosis of the muscles, and does not occur until long after the muscles have undergone hopeless

degeneration. These fibrous bands are apt to undergo contracture, which results in structural shortening and deformity. Rarely the connective-tissue corpuscles, contained in the fibrous bands, in their turn become distended with fat, thus giving rise to a deceptive fulness instead of the previous atrophy. This second fatty deposit may be so great as to lead to a diagnosis of pseudo-hypertrophic paralysis. When such a deposit of fat does occur it is in infantile paralysis of long standing. The ligaments and bony structures also take part in the general lowering of vitality which characterizes the paralyzed limb. The bones do not grow with anything like the vigor of the corresponding bones on the healthy side. This retarded growth results in diminution in the length as well as in the thickness of the bone; the prominences, ridges, etc., are less marked; the bone is more readily bent; closer examination shows that the compact tissue is relatively diminished, while the cancellous tissue is coarser and has scattered through it a larger number of fat cells. The bones are thus softer, but microscopically no changes in the structure of the bone tissue are found. All this results in a weakening as well as a shortening of the bone, and, necessarily, of the limb. Seeligmüller considers this bony change mostly the result of the disuse which is necessarily connected with the paralyzed member; the fact, however, that these atrophic bone changes are noticed in limbs in which the paralysis is insufficient to interfere with the adequate use of the member, would militate against this view, apart from the fact that the changes indicated seem to be far more radical than would be accounted for by ordinary functional atrophy due to disuse.

Partly in consequence of this bone atrophy, and partly as a result of the relaxation of the ligaments and muscles, the joints are apt to become altered. In extreme cases the ends of the bones which form the joint are not in contact, but hang apart from each other, so that the finger can almost invaginate the skin and ligaments between the joint surfaces. As a result, the articulation admits of adnormal mobility—motion resulting in subluxation of one joint surface upon the other. These changes are most readily observed where a muscle which passes over a joint is more or less completely paralyzed; thus, when the deltoid is paralyzed in the arm, the shoulder-joint is apt to show the above-mentioned changes very markedly. No pathological changes have been observed in any other organs of the body.

Etiology.—From modern investigations we are led to believe that poliomyelitis anterior is an infectious disease occurring sporadically, although frequently also in epidemics. Whether the disease has for its causative pathological agent a specific germ or its toxin, or whether it can be produced as a result of the activity of various germs, such as the pus organisms, etc., is not yet determined. That the disease is an infection is most certain, and from this starting-point all other factors in etiology are to be viewed as subordinate. Up to recent times poliomyelitis anterior acuta was no exception to the rule in the obscurity of its etiological chapter. Even now we know little or nothing as to the causes which produce the disease. We must, therefore, satisfy ourselves with an inquiry as to the causal relation borne by certain conditions, which precede the appearance of the paralysis, to the more or less acute inflammatory process. Before proceeding to this study there are certain factors which can be eliminated, and thus limit the field of inquiry.

Infantile paralysis is by far the most frequent form of paralysis to which children are subject. Jacob von Heine found, among 192 paralyzed children, 158 suffering from this disease.

The endemic disease in its acute form occurs with preponderating frequency in childhood and infancy, but exceptionally and not rarely in adults during epidemics, and is most frequent in the first, second, and third years of infant life. Duchenne the younger has noted one case occurring at the early age of twelve days. Seeligmüller has noted the oldest of his seventy-one cases as six years, but almost ninety per cent. of all cases reported were under three years of age. Sex is not a predisposing cause, the sexes being affected with about equal frequency.

The disease is found all over the civilized world, so that climate can scarcely be considered as exerting a predisposing influence, nor does the season of the year make any difference, cases occurring indiscriminately at all seasons. Wharton Sinkler[59] states, however, that forty-seven out of fifty-seven cases occurred in the warm months of the year.

Heine has stated that the disease most frequently affects strong, healthy children; and, indeed, one who sees many of these cases cannot fail to have observed many large, robust little patients whose otherwise handsome physique has been deformed by an attack of poliomyelitis anterior. But, on the other hand, most observers find that the majority of cases occur in children who are weak and delicate, even if a strumous constitution cannot generally be affirmed of them.

One of the most frequent causes assigned by mothers for this disease is "catching cold," particularly exposure to the direct action of a "draught." Or another very common cause, as stated by the parents, is a fall from the arms of the nurse or from a chair. Whether a traumatism of this kind can give rise to infantile spinal paralysis proper is questionable. It is conceivable that spinal paralysis, resulting from hemorrhage into the gray matter of the cord, may follow a traumatism; but this is not poliomyelitis anterior, although the clinical symptoms may be those of the latter disease, and it may be impossible to differentiate these cases from those of inflammatory origin.[20]

The endemic disease being one of the first dentition period, it seemed natural to look to conditions connected with this process for etiological factors in its production.

There is no question that the process of dentition throws the nervous system of the child into a state of exalted irritability, during which eclampsia, tetany, and other neuroses are commonly observed. These nervous phenomena are chiefly conditions of exalted nervous irritability, in which it is conceivable that the gray ganglion cells of the cord take part. From this irritated condition it is only a step to inflammation. Henry Kennedy[58] has called this disease dental paralysis. The restlessness of children while teething, the disturbed nutrition, want of sleep, and febrile disturbances common to this period of life, all are sufficient to render the spinal cord more sensitive to slight active causes, such as refrigeration, etc.

It may be objected, however, that all of these influences would affect the spinal cord as a whole, while in this disease only the anterior gray columns of the spinal cord are primarily affected. This might be explained by reference to the fact that motor areas of the cord in infants are much more in demand and further developed than the sensory tract. Infants are in constant motion, the extremities are thrown about whether in health or disease; during the waking hours infants constantly move and throw about the limbs and body; as a result the centers for these movements are supplied with an excess of blood, and hence are more prone to take on inflammatory processes.

Acute febrile conditions are commonly assigned as causes for this disease. It must not be forgotten, however, that the disease is in very many cases ushered in by fever, which is a symptom of the inflammation, and cannot be considered an etiological factor. But there are many cases which occur during the course of, or follow upon, the acute exanthemata—

scarlet fever, measles, and typhoid fever. Such cases must be carefully distinguished from postdiphtheritic paralysis, the more so since diphtheria often complicates scarlet fever, measles, etc. Duchenne and Seeligmüller report two cases following upon vaccination.

In many of the cases careful inquiry into the family history of the patient will reveal the existence of nervous affections in other members of the same family—either paralysis, convulsions, or insanity. Thus I have seen infantile spinal paralysis of the leg in a little girl, and paralysis of the upper arm in a younger brother of the first patient.

The study of the epidemic types of this disease has yielded more or less limited but accurate knowledge of the causative virus of this disease.

Notwithstanding the marvelously painstaking work of Flexner[50] and Lewis in the attempt to obtain a culture medium favorable to the growth of the unknown causative agent of poliomyelitis using spinal fluid obtained by lumbar punctures as the inoculating medium, yet all efforts in this direction have practically resulted negatively.

All investigations to the present time seem to show that the active virus of poliomyelitis is not a bacterium or microorganism which is easily grown upon any known medium. It is presumed that the organism is ultramicroscopic so that we know nothing of the morphological characteristics of such an organism. It is known, however, that it is a filterable virus. Experimental poliomyelitis has been first produced by Landsteiner and Popper by inoculating two monkeys intraperitoneally with spinal cord emulsion from a nine-year-old child who died on the sixth day after an attack of acute poliomyelitis. The pathological findings in the spinal cord in both monkeys after death (eighth day and nineteenth day respectively) were similar to those found in the spinal cord of human beings dead from poliomyelitis.

The inoculation of subsequent monkeys by emulsion of the spinal cord of the first animals did not produce poliomyelitis in the experimental animals, so that it was still doubtful as to whether the cause of poliomyelitis was a living virus or a toxin. However, in 1909 Flexner and Lewis, Leiner and von Wiesner, Paul H. Roemer, and finally Landsteiner and Levaditi[57] all succeeded in producing experimental poliomyelitis by injecting spinal cord emulsion of monkeys, killed after inoculation with experimental poliomyelitis, into other monkeys. Monkeys thus finally infected show, during life, the characteristic paralysis of poliomyelitis. Young apes are more readily infected than older animals.

For many reasons rabbits are not good subjects for experimental poliomyelitis and particularly because in these animals injections of various germ cultures, and other traumatisms readily produce paralysis.

We know nothing of the incubative period of the disease in human beings. Even in experimental poliomyelitis where the disease is produced by intracerebral injections the incubative period varies from about eight to forty-six days as reported by various experimenters. Here the conditions of infection or rather inoculation are entirely different from the infection in human beings as seen clinically. The virus remains fully virulent at freezing temperature. It resists drying. Permanganate of potash and peroxide seem to be powerfully antiseptic for this virus.

It seems to retain its virulence in the nasopharynx of infected monkeys for months. The virulence of this virus is increased by passage through animals of the same species.

Epidemiology of Acute Epidemic Poliomyelitis.—Medin made his studies upon this disease in an epidemic that occurred in 1887, in Stockholm and a second in 1895, while Wickman[52] studied the disease with results that are classical in epidemics in Sweden occurring between 1899 and 1905. In Norway numerous epidemics have occurred in the last twenty-five years and were studied by Hansen,[53] Harbitz, and others. In Germany epidemics have occurred and the disease has been studied since 1882 by numerous and competent observers. In Austria epidemics of this disease have been observed and the cases carefully studied since 1898. The same is true of epidemics occurring in the last twenty years in Holland, Switzerland, England, and France. In France there was noted a tendency to contagion in the cases affected. They occurred frequently in the same districts and especially in houses adjoining those in which a case had already occurred.

Epidemics have occurred in these years in Spain, Italy, and Russia and in the United States, Cuba, and Australia.

In 1907, there were in the City of New York about 2,500 cases reported by Gibney, Koplik, Starr, Holt, Clowe, Berg[27], and others. The epidemic extended throughout the Eastern and Middle States of the United States. Flexner is of the opinion that but few of the States of the Union escaped. The epidemics seem to have been more frequent in the colder northern countries. Authorities agree, however, that we do not know why this disease, although endemic in most of these countries, should periodically take on the violently epidemic character that it does. While it is believed to be contagious, there is no positive proof of such contagious character. Nor do we know anything positive of the conditions under which it is contagious. The clinical history of the epidemic as well as of the endemic cases teaches that one attack generally protects against a second attack. It is positive that one attack of experimental poliomyelitis in monkeys gives immunity against any subsequent attack of the disease. Monkeys have been rendered immune to inoculations with the virus of experimental poliomyelitis for two months after hypodermic injection with 10 c.c. of a carbolized virus. No immunizing attempts have been made upon human beings as far as I know.

Bacteriological Data.—Complement-fixation antibodies have been sought for in the blood of monkey patients recovered from the disease but have not been found. Although there is no doubt of the existence of specific active antibodies in the blood of patients who have recovered from poliomyelitis, and it seems to be proven that these specific antibodies are present in such patients for six years after the disease occurred. The poliomyelitis virus is neutralized by the serum of such patients. This is so whether such patients have suffered from epidemic or endemic poliomyelitis. This latter fact is sufficient proof of the identity of the two forms of this disease.

Some attempts have been made to use the serum of such recovered patients for the cure or prevention of poliomyelitis, but as yet with positive results.

Symptomatology.—In discussing the symptoms of this disease it is perhaps wise to take up in order the characteristics of the invasion, the appearance of the paralysis, and lastly, the deformities and contractures resulting from the paralysis. The symptomatology of this disease in the epidemic type differs in many respects from that of the endemic cases. This difference is chiefly marked in the stage of invasion. I shall first describe the invasion stage in the older known type of cases—the endemic type; then that of the epidemic type in the stage of invasion.

Stage of Invasion, Endemic Type.—Although various prodromal symptoms have been laid down in the textbooks as preceding the onset of the disease, yet none of these appears to me to be peculiar to this affection, even in slight degree. The children are irritable, slightly feverish, and suffer from loss of appetite; the bowels are constipated or relaxed; some of the little patients complain of pains in the back and limbs.

One observer[21] has noted that these patients refuse to walk, or, if they walk, are easily made tired and wish to be carried. I myself have not noticed the latter symptom as part of the history of my cases, and have found very many cases—indeed, the large majority of my cases—in which no prodromal symptoms at all occurred. Cases may be divided, as regards the character of the invasion, into two classes: First, those in which the onset is shown by high fever, with or without convulsions; second, those in which the stage of invasion is entirely absent, the patient becoming suddenly paralyzed.

Cases belonging to the first class will be found to have either the febrile disturbance or the nervous symptoms most prominent. The patient is suddenly attacked by high fever, 100° to 102° or 103° F., rarely above; there are great thirst and restlessness. At the beginning of this fever there may occur a convulsion lasting a short time, and often followed by others, or the fever may be slight; but the child lies in a state of semi-coma for a few days, from which it gradually rallies, when the friends find one or more groups of muscles, or one or more limbs, paralyzed. The fever may last from a few hours to two or three, or even more, days; but, as a rule, it continues only a few days, after which it subsides, and the parents believe the child to be on the road to recovery. Then suddenly paralysis is discovered to have taken place. If the paralysis is slight, it may not be noticed until the initial fever has long passed, so that the parents will assure the physician that there was no fever before the onset of the paralysis.

In cases occurring during the course of convalescence from measles or some other acute febrile affection, the paralysis is supposed by the friends to be due to the general disease.

In many of the cases, in addition to the fever, with or without convulsions or semi-coma, the patients suffer from diarrhea and often from vomiting. Hyperesthesia of the limbs and other portions of the body may also occur. There may be frequent micturition, but there is never paralysis of the bladder or loss of sensation.

The cause of the initial fever would appear to be the acuteness of the inflammatory process in the cord, together with the reaction of the organism to the virus of the infecting cause. The fever is not a constant accompaniment of this disease; it was present in about one-half of my cases. Frequently parents do not notice the fever, which may occur at night, when the child is asleep. When the little one awakes in the morning the paralysis is observed, although the fever, if only of a few hours' duration, may have been overlooked. The antecedent fever is noted, however, in the cases in which it is of longer duration. It has been known to last for twelve days; but in most cases it is of less than two days' duration, and commonly lasts only twenty-four hours. The temperature rarely rises above 103°, or, at most, 104°, and even these figures are exceptionally high. We have had no good thermometric records; the diagnosis being never possible before paralysis has set in, and the fever has, as a rule, come to an end, although cases have been reported in which the fever lasted after the paralysis was complete.

Convulsions occur, in the opening stage of this disease, in many cases in which fever is present, and also in some in which there is no rise of temperature. This would seem to prove that the convulsions are not dependent upon the cerebral hyperemia produced by the fever. It is, furthermore, not probable that these attacks, which are epileptiform in character, are due to lesions in the spinal cord, for the muscles which become convulsed are not only those that are afterward found to be paralyzed, but impartially those of the whole body. Some writers, however, state that the convulsive movements are more violent in those muscles which afterward become paralyzed. The attacks vary in duration, number, and frequency. Frequently only a single convulsion ushers in the disease; at other times the patient is thrown into a status epilepticus lasting some hours, and it is conceivable that in this condition the patient may die, the diagnosis of poliomyelitis not having been made. On the other hand, the convulsion may be so slight as to be entirely overlooked, and, if it take place during the night, the fever as well as the convulsion may be entirely overlooked. The recovery from the convulsion may be complete, or the child may fall into a stupor, and even coma, from which it only emerges when all acute symptoms have disappeared. Frequently the little patient has no convulsions, but still is restless and trembling, or apathetic and drowsy. Either of these conditions may be present in the opening stage of the disease, with or without the fever.

Another symptom, to which we must call attention, is one which accompanies all febrile conditions, but is here particularly prominent, namely, hypersensibility —the patient cannot be touched without feeling pain —he cannot be moved without crying out. Some writers have stated that this exalted sensibility is most marked in the spinal column. My own experience does not show that the little patients ever complain of a sensitive spine. On the contrary, I have found these children very easily handled, and the spine very flexible, this fact forming one of the data for the differential diagnosis between this disease and Pott's paraplegia, although patients may have passed through the initial stage of the malady with more or less of the above symptoms, or so little of them as to escape the observation of the friends.

Stage of Invasion, Epidemic Type.—Before discussing the second or paralytic stage of both the endemic and epidemic forms of the disease I must not neglect to speak of the preparalytic stage of the epidemic types of the affection. It is claimed and with some justice that during an epidemic many cases occur in which while the constitutional symptoms of the invasion stage such as the headache, fever, occasional convulsion, and symptoms of catarrhal inflammation of the mucous membranes as well as the hyperesthesia are present, the disease does not pass on to the stage of paralysis, but goes on to recovery. By such cases the disease is supposed to be communicated to the well with even more frequency than by the paralytic cases. The difficulty of recognizing these as abortive cases of "infantile paralysis" is obvious. It is the play of Hamlet with the character of Hamlet omitted. Nevertheless, this is possible particularly by an application of the complement-fixation test on the lumbar puncture fluid of the suspected patient, and by the fact that such cases are apt to occur in the neighborhood of real cases of poliomyelitis with paralysis. The danger of making such a diagnosis on insufficient ground, however, is obvious. We now come to the second or paralytic stage of the disease. One peculiarity that stamps the epidemic form of the disease and distinguishes it from the sporadic form is the fact that it occurs in older children as well as in infants. Indeed, young adults have not been free from it. Children from five to eight years of age were not infrequently affected by it, although the vast majority of cases were in children under five, and very many of them infants. One of my cases which terminated fatally after three days' illness was a young girl eleven years of age with bulbar symptoms, which I diagnosticated as a case of acute ascending paralysis, the so-called Landry's paralysis. This case was seen in the hospital and came to autopsy. Another similar case with bulbar symptoms was that of a boy seven years of age, seen on the second day in consultation, and death on the fifth day. All my other cases were under five years of age. Dr. Geiersvold found both children and adults were attacked in the Norwegian epidemics. Of the nineteen autopsies on recent epidemic cases studied by Harbitz and Scheel,

eight were in adults. Other observations of epidemics found similar conditions with regard to adult susceptibility to the disease. This is a very important distinction between the epidemic and sporadic disease, which owed its name, acute infantile spinal paralysis, to the fact that the sporadic form of the disease was not known to affect adults.

The symptomatology of the epidemic type of this disease is very different in many respects from that of the acute stage in a sporadic case. The fever is of greater duration in the epidemic cases, it is a more prominent factor and is never absent in any of the cases, while sporadic cases frequently occur in which a healthy child has gone to bed at night and waked in the morning with the characteristic spinal paralysis. In all of my cases the fever was present and in most of them it endured many days after the paralysis had appeared. The temperature curve was slightly irregular, but not septic in character, however. Many of the children were delirious and semi-comatose, a condition from which they emerged very slowly. There was no vomiting except at the onset. There was hyperesthesia of all the surface of the body, and in many cases seen on the first, second, or third day there was some rigidity of the neck and spine. Even the paralyzed limbs could not be handled without pain. The patella reflexes were in most of the cases absent. The initial rigidity at the back of the neck soon gave way to a flaccidity of the muscles about the neck, in some cases, particularly those in which the muscles of the back were paralyzed. I saw several cases in older children (three to eight years of age). In some of these there was incontinence of feces and urine, symptoms that do not form a part of the history of sporadic cases of this disease in which the sphincters are never affected. Three of my cases had bulbar symptoms and died of symptoms due to the involvement of the hypoglossal, glossopharyngeal, and pneumogastric nuclei. One of these cases had a comparatively low temperature, mental condition absolutely clear, and yet total paralysis of all the extremities and muscles of the back, together with the muscles of deglutition and speech, and finally died of diaphragmatic and cardiac paralysis. In one or two of the cases in this epidemic there was a temporary, at least, analgesia (pin test) in some of the paralyzed muscles from which the patient recovered about the time when the fever disappeared, so that clinically in these epidemic cases symptoms are present, not met in the sporadic cases of the disease, presupposing for their explanation a general inflammatory disease of the cerebrospinal axis, including nuclei in the pons and medulla, and longitudinally a more or less extensive myelitis not only of the anterior gray horns, but of the posterior gray horns, the white columns, the anterior and posterior nerve roots, and even the meninges (pia mater).

Second, or Paralytic Stage.—The paralysis may develop very suddenly, the child being paralyzed almost as rapidly as though from apoplexy, or it may develop more slowly, the paralysis gradually extending in the course of one, two, or three days. In the first class of cases a large number of the muscles of one or more limbs become paralyzed simultaneously. This includes also the cases of bulbar paralysis, and of which most patients die after rapid development of the paralysis or recover in very rare instances after an equally rapid regression. In the second class of cases the paralysis extends from one group to another until the maximum paralysis has been attained. Sometimes the paralysis is so complete that the patient lies without being able to move a muscle. At other times the paralysis is so slight that it is unnoticed until the function of the paralyzed member is interfered with.

However complete the paralysis at first may be, yet it is characteristic of this disease that after a short time (one or more days) many of the paralyzed muscles begin spontaneously to recover their power; this is known as the regression of the paralysis. Spontaneous recovery from the original paralysis may be complete in certain individual muscles, although entire recovery for all the muscles never occurs. Many writers state that in most cases the height of the paralysis is attained at the end of twenty-four hours. My experience leads me to give a longer period for the development of the palsy, certainly not longer than a few days, when the paralysis will cease to extend. Regression, however, begins in many cases as early as the second day, continues rapidly for the first few weeks, then much more slowly, although even up to four or five months the muscles may still undergo spontaneous recovery of power. Any power restored after that is due either to the good effects of treatment or to the use of the limb. However complete the restoration of some of the paralyzed muscles may be, it may be positively affirmed that complete recovery in all the muscles affected by infantile paralysis is impossible.

Muscles Affected.—All the voluntary muscles of the body may be the seat of this paralysis, rarely those supplied by the cranial nerves, although in epidemic cases this is not so rare. Seeligmüller reports one case in which the muscles supplied by the facial were affected as well as the nerves supplying the eyes, ears, mouth, pharynx, and larynx. On the other hand, the sternocleidomastoid has been found affected, the muscles of the trunk, including those of the back and abdomen, and, above all, the muscles of the extremities.

The paralysis may affect the back, so that the patient cannot sit or stand; the neck, so that the head falls forward or to the side; and it may affect one or more extremities, giving rise either to crossed paralysis (one arm and the opposite leg), or paraplegia (all four extremities or the two lower extremities), both upper extremities, or the arm and leg of the same side (hemiplegia).

Most frequently only one extremity is affected. Next in order of frequency comes paralysis of both lower extremities, while crossed paralysis and hemiplegia are much rarer. The upper extremity is less frequently affected than the lower, while paralysis of all four extremities is extremely rare, but three cases having been reported in the literature (see Seeligmüller).

It is extremely rare for a limb to remain totally paralyzed, nor do we find in any two cases an exactly similar distribution of the paralysis.

Certain groups of muscles will be found to have escaped the paralysis, and sometimes even portions of the same muscle will retain power, while the rest of the muscle is paralyzed.

The anterior tibial group of the leg and the extensors of the thigh are most frequently affected. The psoas, on the other hand, is rarely affected, even in the most extensive paralysis.

In the upper extremity the deltoid is most frequently paralyzed.

The sphincters of the bladder and rectum are never affected, although in epidemic cases during the coma of the stage of invasion, the sphincters are involved. In this respect we have an important difference between this form of paralysis and that following transverse myelitis. It is true that in some very young children the general disturbance with which the disease is ushered in may give rise to a few involuntary passages, but this is only temporary, and will not be present when the paralytic stage has set in. After the sixth to the ninth month has passed, we can no longer look forward to spontaneous recovery in the paralyzed muscles. Muscles which have not improved until then are apt to remain paralyzed, and go on to the third stage of the disease, the atrophic stage, in which extreme atrophy of the paralyzed muscles is the most prominent symptom. It must not be supposed, however, that the paralyzed muscles do not

atrophy until six or more months after they have become the seat of the paralysis. On the contrary, atrophy of the fibers of the paralyzed muscles can be found with the microscope very soon (two or three weeks) after the paralysis has set in, and several authorities claim to have observed atrophy, evident to the naked eye, as early as the third week after the paralysis. In my own cases I do not remember to have observed any evident atrophy earlier than three months after the first occurrence of the paralysis. The cause of this atrophy is, as we have already seen under the head of pathology, not simple disuse of the paralyzed limb, but a cutting off of the trophic influence of the nerve cells of the anterior gray horns of the spinal cord; this results in a disturbance of the nutrition of the muscle tissue as well as organic degeneration of the nerve fibers. Disuse of the paralyzed limb undoubtedly aids in producing a diminution in the size of the paralyzed member. As a result of these causes we have a very extensive atrophy of the paralyzed muscles—so complete that frequently the configuration of the bones, with their anatomical points, can be felt or even seen with startling distinctness. Often all muscular tissue seems to have disappeared, leaving only the bones, connective-tissue bands, and skin. As already explained, however, these atrophic members in the last stages of atrophy may undergo a pseudo-hypertrophy, owing to the deposit of fat in place of the atrophied muscle fibers. In those muscles which undergo recovery after a certain amount of atrophy has taken place, the restoration of volume in the recovered muscle does not directly follow upon restoration to power. The muscle is only gradually restored to its former size some time after power has returned.

It is true of endemic cases that while spontaneous recovery from the paralysis may be very extensive yet never is a total recovery of all the paralyzed muscles seen. This is true also of almost all of the epidemic types of cases. Nevertheless both in my own observation and that of many other observers there occur in epidemics rare cases of the most extensive paralysis which recover practically entirely in a few months so that no paralysis that leaves an obvious disability remains. Such a fortunate termination of the disease, as I have said before, is extremely rare.

Atrophy is not limited to the paralyzed muscles, but affects the bones and ligaments, and even the blood-vessels; the extent and character of the atrophic changes have already been discussed. There is also atrophy of the skin; it is apt to be more delicate and thinner; it is of finer texture, and paler in color at first, although later on it becomes cyanotic in color, owing to the diminished blood supply in the paralyzed limb. This diminished blood supply is due to atrophy of the blood-vessels and the disappearance of the finer capillaries. The muscular coat of the arteries is atrophied, giving rise to a diminished arterial tension. In consequence of this diminished blood supply the surface temperature of the paralyzed member becomes greatly diminished. Fluctuation in temperature is very great, especially when the body has been exposed to cold. Thus the difference between the healthy and paralyzed limbs may be 20°, 30°, or even 40° F. It is almost impossible to keep the paralyzed limbs warm; friction and artificial heat serve to restore warmth for a time, but, unless frequently applied, they do very little good. As a result of the lowered temperature and slowness of circulation, the skin sometimes becomes the seat of ulcerations, which are very slow to heal, and are exceedingly painful. These ulcers affect only the scarf skin, and consist of a desquamation of the epidermis, the derma remaining unaffected. As part of the symptomatology of the paralytic and atrophic stage of the disease, we must devote some space to the discussion of the accompaniments and results of both of these conditions, namely, the deformities so characteristic of the final stages of this affection.

Third Stage.—Deformities Resulting from Infantile Spinal Paralysis.—A careful analysis of the deformities resulting from infantile paralysis will warrant their classification into two groups:

1. Deformities due to trophic changes in the limbs.
2. Deformities depending on the paralysis of muscles.

1. Deformities Due to Trophic Changes. In discussing the symptomatology of this disease, it was seen that, owing to destruction or interference with the trophic centers in the cord, all growth of the parts supplied by the nerves passing from the affected region was arrested, and the development which the affected tissues had attained before the time of seizure was diminished, the tissues retrograding and undergoing degenerative changes. The deformities of this group, then, are due, first, to cessation of growth; second, to retrograde metamorphosis. Cessation of growth is in every direction, and results in shortening and attenuation of the affected member as compared with the condition of the limb in health. Retrograde metamorphosis or atrophy will also cause deformity, either by shortening, or, more commonly, by attenuation; so that lack of growth, aided and reinforced by atrophy and degeneration, results in deformity by producing shortening or attenuation, or both together. From a consideration of the function of the upper, as compared with the lower, extremity of the body, it is evident that deformity due to shortening is of far more importance when it affects the lower extremity than when it affects the upper. Not only is it essential that the two limbs should be of equal length in order that the patient may walk and stand without deformity, but the proper performance of the functions of other parts of the body depends upon the lower extremities being of equal length. For, the trunk being supported by the two lower extremities acting as pillars, the shortening of one of these pillars as compared with the other will result in a corresponding lowering or sagging of that side of the body; the pelvis will become oblique, the normal side being on a higher plane; and were it not that conservative nature seeks to rectify the result of the disease, we should see these patients walking and standing with the body bent over to the side of the shortened leg. To maintain equilibrium the patient is compelled to throw the body to the opposite side, giving rise to a functional lateral curvature of the spine, which, in its turn, again in the effort to maintain equilibrium, is modified by a secondary curve. We have, then, as a result of the shortening of the lower extremity, deformity in walking and functional lateral curvature.

Atrophy and attenuation are of less importance here than in the upper extremity, disability rarely resulting from this cause alone; while, on the other hand, shortening is of less importance in the upper extremity than in the lower; for one arm or hand may be shorter than the opposing member, but were it not for the paralysis which accompanies the shortening, it would be of little importance. On the other hand, atrophy is of great importance in its effects upon the upper extremity. An atrophic shoulder will sag downward, producing even, in some cases, a lateral curvature high up. But, what is more common, the head of the humerus becoming atrophied, and the hand having no resistance below, as is the case with the foot, we have a resulting subluxation, which in itself would interfere with the use of the arm. In one of my cases this subluxation in every direction resulted from the slightest motion, and was an important element in the treatment of the case. Although, in the limits of this article, I consider it more profitable to indicate the *principles* which govern the production of deformities which result from infantile spinal paralysis, rather than minutely to catalogue all of these, I cannot here overlook a seemingly minor deformity which results from the muscular atrophy characteristic of this disease. I refer to the undue prominence of the articular extremi-

ties of the bones in cases in which the muscular atrophy has become extreme. This deformity is so marked in some cases as to lead the patients to believe that the joints are dislocated or are the seat of osteophytic growths. Although this undue prominence of the extremities of the bones does not interfere with locomotion, yet it is of great importance in the treatment of these cases; for a careless application of rigid orthopedic apparatus often results in the formation of callosities over these bony surfaces which are painful to the patient, and when once formed are difficult of removal.

The second group of deformities which result from this disease are by far the most important; they are the deformities depending upon the paralysis of muscles. Inasmuch as individual cases differ greatly as to the extent of the paralysis and the number of muscles involved, so also the variety of deformities resulting from infantile paralysis includes almost every form of inability and perverted motor activity. But before considering these deformities it will be proper to consider the laws upon which their production depends. This subject was studied by Volkmann in the first of the "Klinische Vorträge." Although inability is the immediate result of paralysis, deformity is not the consequence of the paralysis itself, and does not occur until a later stage of the affection is reached, when it is found that permanent contractures have taken place, of which the paralyzed muscles are generally, but by no means exclusively, the seat. As to the cause of these contractures which so deform the already paralyzed limb, many explanations have been advanced. The oldest and most popular is that of unopposed muscular action. This explanation rests upon the theory that all muscles in their quiescent state are the seat of a reflex tonicity. That is to say, it is supposed that the higher centers of the brain and spinal cord are constantly sending out innumerable and minute impulses in response to constant and unconscious peripheral excitation. This constant state of contractility is known as the reflex tonicity of the muscles, and, being constantly present in all of the voluntary muscles, the parts moved by them are kept at rest except when the will or reflex causes throw excess of energy into any single group. The principle is similar to that by which the heavenly bodies are enabled to retain their places in the universe, although constantly acted upon by centrifugal and centripetal forces.

Reasoning from this assumption, it is supposed that as soon as any group of muscles is cut off from the motor centers in the cord, the opponents, being still the seat of the normal muscular tonus, undergo contracture because the equilibrium has been destroyed. Were such the explanation, however, we should expect immediately after the paralysis to see the remaining healthy muscles become permanently contractured. Volkmann did great service in combating this theory, although he has gone to the opposite extreme and proposed one almost equally untenable. He found that in children with infantile paralysis of all of the muscles of the lower extremity, in which the muscular groups on the anterior as well as those on the posterior portion, or calf of the leg, were paralyzed, the tendo Achillis was the seat of contracture, and the foot assumed the equinus position, just as though the anterior tibial group alone had been paralyzed and the calf muscles had remained intact. Again, in cases of talipes equinus, immediately after the performance of tenotomy of the tendo Achillis, if the child were placed in a chair with the legs pendent, the foot, instead of assuming the calcaneus position, in obedience to the unopposed action of the anterior tibial group, is found to place itself in the equinus position; this is explained by the action of the force of gravity upon the foot. On the strength of both of these observations he explains the production of the deformity in many cases by the action of the force of gravity, claiming that the position which this force compels the paralyzed limb to assume, as the patient sits or stands, will be the position in which contractures will most frequently fix the limb. But on consideration we find that, even in the extremity on which the force of gravity is most influential, namely, the foot, this theory is not substantiated; for which one of us has not seen an acquired talipes calcaneus with toes raised and heels bulbous and boring the ground? The study of a recent case of facial paralysis will help to clear up this subject.

It will be found that, after the paralysis has occurred, as soon as the patient has made the first use of the non-paralyzed side, the face is slightly drawn to the healthy side. I say slightly, not so completely as it would necessarily be if the cause of the deviation were the unopposed action of the healthy side, but just enough to make it noticeable. This deviation, I think, can be explained in the following manner: The first facial motor impulse that occurred immediately after the paralysis had taken place found only the healthy side of the face ready to act. It contracted, and as soon as the motor impulse ceased the tissues returned to their relaxed condition; this passive relaxation is almost, if not quite, sufficient to restore the tissues to the position they occupied before contraction. The residual work necessary to complete the restoration the opposing muscles do for each other, and since in our suppositious case the opponent was paralyzed, the healthy muscles had almost but not quite, returned to their normal position. In other words, the origin and insertion of the muscles have been brought slightly nearer to each other than they should be normally in the condition of rest with increased activity. After a time the shortening will become more marked, and the muscle will assume the contractured appearance so familiar in deformities following long-standing paralysis. The paralyzed muscles, in order to adapt themselves to the contracture and shortening of the healthy muscles, become passively stretched, for it is evident that every time the activity of the healthy muscles is called into play the paralyzed opponent is stretched and becomes longer, just as the healthy muscle becomes shorter. The contracture or shortening of the healthy muscles, which is primarily the result of the use of the healthy muscles, is increased by, and at the same time the cause of, the elongation which the paralyzed muscles undergo. I conceive that the only contractures which are properly the result of the action of gravity are those in which all the muscles of the limb are paralyzed, and in these cases there is no question of the non-applicability of the theory of muscular tonicity. There is another form of contracture of which the paralyzed muscles themselves are sometimes the seat; this is the result of the final stage of atrophy which the paralyzed muscle undergoes. Then the muscular fibers disappear, the muscles proper being replaced by connective-tissue bands; these contract, and when such contractures occur they counteract other previous contractures of the non-paralyzed muscles.

It follows, then, that paralysis of muscles causes deformity in one of two ways: first, by mere inability resulting from the paralysis; second, by the resulting contractures in the healthy or paralyzed muscles.

Deformities of the Lower Extremities.—Extensive paralysis, involving all of the muscles of the lower extremity, will produce a deformity well described as "flail-like." Here the lower extremity is so flaccid, and the patient has so little command over it, that in walking (with crutches) it swings as loosely as a flail; and yet, however complete the paralysis may be, careful examination will show here and there a muscular group of which the patient has retained the use. The psoas magnus is frequently preserved, so that the thigh can be flexed slightly, although the leg cannot be extended. Another very common deformity at the hip-joint is inability to extend the thigh because

of a contractured psoas. In these cases the hip-joint cannot be extended even to a right line with the body; in cases in which the rectus femoris and tensor vaginæ femoris are preserved this deformity is increased in degree. The prominent tensor vaginæ femoris appears to be so important a factor in the production of the deformity that the effect of the contractured psoas is overlooked. Hence disappointment in the operative and mechanical treatment. When deformity occurs at the knee-joint it is generally due to contracture of the outer and inner hamstring tendons. In these cases the muscles which extend the knee are paralyzed, the ligaments of the knee-joint are weakened by disease, and hence, when the patient attempts to rest the weight of the body upon the knee-joint, it closes up like a jack-knife. When the muscles on both the extensor and flexor side of the thigh are paralyzed, it is impossible to use the knee-joint in standing or walking, and the inability is almost as great as in flail leg. The most common seat of the deformities resulting from this disease is undoubtedly the ankle and mediotarsal joints; in other words, the joints involved in the various forms of club-foot. The forms of paralytic club-foot conform more or less closely to the classical varieties. The order of their frequency is, in my experience, as follows: (1) talipes equinovarus; (2) talipes calcaneovalgus; (3) talipes equinus; (4) talipes calcaneus.

Paralysis of both the anterior and posterior calf muscles is apt to result in the equinovarus deformity, that being the position in which the foot is for the most part held. When the anterior tibial group alone is paralyzed, the deformity is apt to be equinus or equinovarus, for reasons already stated. Paralysis of the peronei alone will result in varus. Talipes equinus and equinovarus are often accompanied by contraction of the plantar fascia. This is particularly apt to be the case if the tibialis anticus is preserved, while the rest of the anterior group is paralyzed. Occasionally one or two divisions of the extensor communis digitorum remain normal, the rest being paralyzed; the result is contracture of the preserved tendon, and hyperextension of the first phalanx of the toes supplied by these tendons. In such cases the shoe of the patient presses upon these prominent phalanges, and produces excoriations, thickening, and bunions, which can often be cured only by tenotomy. When the interossei are paralyzed we have a condition analogous to "main en griffe" of the hand, the first phalanx and all of the toes being extended and the ball of the foot prominent. Dr. N. M. Shaffer has described, under the head of "Non-deforming Club-foot," a condition which may be characterized as an incomplete talipes equinovarus; this condition often results from infantile paralysis.

Paralysis of the posterior tibial group, including the gastrocnemius and soleus, will result in calcaneus or calcaneovalgus, contracture taking place in the anterior group owing to the use of the healthy muscles in a limited arc. These patients walk with the toes raised and the heel on the ground; this pressure on the heel results in the formation of incurable callosities of the skin, and inflamed bursæ over the os calcis. Deformities of the upper extremities, although far less important than those of the lower extremities, are equally important when we take into consideration the disability which they cause. I have already referred to the inability caused by paralysis of the muscles about the shoulder-joint and the laxity of the ligaments in these cases. But, in addition to the disability, the pectoral muscles and latissimus dorsi become shortened, owing to paralysis of the deltoid, and the arm is held firmly adducted.

Contractures occasionally are found at the wrist- and elbow-joints, and their production is explicable on the principle already discussed.

In the trunk the most important deformity that can occur is lateral curvature. Not the form due to the shortening of one of the lower extremities, but a paralytic curvature—that is to say, one due to paralysis of the large or extrinsic muscles of the back, or the deep intrinsic muscles of the vertebræ. When the large muscles are paralyzed the corresponding healthy muscles of the opposite side become shorter and cause a bending of the spinal column, composed as it is of flexible segments, to the healthy side, the convexity of the curve looking toward the paralyzed side. If the curve be low down, a secondary or compensatory curve will appear high up. If the primary curve be high up, no secondary curve will be present. This is the result of the necessities of equilibrium. When the deep or intrinsic muscles of the spine are paralyzed, we have, as a result, rotatory lateral curvature, the most deforming condition the orthopedic surgeon has to deal with. The limits of this paper will not admit of the discussion of the cause of the so-called idiopathic cases of lateral curvature; but of the fact that a large number of cases of lateral curvature are the result of infantile spinal paralysis there is no doubt.

Diagnosis of Muscles Affected.—In examining a case of infantile spinal paralysis for the purpose of discovering what muscles are affected, I adopt a plan somewhat as follows: If the patient is able to walk, he should be made to do so while undressed; the movements of the various joints should then be noted and compared with those of the healthy side; any dragging, inversion, or eversion of the leg should be observed. The patient should then assume the recumbent position, and each muscle in turn must be tested as to its activity, beginning with the psoas; the leg may be raised, and the patient requested to maintain it in the raised position; or, if he is intelligent enough, the patient may be required to perform the action which will bring out the muscle under examination. In infants we are aided in this examination by a condition peculiar to them, by which the limb can be placed in any desired position, and will be retained there if the necessary muscular power is preserved, only gradually falling back to the relaxed state. This peculiarity has been compared to a similar condition present in patients under the influence of catalepsy. Finally, the patient should be examined by the most reliable and accurate test of infantile spinal paralysis, namely, the electric current. In this examination we make use of both the galvanic and faradic currents. We test the degree and kind of excitability of the nerve and muscles to both currents, and compare the results with similar tests made upon corresponding healthy muscles. In speaking of the pathology of this disease it will be remembered that the changes which the nerves and muscles undergo were thoroughly discussed. These changes were of the kind known as degenerative changes. They are not the result of all forms of paralysis, but occur only in those cases in which the lesion which is the cause of the paralysis cuts off the connection between the gray matter (anterior horns in the spinal cord, bulbar nuclei in the case of cranial nerves) and the nerves originating therefrom and the muscles supplied by them. The gray matter exerts upon the nerves and muscles what is known as a trophic influence, and it is the loss of this rather mysterious trophic influence which results in the degeneration of the nerves and muscles thus deprived. Paralysis alone does not cause degenerative atrophy, as is shown in cases of cerebral paralysis, in which the nerves and muscles, although deprived of motor power, still retain their connection with the so-called trophic centers in the gray horns of the cord.

Muscles and nerves which are the seat of degenerative atrophy give rise to peculiar electric reactions, which serve to distinguish muscles paralyzed by anterior-horn or nerve-trunk lesions. If nerves and

muscles paralyzed by infantile spinal paralysis are examined five weeks or more after the paralysis has occurred, it will be found that the faradonervous excitability is very much diminished or, later on, entirely absent. Faradomuscular excitability disappears a little later than that of the nerves. Faradic contractility of muscles is in reality the expression of the faradic contractility of the nerves which ramify throughout the muscle, so that, as soon as the faradic contractility of the nerves is lost, that of the muscles supplied by the nerves is also lost, even if the former are not yet advanced in degenerative changes.

The galvanic current yields even more striking changes. When such a current is passed through a normal nerve the muscles supplied by the nerve will contract. This contraction will be greater at the closing of the negative pole than at the *closing* of the positive pole; or, expressed in formula, this reaction will be K.C.C. > A.C.C.

The *opening* contraction will be A.O.C. > K.O.C.

In a nerve paralyzed by anterior poliomyelitis these reactions will become

K.C.C. < A.C.C., or
K.C.C. = A.C.C.

The opening contraction, if present at all, will also be reversed, A.O.C. < K.O.C.

The contraction will also be altered modally; that is to say, while the normal reaction is quick and sharp, the degenerative reaction is slow and wavering. All of these changes are known as qualitative changes; the former serial, the latter modal qualitative changes.

There is, furthermore, a quantitative change. That is to say, while a certain strength of galvanic current may be needed to produce a certain contraction in a normal muscle, a much stronger current will be needed to produce a similar reaction in the degenerated nerve or muscle. What has been said of the galvanic reaction in the nerves applies also to the muscles supplied by them.

These qualitative and quantitative galvanic changes, together with the diminution or absence of faradic contractility, make up what is known as the reaction of degeneration, and it is a most valuable diagnostic agent for the recognition of muscles affected by infantile spinal paralysis.

Differential Diagnosis.—This disease is so frequent in infancy, and has been so well studied in the past few years, that, in any given case of paralysis in children, the physician, as a rule, thinks of poliomyelitis as a possible condition. It is fortunate that we have in the symptomatology of this disease much that is positive and characteristic, so that it is possible to arrive at a positive diagnosis in almost every case.

We have to distinguish this affection in children from (1) other forms of paralysis, whether cerebral, spinal, or peripheral in their pathology; (2) paralysis following acute disease, such as diphtheria, meningitis (cerebrospinal), etc.; (3) paralysis due to toxic action of poisons, such as arsenic; (4) pseudo-paralysis of rickets and marasmus; (5) deformities of congenital origin, such as club-foot and congenital dislocation of the hip; (6) atrophy and disability due to inflammatory joint disease.

Patients paralyzed from cerebral lesions present the following points of difference from those suffering from this disease: First, the history of the onset of the paralysis is different. It is that of apoplexy or of embolism occurring rapidly, accompanied by repeated convulsions, and, above all, there is the fact that the face and tongue, as well as the limbs, are affected. On examination we find a paralysis corresponding to this history; we may have (with right-sided paralysis) aphasia in older children. There is frequently loss or diminution of sensibility, the tendon reflexes are exaggerated, while in anterior myelitis these are either absent or diminished in the tendons of the paralyzed muscles, and clonus may be present. Even if the muscles of the face have recovered, these symptoms will still distinguish cerebral from spinal paralysis. Furthermore, the limbs are well nourished and not atrophied, the surface temperature is not diminished, and the contractures, if existing, are spastic in variety and present in limbs which have not lost contour through atrophy. What is most important, however, are the results obtained from an electrical examination. In these cerebral cases faradism gives good reactions in the paralyzed muscles, while galvanism gives equally good reactions, the formulas being unchanged either in quantity or in quality. On the other hand, in cases of poliomyelitis anterior we have loss of faradic contractility, while galvanism shows the reaction of degeneration in the paralyzed muscles. The electrical examination, together with the history, should certainly yield sufficient data for a positive diagnosis. It is furthermore found that children paralyzed from brain lesions are apt to show a diminution of mental power, which is never present in the patient suffering from poliomyelitis.

Diseases of the spinal cord resulting in paralysis affect directly or indirectly either the anterior gray horns, together with other portions of the cord, or do not affect these horns at all, as, for instance, in secondary sclerosis of the lateral columns. Of the first class we have transverse myelitis, compression myelitis of Pott's disease, and most probably progressive muscular atrophy, and pseudo-hypertrophic paralysis. Here also belong cases of hemorrhage into the spinal cord. Here electrical examination, although of some, is not of so great utility as in the differentiation from cerebral paralysis. In transverse myelitis we have a paralysis of sensation as well as of motion. There is paralysis of the sphincters, there is the appearance of bedsores, while the history shows no regression of the paralysis, and the presence of long-continued fever. In the myelitis, or rather meningitis with myelitis as a secondary affection, of Pott's disease, the anterior horns of gray matter may or may not be involved, giving rise to various forms of paralysis. When the anterior horns are involved we shall have paralysis (paraplegia) it is true, but we shall also have the symptoms of vertebral caries, reflexes not abolished, but often increased, and paralysis of the bladder. Faradic contractility is generally preserved, although when the affection of the cord is very extensive it may gradually disappear. Progressive muscular atrophy is not frequent in children, and when it does occur the gradual and progressive nature of the paralysis serves to distinguish it from poliomyelitis. There is also a peculiar "cut-out appearance" characteristic of the atrophied muscles in progressive muscular atrophy, the atrophied portions being at first isolated and sharply bounded by well-developed muscles. In pseudo-hypertrophy of the muscles the gradual hypertrophy which accompanies the paralysis is sufficient to distinguish this disease. In the last stages of atrophy in cases of infantile paralysis, as we have already stated, there may be a deposit of fat in the atrophied muscles, but this occurs so rarely and so long after the paralysis has set in, that the history also will be a certain guide. Hemorrhage into the anterior horns of the spinal cord, when affecting these portions of the cord alone, can with difficulty be differentiated; when it affects other portions of the cord the corresponding symptoms will be sufficient to localize the lesion.

Of diseases of the spinal cord which do not affect the anterior gray horns, the most commonly met with in children is spastic paralysis (Erb) or tetanoid pseudo-paralysis (Seguin). These cases were formerly classed with those of infantile spinal paralysis, although the two diseases have scarcely a symptom in common. What has already been said of the differential diagnosis from cerebral paralysis will also apply

here, the cord lesion in both cases being a sclerosis of the crossed pyramidal tracts. We have then, here, the absence of the degeneration reaction to both currents, the increased reflexes, the spastic contractures, the absence of atrophy, and sometimes diminished intelligence.

In cases of peripheral paralysis the physical symptoms, those obtained both by the electric currents and by examination, are exactly similar to those present in infantile spinal paralysis. The only important point of difference is that sensation, as well as motion, is apt to be involved in the paralysis of the affected nerve. When the patient is too young for satisfactory tests of sensation to be made, the diagnosis is extremely difficult.

In diphtheria we have the history of the disease (if the diphtheria has not escaped the attention of the patient's friends), the involvement of the muscles of the palate and throat generally, and finally the rapid recovery. We may also have ataxia and paralysis of the eye muscles. The faradic contractility is preserved.

From the paralysis of cerebrospinal meningitis, the history and what has already been said of cerebral and spinal paralysis will serve to make the diagnosis.

Arsenic and other metallic poisons as a cause of paralysis in children must be extremely rare. I have never seen a case. E. C. Seguin has described several cases in adults in which paralysis resulted from acute arsenical poisoning, and which simulated anterior myelitis.

Cases in which rickets or marasmus have so disabled the lower extremities as to interfere with their use in locomotion are easily distinguished by the fact that there is no true paralysis; these muscles can be used, but walking is impossible, owing to tenderness and softness of the bones in the rachitic patients, and the weakness of the muscles of patients suffering from marasmus.

Congenital club-foot can be distinguished from paralytic cases by the absence of the characteristic electric reaction, and of other symptoms of infantile spinal paralysis.

The disability produced by congenital dislocation of the hips may be mistaken for paralysis, but a careful examination of the hip-joints, together with the peculiar gait and the absence of all the symptoms of this disease (infantile spinal paralysis), will serve as aids in making a diagnosis. Finally, inflammatory disease of the joints, especially of the hip, may give rise to atrophy and disability which might cause a suspicion of the presence of infantile paralysis.[23] When the history of joint disease is taken into consideration, together with the pain and swelling accompanying this condition, it will be hardly possible to be in error for any long period.

Prognosis.—It has been frequently stated with regard to the endemic type of the disease that the prognosis for recovery is very bad, but for life very good. This prognosis does not hold for the epidemic type of cases in which the death rate is high, and particularly is the prognosis bad for the cases with bulbar paralysis. The prognosis is worse in cases of this type affecting adults. The prognosis is also grave in the foudroyant cases resembling clinically acute meningitis. Indeed the pathology shows that there is in such cases a meningitis. The death rate varies in different epidemics. There is no question that in later years epidemics have been not only more frequent and extensive than formerly, but more virulent in the danger to life.

Treatment.—Inasmuch as there are no characteristic and pathognomonic signs by which a diagnosis can be made in the inceptive stage of the disease, before the paralysis has occurred, our treatment is necessarily one of symptoms and not rational. We treat, in other words, the fever, the convulsions, and the general conditions that may be present. But as soon as the disease itself can be diagnosticated by the presence of paralysis of motion in one or more members, the loss of reflex action, and the retention of sensibility in the paralyzed muscles, then a rational treatment can be instituted. We can attempt a derivative action to the skin by counterirritation applied either locally to the spinal column, or to the whole of the cutaneous surface. As local counter-irritants in robust subjects, cupping and other forms of local blood-letting have been tried. Iodine may be painted along the whole length of the spinal column, or fly-blisters may be applied over the portion of the cord where the lesion is supposed to be located. General derivation to the skin may be accomplished by a strong mustard bath, repeated frequently in the course of a day. These baths, by reducing temperature, will serve to render the patient more comfortable, and will also exert a beneficial action upon the central disease. A brisk purgative may aid in reducing the congestion of the cord, and under any circumstances will benefit the general condition of the patient. Ice applications to the spine are indicated in cases in which the fever is an important factor in the treatment of the patient. The drugs which may be useful in this stage are those which antagonize the febrile movement, and those which are commonly termed antispasmodic. Of the former class are antifebrin and antipyrin, in doses sufficient to reduce temperature; among the latter are the bromides and chloral, which, together with the antipyretics, will generally succeed in stopping the convulsions. Ergot has been especially recommended by Althaus. He uses Bonjean's ergotine in watery solution (Julius Althaus: "On Infantile Paralysis," London, 1878, p. 51). The dose varies according to age under five years; from 0.01 to 0.02 gram is injected once or twice a day. The treatment is continued until the temperature has become normal.

During the paralytic stage of the affection the treatment is well understood. Here the indications are, first, to treat the myelitis and thus promote and aid the regression of the paralysis; second, to treat the paralysis.

I have found that the most valuable remedy that has been suggested and used only in the recent epidemics is urotropin in large doses. The raison d'être of the good effect upon the acute stage of the disease is not very clear. It is supposed that it finds its way into the cerebrospinal fluid, where it exercises an antiseptic influence upon central nerve structures.

During the paralytic stage of the affection the treatment is well understood. Here the indications are, first to treat the myelitis and thus promote and aid the regression of the paralysis; second, to treat the paralysis.

For the inflammation in the cord we can do but little. Ergot is given with supposed benefit. But the natural course of the inflammatory process is to destroy the ganglion cells in the gray anterior horns; when this has taken place, it is difficult to conceive how any internal medication can restore the destroyed nerve elements. It is claimed, however, and perhaps with some propriety, that those portions of gray matter which are only the seat of congestion can be benefited by internal medication; hence the ergot. With the same object in view counterirritants to the spine are also used, such as iodine painted externally, blisters and cupping, either wet or dry. Dry cups applied to the spine on a level with the supposed lesion are better than wet cups. For obvious reasons they are also better than blisters.

Electricity is the curative agent in this affection. It may be applied locally to the spine, and also to the paralyzed muscles. Both galvanism and faradism are recommended. In my opinion, however, galvanism is more rational in theory and more effective in practice. Central galvanization of the spine is performed

by placing one large flat electrode over the site of the lesion and the other over the farther extremity of the spinal column. An ascending (irritating) current should be employed, of strength sufficient to be felt by the patient; generally from twelve to sixteen Leclanché elements are sufficient. The duration of the applications should not exceed five minutes, and they should be repeated once every second day.

The application of electricity locally to the paralyzed muscles is the most effective use of this agent in this disease. Under the head of deformities we have already discussed its importance as a diagnostic agent. By the use of faradism alone we can recognize whether a patient has been the subject of a spinal-cord or peripheral-nerve lesion, or of a cerebral lesion. In advanced cases of atrophy from this disease the reaction to faradism is entirely destroyed; in these cases, therefore, the application of faradism as a therapeutic agent is certainly useless. I never apply this current until the muscles have sufficiently recovered to show a slight reaction when it is applied. Very few muscles, however—with the exception of those which are entirely destroyed—lose their excitability to galvanism, although the reaction present is generally that of degeneration. Galvanism, therefore, applied to the paralyzed muscles and nerves, causes both to become excited. This stimulus is undoubtedly beneficial, and persevering treatment with galvanism, continued for months and even years, is frequently successful in restoring muscles that were hopeless, to all appearances, when the treatment began. I apply the current by the aid of the interrupting electrode to the paralyzed muscles, and the other pole, generally the cathode, to some indifferent point. Applications to a limb should not exceed three minutes in duration.

Treatment of Deformities.—The principal therapeutic means at our command in the treatment of the deformities are tenotomy and mechanical appliances. Under the latter head I also include massage.

It has long been a question whether it is permissible to cut the tendons of the contractured muscles, and thus virtually paralyze all of the remaining healthy muscles of the limb. But, as is often the case, we find here that what would theroretically appear to be unwarranted, is found, in practice, to be sound and proper treatment. Careful consideration will show that the above objection is only apparently valid. Tenotomy disables a muscle only for a short time. The tendon soon reunites and the muscle is enabled to perform its functions to far better advantage than before. The strained position of the limb is relieved and the patient is enabled to use a joint which was entirely disabled before tenotomy was performed. Conservative surgeons prefer to stretch a contractured tendon, provided it admits of stretching. But such stretching, unless maintained for a very long period, is apt to be of but temporary utility; for a relapse is sure to occur when extension has been remitted. Where time, then, is important, tenotomy is certainly preferable to extension. I do not believe that the argument that tenotomy weakens a muscle is tenable. The active portion of a muscle is certainly not the tendon, but the muscular fiber. Tenotomy results in lengthening the tendon, the muscular fibers retaining their integrity. If healing has been properly looked to, the united tendon will not stretch more than is proper for the restoration of the joint to its proper function. Where, however, the contracture is yielding, traction will readily accomplish all that is necessary, and should be preferred to tenotomy. It will be impossible, in the limits of this article, to describe all of the instruments used for purposes of extension of different muscles. For talipes equinus I know none better than Dr. Shaffer's "extension shoe," the working of which has been thoroughly described in papers read by him at various times. For varus, Dr. Shaffer has devised an equally effective "lateral-extension shoe." In calcaneus the chief indication is to raise the heel, the contracture rarely requiring extension or tenotomy. For these cases, as in all cases of paralytic club-foot, the shoe that is worn daily should have inside, covering the sole, a steel plate, to keep the sole firm and to prevent the shoe yielding itself to the deformed position of the foot. If the case be one of equinus, the heel should be fixed to the sole of the shoe by means of a strap passing over the instep. In all cases the shoe should be laced and made so as to open to the toes. The paralyzed muscle in many of these cases can be replaced, to a certain extent, by properly applied elastic straps, to act as artificial muscles. Contracture at the knee-joint should be overcome by tenotomy or extension. If the muscles about the knee-joint do not retain sufficient power to enable the patient to stand or walk with some firmness, we can virtually ankylose this joint by an apparatus in which a rigid bar passes from the hip or thigh down to the foot, without a movable joint at the knee; or a joint may be made at the knee, which, being guarded by an automatic spring, becomes rigid as soon as the patient assumes the standing position. One important principle in the application of apparatus for these deformities must not be lost sight of, and that is, that all apparatus must be so attached to the limb or body that the healthy muscles may be able to control or carry it, while it aids and takes the place of the paralyzed member. On the mechanical treatment of lateral curvature we will say nothing, the field being too large for the limits of this article. In treating the deformities of the upper arm and hand the principles already laid down will serve as a guide.

In the final stages of the disease, when contracture and paralysis have destroyed the function of limbs, and flail joints have rendered utterly useless whole extremities, certain surgical procedures will benefit the patient very greatly. Thus a healthy contractured muscle, which is useless owing to paralysis of its opponent, may have its tendon implanted at or near the insertion of the paralyzed muscle, and thus to a certain extent be enabled to perform the function of that muscle. This operation, known as tendon grafting, was first performed with good result by Nicoladoni in 1882. Goldthwait, of Boston, in 1896 reported a series of very interesting cases of this type. Arthrodesis has been useful in converting a flail leg into an efficient prop, much superior to a splint. Such ankylosis of joints is useful in bringing a useless joint into better position than that in which it has been left by the paralysis and resulting contractures.

Endemic Acute Poliomyelitis Anterior in Adults.—Even before the occurrence and study of the epidemic type of cases, when adults are frequently the subjects of the disease, it was exceptionally observed that the endemic form of this disease occasionally affected adults. This has been evident from cases reported since that of Moritz Meyer in 1872 to the present time. Many of the cases reported as cases of acute poliomyelitis anterior in adults were in reality cases of polyneuritis without sensory symptoms. Indeed, a multiple neuritis of anterior spinal nerve roots would produce a condition simulating poliomyelitis anterior acuta in its symptomatology almost perfectly. The adults in whom this disease may occur are rarely more than thirty years of age. The disease is apt to affect adults who have recovered from an acute infectious disease, such as measles and scarlet fever. One case was reported as following an attack of rheumatism. Another case was supposed to be due to an exposure to cold after active physical exercise. The adult cases occur far more rarely than the infantile cases.

The symptomatology is almost identical with the same disease in children. Pain in the limbs preceding the occurrence of the paralysis is a symptom which has been reported in most of the cases. This pain disappears as soon as the paralysis occurs. The

paralysis has the characteristics described in discussing infantile spinal paralysis. Its distribution in adults is characterized by the same lack of uniformity as in children. It is regressive. In adults, however, complete spontaneous recovery is believed to be possible. There is absence of patellar reflex. There are no sensory disturbances except the temporary pain just referred to. One or more muscles, groups of muscles, or extremities may be involved. There is sometimes backache. There are no motor disturbances of the rectum or bladder. Atrophies and degenerations occur as in the same disease in children. Similar electrical manifestations can be demonstrated in the paralyzed muscles. The reactions to galvanism and faradism are the same as in the infantile form of the disease. Deformities are not so apt to occur as a result of contractures in paralyzed muscles and their opponents, owing to absence of the factor of growth, which has such an important influence in disturbing the equilibrium between the healthy and paralyzed muscles of an extremity in young children suffering from this form of paralysis.

The diagnosis of the endemic form in adults is difficult, because the paralysis of poliomyelitis anterior acuta resembles that due to other pathological lesions to which adults are more often liable. Polyneuritis has already been mentioned. However, fever, followed by a rapidly developing motor paralysis, acute in its onset, which when it has reached its height begins to improve, together with the characteristic electrical symptoms, should enable the physician to make a diagnosis, at least as soon as the fever has subsided and the paralysis has become stationary.

The pathology of this disease in adults is the same as when it occurs in children.

The treatment is that which we have indicated in the same condition when it occurs in children, both in the stage of onset and in the chronic stage.

Poliomyelitis Anterior Subacuta et Chronica.—This form of poliomyelitis anterior is also generally found in adults; it is very rare. The condition resembles multiple neuritis in its symptomatology in a general way, and doubtless most of the cases reported clinically as poliomyelitis anterior subacuta were in reality cases of multiple neuritis. Yet cases have been reported in which postmortem findings demonstrate that subacute or chronic poliomyelitis anterior is an actual entity, although a rare condition.

As etiological factors we find first metallic poisoning. In these cases this condition may be present alone or it may be accompanied by a toxic neuritis of peripheral nerves. The condition has also been seen during pregnancy. One case reported gave a history of an attack of infantile paralysis during infancy, followed in adult age by a gradually developing chronic poliomyelitis.

Pathologically the findings are similar to those in poliomyelitis anterior acuta, which have been recounted in the earlier portion of this article. Some of these cases, however, while they show degenerative changes with atrophy and sclerosis of the gray anterior horns, show also degenerations in the crossed pyramidal tracts and anterior nerve roots. One case reported by Oppenheim also showed systematic degeneration of the columns of Burdach in the cervical and dorsal regions, together with atrophy of the posterior nerve roots. One case has even shown an extension of the process to the columns of Clarke, and the posterior horns were also slightly involved, in addition to the changes in the anterior horns. The root of the hypoglossus has also been found involved.

The atrophic changes in the peripheral muscles and nerves, as well as those occurring in the bones, while less marked, are similar to those found in poliomyelitis of children.

The symptoms are as follows: A paresis developing with a paralysis of a single limb or muscle is followed, in a week or month or year, by a gradually developing paresis or paralysis of another limb or of other limbs. This gradually extending, paralysis may continue, at intervals of longer or shorter periods, to involve more muscles until a large portion of the voluntary muscular system is affected, although one case has been reported in which there were bulbar symptoms. The muscles that are the seat of the paralysis gradually undergo atrophy, and give the complete and partial degeneration reaction found in poliomyelitis anterior acuta. The paralysis keeps extending for a year or more, and then may become stationary for the remainder of the life of the patient. In this form of the disease, unlike the acute form, there is observed little or no spontaneous improvement in the paralysis, while in infantile paralysis it is the rule that the paralyzed muscles recover, to a greater or less extent, spontaneously shortly after (*i.e.* a few days or weeks after) the paralysis has set in. In the subacute and chronic form of the disease there is no spontaneous improvement.

Death generally occurs through some intercurrent disease, such as pneumonia, or, in rare cases, by paralysis of the nerves of respiration.

The differential diagnosis rests upon the absence of bladder and rectal symptoms. The diminished or lost patellar reflex; the absence, with rare exceptions, of sensory symptoms; the atrophy of the paralyzed muscles and limbs, are also important symptoms of the disease.

Progressive muscular atrophy can be differentiated from this condition by the fact that the paralysis in poliomyelitis subacuta and chronica precedes the atrophy, while in progressive muscular atrophy the atrophy precedes the paralysis. From multiple neuritis the condition is distinguished by the absence of sensory symptoms both subjective and objective. From amyotrophic lateral sclerosis it can be distinguished by the absence of the contractures and exalted patellar reflex which is characteristic of this affection.

The treatment consists of electricity, massage, baths, orthopedic apparatus, and drugs. The rules laid down, under acute infantile paralysis, for the employment of these agents in the treatment of the disease hold good here.

Orthopedic apparatus should be so constructed as to give rest and firmness to the paralyzed limb, by fixation of incompetent joints, etc., and to cause healthy muscles and limbs to do the work of those that have been paralyzed. Of the drugs that may be used, intramuscular injections of strychnine are the best. Galvanism is the form of electricity most applicable. It should be used in accordance with the directions already laid down.

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Pollenia.—A genus of flies. *P. rudis*, the cluster fly, has golden yellow hairs among the bristles on the thorax. This distinguishes it from the house-fly, which it resembles. It is often found in houses in spring. A. S. P.

Polychromatophilia.—(*Polychromasia.*) The term applied by Ehrlich to that condition of the red cells in which they take, not only the diffuse stain, but also the nuclear, so that they exhibit a bluish-red or violet tinge, or may even take a deep blue stain when stained with hematoxylin and eosin, or methylene blue and eosin. By Ehrlich and others this phenomenon is regarded as essentially degenerative, a progressive "coagulation necrosis," whereby the cell loses its affinity for acid stains. They are supported in this view by the presence of such cells shortly after hemorrhage and in starving animals, and by the polychromatophilic character of megaloblasts. Further, cells showing this characteristic are usually ragged in contour or show vacuoles. On the other hand, Askanazy and others hold that the polychromatophilic cells are the *youngest* cells of the blood, and are not degenerating forms. This view is based chiefly upon the fact that a large portion of the red cells of the fetus are polychromatophilic.

Most writers now regard polychromasia as occurring most frequently in young cells, and consider degenerative polychromasia as of rare occurrence. The great frequency of polychromasia in the blood cells of the embryo, its association with nuclei, nuclear fragments and nuclear rings, its occurrence in blood showing other signs of regeneration, and its scarcity or total absence in aplastic anemias are all arguments for the above view. Degenerative polychromasia occurs only in degenerating red blood cells outside of the blood stream. The terms polychromatophilia and polychromasia are also applied to degenerating cells other than red blood cells (degenerating ganglion cells, etc.). Aldred Scott Warthin.

Polycythemia.—See *Erythremia.*

Polymastigina.—An order of flagellate protozoans which includes those which have from three to eight flagella of approximately equal size. *Trichomastix*, *Trichomonas*, and *Lamblia* are genera which occur in the human body. A. S. P.

Polymastix.—A genus of flagellate protozoans. There are four to six flagella at the broader anterior end and two or three membranes. *P. melononthæ* is found in a beetle larva. A. S. P.

Polypus.—From πολύς, many, and πούς, foot. A polypus is a pedunculated tumor or tumor-like growth, arising usually from a mucous surface and extending into a body cavity or canal. The use of the term in this connection has no significance as to the multiplicity of the points of attachment of the growth, as the etymology of the word would seem to suggest. In fact, a polypus has always but a single point of attachment except in those very rare cases in which it becomes secondarily implanted as a result of an inflammatory process. The use of the term is rather to be explained through a fancied resemblance in consistency, color, rate of growth and regeneration, or of attachment in a hidden recess, to certain of the marine polyps.

Used by the earliest Greek and Latin physicians to designate the familiar growths of the nasopharnyx which still bear the name, *polypus* has come to designate similar growths arising from practically any of the body surfaces. The term is purely descriptive and implies certain facts in regard to the location, shape and habit of growth of the mass in question but has no reference, unless the term is modified, to etiology, structure or malignancy. Polypi are usually somewhat pear shaped, although their form may be modified by the shape of the cavity in which they grow. When situated near the orifices of body cavities, they tend to grow particularly toward the exterior and frequently present at the opening of the canal. In such cases the surface, usually soft and moist, may become hard and dry, or secondarily infected and ulcerated. These outgrowths may be single or multiple. Many sorts are of very rapid growth and readily recur after removal unless the tissue at the point of attachment of the pedicle is excised.

Sites.—Polypi are found particularly in the nasal fossæ, uterus and cervix, and the rectum. In addition, they are frequently met with in the larynx, external auditory canal, accessory sinuses and intestinal tract; and still more rarely on the conjunctiva in the lacrymal and nasal ducts, Eustachian tube, esophagus, etc. For discussions of the polypi of particular regions, their significance and treatment, reference should be made to the articles dealing with the pathology of the part in question.

Etiology.—Polypi are often of purely inflammatory origin, inflammatory hyperplasias. They may be true neoplasms, either benign or malignant. The term is also applied, through an extension of its original sense, to parietal thrombi of the heart (heart polypi) and to masses of fibrin, blood clot, and retained placenta attached to the uterine wall following an incomplete abortion (fibrinous or placental polypi).

Structure and Varieties.—Various terms are used to describe the structure or character of polypi. The most important of these are *adenomatous* polypi, composed chiefly of glandular tissue; *edematous* polypi, having a high fluid content and which are spoken of as *mucoid*, *myxomatous* or *gelatinous* polypi when rich in connective-tissue mucin; *fibroid* polypi, a term rather loosely used since it sometimes means a chronic inflammatory hyperplasia of connective tissue, sometimes a true fibroma and sometimes a leiomyoma (uterine fibroid); *malignant* polypi, which may be either carcinoma or sarcoma; *raspberry cellular* polypi, small raspberry like masses attached in the external auditory canal and constituting the most common polypus of that region. A large number of descriptive terms in addition to the above have been applied to polypi, but such are altogether self-explanatory.

Clinical Significance.—The clinical significance of a polypus depends upon a number of factors and each case must be judged upon its own merits. In a general way, the most important considerations are such points as whether histologically malignant (carcinoma, sarcoma) or not, the pressure exerted upon surrounding structures; invasion of surrounding structures by expansive growth, since even bony structures like the orbital wall and floor of the cranium may be destroyed by the pressure of a growing polypus; infection of exposed surfaces with ulceration; and hemorrhage, both from the polypus itself and from neighboring structures. For additional information upon this point and for the treatment of polypi in various situations, the articles under the names of the organs or tracts in question may be consulted. Carl Vernon Weller.

Polysaccharides are complex carbohydrates characterized by yielding simple sugars upon hydrolysis. The polysaccharides include the starches, dextrins, plant gums and mucilages, glycogen, and the celluloses. See *Aliment*. F. P. U.

Polysporocystidæ.—A family of Neosporida in which the oocyst has many spores. The only species in this family which occur as parasites in man are *Eimeria stiedæ* and *E. hominis* which rarely infest the liver or intestine. The usual host for these sporozoans is the rabbit. A. S. P.

Polyuria.—See *Diabetus Insipidus*.

Pomegranate.—See *Granatum*.

Pompholyx.—*Synonyms:* Cheiro-pompholyx, Dysidrosis.

Definition.—An acute exudative eruption characterized by the formation of vesicles and blebs, usually of moderate size, and occurring for the most part on the hands and feet; in some instances it may be limited to the palms and soles. It is a disease of infrequent occurrence and is liable to be confounded with other eruptions of the vesicular or bullous type.

Symptoms.—The clinical features of pompholyx are well-defined and distinctive, and in most works on dermatology the disease is recognized as a distinct affection. It was first described in 1875 by Jonathan Hutchinson and Tilberry Fox, of London. The former gave it the name of cheiro-pompholyx, while the latter in reporting the same case gave it the name of dysidrosis. During a period of over thirty years the present writer, in encountering many thousand cases of skin diseases, has seen but few typical examples of this affection; while less clearly defined or mild forms which clinically merge into other affections such as vesicular eczema, impetigo, or hyperidrosis are not especially uncommon. While a student in the Black Friars Skin Hospital in London I had the opportunity of studying several cases that were regarded by Mr. Hutchinson as typical examples of the affection. In some of these, if I remember correctly, the disease likewise extended to the forearms, and frequently the feet were exempted. The disease in my experience most frequently occurs in the spring and autumn, especially during changeable weather. The first symptoms complained of are burning and tingling, with the development of deeply seated vesicles which are single and later become grouped by the development of new lesions; the most characteristic position at first being the sides of the fingers and backs of the hands. The eruption gradually extends to the palms. The feet are the next most frequent seat of predilection. Not infrequently the eruption extends involving both the forearms and legs. When the lesions are confined to the thick skin of the palms of the hands and the soles of the feet they have been very aptly compared to boiled sago grains embedded in the skin. This appearance is due to the thickened epidermis, as pointed out by Crocker, rather than to any special variation in the lesions themselves. The eruption is usually symmetrically distributed. As the lesions develop the groups of vesicles not infrequently coalesce, forming large, irregularly outlined bullæ filled with a serous fluid, and projecting above the level of the skin. At first the contents are translucent, but later they become opaque. In reaction the fluid is neutral or slightly alkaline. At no time is there much inflammation in the surrounding skin, unless secondary pyogenic infection takes place, in which respect the disease differs from certain affections with which it may be confounded. The invasion of pyogenic organisms such as the staphylococcus is not uncommon in pompholyx and may modify or mask the appearance of the original disease. In the course of two or three weeks the lesions begin to subside, although new ones appear from time to time. The contents become absorbed and finally the outer epidermic wall exfoliates, exposing a reddish area of delicate new skin, which marks the site of the former lesion. The disease often runs its course in a few weeks, or at most in one or two months, although it is liable to recur the following year. At times, in debilitated subjects, the lesions may assume a red color and the surrounding derma become slightly edematous. The epidermis not infrequently becomes undermined and then soon ruptures, exposing to view a red, exudative surface. Gradually, however, this process subsides, and recovery may take place as before stated. The subjective symptoms are usually slight. Aside from the burning and tingling previously mentioned, there may be marked impairment of the general health, in which case excessive sweating is sometimes complained of. Itching is never a prominent symptom.

Pathology.—As the name given to the disease by

Tilbury Fox[1] indicates, this writer regarded the affection as in some way associated with the sudoriparous glands. Nestorowsky's findings tend to confirm this view.[2] Other investigators, however, especially Robinson,[3] Santi,[4] and Sutton,[5] have demonstrated that the lesions show no especial connection with these structures. These observers have shown that the pathological condition is one of inflammation which takes its origin in the rete, gives rise to a serous exudate from the capillary blood-vessels, and then, collecting between the rete cells, forms variously sized vesicles or bullæ. As this effusion takes place there follows a gradual degeneration of the cells of the rete mucosum. While some of the vesicles, especially those situated on the outer surface, may rupture when the inflammatory process is more extensive, there may be a general extension of the fluid at the periphery, thus causing the undermining previously mentioned. Later, the entrance of pus corpuscles changes the translucent fluid to one of an opaque or even yellow color.

Etiology.—The disease is nearly always associated with general debility, or it occurs in those whose nerve tone is below par. It is especially liable to occur in women who have been subjected to excessive mental strain or worry; and yet, while it is more frequently met with in women, men are by no means exempted. Middle age seems to be the period of life in which the disease is most frequently encountered; only a few cases have been reported in children and the disease is extremely rare in old age. Crocker has not seen it under twelve years, and the oldest patient was thirty-eight, while Hyde[6] records a case at sixty. The disease is supposed to be due to some abnormity in the innervation of the skin, although its exact nature has not been determined. On the other hand, Unna has found a bacillus resembling the tubercle bacillus, although slightly thicker, and he is disposed to regard it as an essential pathological factor in the disease.

Diagnosis.—The limitation of the disease to the hands and feet—a characteristic which is considered by some authorities to be essential—renders the affection less liable to be confounded with other affections to which it bears some similarity; namely, with eczema, pemphigus, and dermatitis herpetiformis. In my own experience the line of demarcation is not so sharply drawn, and the affection gradually merges in type with other well-recognized diseases. When limited to the palms and plantar surfaces the only condition to which it bears a close resemblance would be blisters from slight traumatism, eczema, and an accumulation of sweat under the thickened epidermis. Eczema is seldom limited to these surfaces, and is always accompanied by inflammation and marked itching; while inflammation and itching are usually insignificant features in pompholyx. The persistence of the eruption, together with the formation of new lesions extending over a period of a week or more, would enable one to exclude blisters arising from slight injuries. More difficulty, however, would be encountered in differentiating the affection when seen on the lateral surfaces of the fingers and on the backs of the hands. Here the affection bears a close resemblance to eczema; but in eczema there are more extensive inflammation and less tendency to the formation of bullæ, and in eczema the outer wall of the lesions easily ruptures, giving rise to excoriated itching surfaces of irregular outline. In pompholyx, on the other hand, the epidermic wall seldom ruptures and the lesions remain circumscribed, or coalesce in such a manner as to form bullæ. Furthermore, it should be borne in mind that pompholyx is most liable to occur in adults, and especially in women who are debilitated or who have been overwrought, and that the disease tends to a spontaneous recovery, and at the same time is likely to recur upon the recurrence of conditions favorable to its development. Ivy poisoning must likewise be excluded in making a diagnosis, but the acute inflammatory character of this disease and the tendency of the eruption to appear on other parts, render it, as a rule, easy to distinguish from pompholyx. The last doubt, however, would be removed if in addition, the history of an exposure to the poisonous plant could be obtained.

Prognosis.—The prognosis in pompholyx is good so far as the individual attack is concerned, although there is a tendency for the disease to return with successive years. In some instances the irritation to which pompholyx gives rise has engendered an eczema which may persist indefinitely. On the other hand, the disease may not return, although, under suitable provocation, it will be very likely to appear again.

Treatment.—The treatment should be both constitutional and local. The former seems to be of the more importance, as the individual attack is self-limited. First, all debilitating influences should be removed, and as far as possible the patient should be urged to avoid worry, overexcitement, or intense mental labor. General hygienic measures should be advocated, namely, exercise in the open air, cold bathing, if well borne, with vigorous friction immediately thereafter, and diversions of a relaxing nature. Change of location from inland to the seashore, or from the seashore to the mountains, is in some cases highly beneficial. In addition to this the patient should be given a generous diet and in some instances tonics, and the room which he occupies should have a sunny exposure and be well ventilated. Aside from these general measures individual cases should be treated according to the indications present. Strychnine is a drug which must frequently be called into requisition. Iron, especially in its more assimilable forms, quinine, cod-liver oil, and in some instances arsenic, are valuable drugs.

The local treatment consists in soothing applications and in those which protect the surface from the air and from the irritation of clothing and other extraneous substances. It is best forcibly to rupture the lesions, especially when large, and flush out the cavity with a saturated solution of boric acid and water. In some cases, when the lesions rupture, black wash may be used. The following application can also be recommended: Salicylic acid two per cent., and diachylon ointment q.s. 100 per cent. This should be spread on some firm white cloth and kept constantly applied to the diseased area. Every twenty-four hours the surface of the skin should be cleansed with a saturated solution of boric acid, or with water to which a small quantity of carbolic acid has been added, and a fresh application of the ointment should be made. This ointment is especially valuable when the soles of the feet are involved. Stelwagon[7] recommends the following: Menthol, 0.13 (gr. ij.); acidi salicylici, 0.65 (gr. x.); emplastri plumbi, emplastri saponis, āā 45.0 (℥iss.); petrolati, 150.0 (℥ v.) M. The prevention of local infection is one of the main objects in treatment, and, to accomplish this, we may with benefit apply a solution of corrosive sublimate (1 to 2,000) or white precipitate ointment (five per cent.), the latter serving as a parasiticide as well as a protective agent.

William Thomas Corlett.

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Ponos.—See *Leishmaniasis.*

Pons and Medulla, Diseases of the.—It is a fortunate fact that the occurrence of vascular lesions, such as hemorrhage, embolus, and thrombosis, is rare in the neighborhood of the pons and medulla. They may of course occur in the presence of such a favoring element as cardiovascular disease, which in turn may be due to a variety of causes, but when they are of any considerable size they are so quickly fatal that a determination of their exact location within the above structures is practically impossible. It is, moreover, not particularly easy, even though the lesion be so small as to be compatible with life, to locate it with absolute definiteness, and this in spite of the fact that the industry, both of the clinician and of the pathologist, has guided us to a remarkably clear comprehension of the physiologic values of the various nuclei, nerve fibers and tracts which lie in and traverse this anatomically complex territory.

In the case of extensive hemorrhage the victim is struck down so suddenly, and unconsciousness supervenes so rapidly that it is impossible to separate the damage to individual nuclei from the general havoc which the lesion entails. Certain features are, however, usually present which indicate in a measure the general situation of the extravasated blood. The respiration, for instance, rather quickly assumes the Cheyne-Stokes character, and this in itself should arouse a suspicion of the intimate relationship between the hemorrhage and the respiratory center. Conjugate deviation of the eyes is also a fairly reliable indication of ponto-medullary hemorrhage, the eyes being turned toward the side opposite the lesion. The resultant paralysis is apt to be bilateral even though the hemorrhage be unilateral and differs from the flaccid type observed at the outset of an ordinary apoplexy in the tendency of the extremities to assume a degree of rigidity. This rigidity may be accompanied by a recurring shock-like tremor of a rather coarse type. The behavior of the reflexes is not sufficiently constant to be dependable, and there is nothing strikingly characteristic about the pulse and temperature.

In arterial lesions of lesser grades of severity the symptoms may be grouped in a variety of ways, dependent upon their site and extent. A lesion involving the pyramidal tract in the upper pons produces an ordinary hemiplegia, but if it be sufficiently extensive to include the facial nucleus, or even its roots, there usually results a so-called alternating hemiplegia; that is to say, a facial paralysis corresponding to the side of the lesion and a paralysis of the opposite side of the body.

A similar type is observed where the nucleus of the sixth nerve is included in the lesion. In other cases both the abducens and the facial nerves may be involved on the side of the vascular disturbance, and the resulting paralysis may be associated with hemiplegia of the opposite side of the body. Oftentimes the disturbance lies not exactly in the sixth nucleus, but near by in the conjoined center for the sixth of the same side and the opposite rectus. This produces the conjugate deviation of the eyes away from the side of the lesion spoken of above.

The variety of clinical combinations which may occur in vascular lesions of the pontomedullary region is relatively extensive. An examination of its anatomy reveals the fact that it contains the nuclei of the larger part of the cranial nerves, nuclei which serve also as trophic centers. It contains furthermore centers governing the respiration and the heart's action; likewise the great tracts and network of fibers which have to do with motion, sensation, and equilibration. The act of vomiting, the secretion of the saliva, and the vasomotor activities of the body also doubtlessly depend upon centers located in this important region. Nowhere else in the central nervous system are so many important structures in such close proximity; hence it is easy to understand the eccentric grouping of symptoms arising from simultaneous destruction of nuclei and nerve tracts, both sensory and motor.

To attempt to give in detail all the clinical combinations to which acute vascular lesions of this region may give rise would be as fruitless as it is impossible, the element of fortuitousness being too strongly in the ascendant.

The symptom-complex which accompanies occlusion of the posterior inferior cerebellar artery is, however, sufficiently clear cut and constant to deserve special description. Here the area of softening is in the lateral field of the medulla oblongata, is sharply limited to the formatio reticularis grisea and restiform body, and has a vertical extent from about the middle of the hypoglossal nucleus to the point where the restiform body passes into the cerebellum. Its greatest anteroposterior extent is from the dorsal blade of the lower olive to the restiform body.

The parts usually involved in this field of softening are the ventrolateral ascending tract of Gowers; the direct cerebellar tract; the descending vestibular and trigeminal tracts; cerebello-olivary fibers; nucleus ambiguus, vasomotor and sympathetic fibers, and other fibers which pass via the restiform body. The auditory nuclei and nerves are occasionally involved, while the facial and abducens are rarely implicated unless the thrombus extends into the vertebral.

The symptomatology is as follows:

(1) Sudden onset without loss or disturbance of consciousness.

(2) No paralysis or paresis of the muscles of the extremities or of those innervated by the fifth nerve (owing to the motor parts contained in the ventral pyramids being supplied by the vertebrals and anterior spinal arteries, while the nucleus and axones of the motor fifth are nourished by the basilar).

(3) Diminution or loss of pain and temperature sensations in the limbs of the side opposite to the lesion, rarely also in the side of the face opposite to the lesion. Diminution or loss of sensation of pain and temperature in the distribution of the fifth nerve on the same side as the lesion (formatio reticularis grisea, Gowers' tract, ventral fasciculus, descending trigeminal tract). Spontaneous pain, or some form of paresthesia in the area of disturbed objective sensation.

(4) Tactile sensation intact in all parts (median fillet not involved). Sense of position usually intact.

(5) Ataxia in the limbs corresponding to the side of the lesion (involvement of the direct cerebellar tract, restiform body and cerebello-olivary fibers, indicating that the fibers of coordination do not decussate below the medulla oblongata).

(6) Tendency to fall or sway toward the side of the lesion; tendency of the head to drop toward the side of the lesion (restiform body).

(7) Nystagmus bilateral, more intense when eyes are directed toward the side of the lesion (Deiter's nucleus?).

(8) Ménière's symptom-complex, vertigo, revolving vertigo, auditory hallucinations, vomiting, deafness on side of lesion (Deiter's nucleus, vestibular nerve and nucleus, cochlear and vagus nerves).

(9) Paralysis of the muscles of deglutition on the side of the lesion, but causing complete inability to swallow, with impaired sensation of pharynx. Paralysis of soft palate on the side of the lesion, vocal cord immobile in cadaveric position, voice hoarse, and speaking is in a whisper (loss of phonation with preservation of articulation). (Nucleus ambiguus and vagus.)

(10) Tongue rarely a little weak on the side of the lesion, but weakness soon passes away, as the hypoglossal nerve and nucleus usually escape.

(11) Taste may be lost in anterior two-thirds of tongue, although this is only an occasional symptom.

(12) If the sixth and seventh nerves are implicated, it indicates an extension to the vertebral, as these

nerves are not involved when the thrombus is confined to the posterior inferior cerebellar artery.

(13) Sympathetic disturbances on the side of the lesion (formatio reticularis grisea), smallness of the pupil, ptosis, narrowing of the palpebral fissure, retraction of the eyeball on the side of the lesion. Loss of sweating of the face on the side of the lesion, or increase of sweating on the side of the face opposite the lesion.

Hiccough, hemiasynergy on the side of the lesion. Pulse may be rapid from paralysis of the vagus or slow from irritation of it.

(14) Reflexes not characteristic.

Generally speaking, the onset of trouble is marked by rather severe vertigo, which may be accompanied by vomiting of equal severity. Consciousness is seldom profoundly disturbed, hence the patient is able to observe and give an account of his troubles. These may consist of the alternating hemiplegia above mentioned, or may be further complicated by a more or less extensive loss of sensation, by ataxia of the upper or lower extremities, by difficulty in speech and in swallowing, by diplopia, or by a complete loss of control of the facial muscles which externalize the emotions.

As stated above, it is impossible to construct a semeiology which will fit every case. The point always to be emphasized is the eccentric grouping of symptoms indicating nuclear palsy combined with more or less extensive implications of the motor and sensory tracts.

The prognosis in this class of cases is fairly good as regards life. The damage to the nuclear elements is, however, practically permanent, the resultant paralysis being for the most part of the atrophic type.

Treatment is of little avail except in cases in which syphilis is the etiological factor.

The medulla may be involved during the course of many diseases of the central nervous system, notably tabes, progressive muscular atrophy, multiple sclerosis, gliosis, and amyotrophic lateral sclerosis. It may also be the seat of tumor, abscess, or tuberculous disease. As none of these diseases can be classed as peculiar to the medulla no further consideration will be given them in this article.

The next disease of essentially medullary origin to be considered is the so-called

Progressive Bulbar Paralysis.—This, called also labio-glosso-laryngeal (pharyngeal) paralysis, is to be classed among the rare forms of nervous disease. Its victims are, in the large majority, found among the aged. A so-called infantile type will be spoken of later. As to its etiology nothing definite is known, hence the usual train of causative factors comes in for mention, namely, exposure to cold, traumatism, mental wear and tear; and even abuse of function of the lips, tongue and palate, although it appears that women are less commonly afflicted than men.

Symptomatology.—The first thing that attracts the patient's attention is an unwonted fatigue after talking for any length of time, with a restricted ability to enunciate certain syllables. The initial disability lies, as a rule, in the articulation of the lingual consonants, *l*, *r*, *n*, and *t*. The tongue can at first still be protruded, but not to the normal extent, and there may be a difficulty in securing its proper apposition to the roof of the mouth for sounding the linguo-palatine consonants *t* and *d*. Up to this time the continuous sibilant *s* may be pronounced. With the increasing weakness of the lips whistling becomes impossible and there is an inability to utter the sounds in which the lips are chiefly concerned, such as *o*, *u*, *b*, *p*, and *m*. So imperfectly are the lips brought together and so sluggish is their separation that the labial explosives *b* and *p* degenerate into *m* and *u*. Finally weakness of the palate fails to shut off the nasal cavity, and a part of the expiratory air stream escaping through the nose gives a nasal quality to the voice, *b* and *p* sounding as *mb* and *mp*.

At this stage of the disease dysarthria is fully established. Words are run together and indistinctly articulated, with an intonation of a decidedly nasal quality. Single words may still by special effect be brought out clearly, but sustained speech of any clearness is impossible.

Either at this time or more commonly after the disease has been established a few months the patient experiences a difficulty in swallowing. Only by great effort can food be carried back through the pharynx to the esophageal opening. Fluids are constantly regurgitated through the nose, and at times are inhaled into the larynx causing choking and paroxysms of coughing. Ultimately neither fluid nor solid food can be successfully swallowed. Chewing also becomes progressively difficult.

Finally both phonation and respiration become involved. The voice is weak and monotonous and lacks modulation. Hoarseness may develop and go on to complete aphonia. Toward the end respiration becomes labored, and not uncommonly severe attacks of strangulation occur.

Examination of the larynx shows in the beginning nothing abnormal; later, paresis of the adductors is obvious. The masticatory muscles betray their weakness by imperfect closure of the jaw and restricted lateral movements of the same.

Bulbar paralysis is of the degenerative type. Atrophy is, however, not an early symptom and almost never keeps pace with the paralysis. It is usually first observable in the tongue, which becomes lax and feels flabby and spongy; the fibrillary twitching is very striking. Ultimately the organ undergoes a marked grooving and furrowing, and its total volume is much diminished. The lip muscles are rarely affected until late in the course of the disease. They then become thin and toneless. The muscles of the jaw are only rarely markedly wasted, although a fibrillary twitching is not infrequently observed in them at an early stage.

The electrical excitability of the diseased muscles is never greatly altered. Late in the course of the disease there may be some quantitative change to faradism, but examination is never very satisfactory.

When the disease is far advanced the expression of the face is very characteristic and striking. The mouth is open, the lower lip sunken; and drooling is constant. The fixed and expressionless lower part of the face contrasts strangely with the still mobile muscles of the upper face and eyes, which alone afford mimic externalization of intellectual activity. The patient is very emotional and cries easily, but even then the mouth is but little discomposed, whereas the respiratory muscles are thrown into a sort of spasm to which is sometimes added a peculiar respiratory stridor. The shrunken, furrowed tongue lies motionless on the floor of the mouth, articulation is almost annihilated, and the feebly mumbled speech incomprehensible. The respiratory movement is hurried and the pulse may run as high as 140 per minute. Emaciation is very marked.

The above symptomatology develops on the basis of a paralysis of cranial nerves which are purely motor, and there is never implication of nerves which are sensory or sensorial. Curiously enough, however, in certain cases there is to be observed a peculiar heightening of tendon reflex irritability in the facial and masticatory muscles.

Diagnosis.—Bulbar paralysis has so many features that are peculiar that its differentiation from other affections of the medulla should present no special difficulties. The gradual character of its onset and development, its practical restriction to persons of advanced age, the symmetrical implication of purely motor nerves with absence of sensory and sensorial disturbances, and the association of paralysis with

atrophy are all factors which serve to crystallize out the disease from other affections of the same region. The features which further distinguish it from acute bulbar paralysis and from the pseudobulbar form will be considered later. Tumors of the medulla involve all structures in their neighborhood; hence, sensory nerves suffer as well as motor; furthermore tumors produce the usual train of symptoms characteristic of a general increase of intracranial pressure.

Pathological Anatomy.—The essential morbid change in bulbar paralysis is a progressive decay of the motor nuclei of the facial, hypoglossal, and glossopharyngeo-vago-accessory, and occasionally of the trigeminal. The ganglion cells of these nuclei lose their processes, shrivel, and gradually disappear. The intranuclear reticulations and the intra- and extrabulbar roots undergo the same destruction, the change in the latter being sufficiently marked in certain cases to be obvious macroscopically. In some cases the pyramidal tracts are involved.

Prognosis.—The disease is, for the most part, steadily progressive and invariably ends fatally. Its duration varies from one to three years. Remissions rarely occur, although in any case there may be protracted periods during which there appears to be no advance in the symptoms. In quickly progressing cases the disease may run its course in less than a year. Death usually ensues by reason of asphyxia, bronchitis, inhalation pneumonia, inanition, or some intercurrent disease.

Treatment.—Many drugs have been tried, but none is of any special value. Strychnine in gradually increasing doses, arsenic, nitrate of silver, and the iodides are among those most strongly recommended. Forced feeding should be instituted early in the attempt to keep up the nutrition, and later, when dysphagia is established, the food should be introduced artificially into the stomach in order to avoid the very imminent danger of inhalation pneumonia.

A galvanic current of two or three milliampères passed from one mastoid to the other is recommended by Oppenheim.

Vocal gymnastics may be tried in the effort to improve the speech.

The Hereditary (Familial) Type of Progressive Bulbar Paralysis.—A few cases of a peculiar hereditary form of progressive bulbar paralysis have been observed among members of the same family, usually among the offspring of consanguineous marriages. The victims are practically always true degenerates. The peculiarity of the disease in these cases is that it usually affects the upper facial territory first and its effects are most marked in this region, opthalmoplegia, especially ptosis, being associated with the bulbar phenomena. These latter do not differ from those observed in the ordinary form.

The paralysis is in most cases of the atrophic type and is associated with partial reaction of degeneration.

In 1895 Oppenheim described an infantile form of pseudo-bulbar paralysis. It was observed by him in connection with cerebral infantile diplegia, and consisted of a bilateral paralysis or paresis of the muscles of the tongue, palate, pharynx, and larynx, which gave rise to the characteristic dysarthria, dysphagia, etc. The paralysis was associated with spastic athetotic movements of the affected muscles. Atrophy and fibrillary twitching were absent.

Oppenheim considers the pathological basis of the disorder to be a bilateral disease or a developmental defect in the central convolutions.

The Acute (Apoplectiform) Type of Bulbar Paralysis.—*Symptomatology.*—Certain cases have definite prodromes, such as pressure in the head, ringing in the ears, vertigo, sleeplessness, and spots before the eyes. The main symptoms develop suddenly. Intense vertigo or even a genuine apoplectic shock with complete loss of consciousness may usher in the attack. Vomiting may accompany the vertigo. In a few cases general convulsions of an epileptiform character have been observed.

Almost immediately after onset a labio-glossolaryngeal paralysis is found in full development. This is manifested by characteristic dysarthria, dysphagia, etc. Although the paralysis is bilateral it rarely affects the two sides equally. In the majority of the cases the extremities are also involved in the same varying degrees. There may be paralysis of both arms with simple weakness of the legs, or there may be simple hemiplegia, the latter usually on the side opposite to that on which the bulbar nerves are most involved. The onset of all these symptoms may be less sudden, a few days or even a week being required for their full development.

Dyspnea and even Cheyne-Stokes respiration, with marked increase of the pulse rate, may be present early and may last for a very long time.

Various sensory disturbances are not unusual, and the patient may complain of painful paresthesiæ in some parts of the body or extremities.

The expression of the face is characteristic; more so in fact than in the early stage of the chronic type of bulbar paralysis, because the disease renders the facial muscles fixed and expressionless in a very short time.

The paralysis of lips, tongue, and soft palate is naturally not often associated with atrophy—first, because this phenomenon requires time; and, second, because it is the supranuclear part of the nerves which is usually affected. The nucleus itself may be directly affected, though rarely, and in such cases the characteristic atrophy with electrical changes may be found in the affected muscles.

The symptomatology is much more variable than in the chronic bulbar form, and naturally varies with the extent and seat of the lesion. The same eccentric grouping of bulbar nerve paralysis, with paralysis or paresis and sensory disturbance in the trunk and extremities spoken of under vascular lesions of the bulb in general, is to be expected.

Pathological Anatomy.—By far the commonest cause of the acute form of bulbar paralysis is thrombosis with softening. Both hemorrhage and embolism do occur, but with nothing like the same frequency. Poliencephalitis inferior acuta may determine the symptoms above described, and like symptoms are also ascribed to the pressure of a dilated atheromatous basilar artery.

Certain authors have observed the occurrence of an acute bulbar paralysis associated with weakness of the extremities during the course of typhoid; sometimes with a fatal outcome. In the latter cases streptococci and other organisms were found in various parts of the central nervous system without any very marked histological changes.

Prognosis.—Death may result, in very acute cases, within a short time from inhalation pneumonia or cardiorespiratory paralysis. In less severe cases the symptoms are slowly regressive and may gradually disappear, although restoration of function is seldom absolute in all the affected parts.

Treatment.—In cases suspected to be of syphilitic origin the prompt and free use of specific medication is demanded. Otherwise treatment should in the main follow the lines indicated in the therapy of cerebral vascular lesions in general. In the cases which arise in the course of an encephalitis of the ponto-medullary region antiphlogistic and derivative measures are appropriate. Very large doses of calomel may serve a useful purpose even in cases not syphilitic.

It is very important to make every effort to keep up nutrition from the beginning. As paralysis of the muscles of deglutition may be absolute even from the outset, artificial feeding often becomes indispensable.

In the later stages of surviving cases electricity may prove useful.

Labio-glosso-laryngeal Paralysis of Pseudo-bulbar and Cerebrobulbar Origin.—In very rare cases after a patient has experienced a number of minor apoplectiform attacks a condition resembling the labio-glosso-laryngeal paralysis of bulbar origin, without any implication of the bulb itself, may result.

The pathological substratum of such cases is a diffuse atheromatosis of the cerebral vessels, which causes a gradual destruction of the cortical representations of the facial, hypoglossal, and motor trigemnal nerves.

To produce a fairly complete analogue of the genuine bulbar type both cortices must undergo considerable destruction in the regions above indicated, with secondary changes in the cortico-bulbar projections. As these changes are all distinctly supranuclear, atrophy and electrical changes in the affected muscles are wanting.

Clinically, while the above picture is in the developmental stage, the patient is observed to have a series of mild shocks which differ in nowise from the ordinary. It is only when the cumulative effects of these various shocks are manifest in a bilateral paralysis or paresis of the muscles of the face, tongue, and jaws with accompanying disturbance of speech, swallowing, etc., that the resemblance to the bulbar paralysis begins. Even then the likeness is not complete, since severe disturbance of the respiration and of phonation is ordinarily absent.

The mental state of such patients differs markedly from that observed in the genuine form of bulbar paralysis in that some type of psychosis, or even dementia, is usually present. So-called bulbar crying and laughing is, on the other hand, commonly present, and may be very marked.

The paralysis is not necessarily limited to the face and tongue areas, so that hemiplegia or diplegia may be present.

A further type—the cerebrobulbar—described by Oppenheim, differs from the above only in the fact that with the cerebral arterial breakdown is associated a similar condition in the bulb. The lesions are never large and the bulbar symptoms are of gradual onset.

Symptomatically, bulbar phenomena are found associated with marked mental deterioration. Both bodily and mentally the patient is in a most deplorable state. With the usual disturbance of speech, mastication, and deglutition is associated spastic paralysis of the extremities on one or both sides. Attacks of dyspnea and Cheyne-Stokes respiration either come on spontaneously or result from excitement, from paroxysms of spasmodic hiccough, or from attempts at motion. The optic nerves may undergo neuritis with consequent atrophy. The bladder and rectum may or may not be involved.

The prognosis in both the pseudo-bulbar and the cerebrobulbar forms is very grave, although life may be prolonged for a considerable period of time.

The treatment recommended is that already described elsewhere.

Asthenic Bulbar Paralysis (Myasthenia Gravis Pseudo-paralytica).—To Erb (1879) is due the credit of calling attention to a symptom complex which so closely simulated that about to be described under asthenic bulbar paralysis that it must be considered its nosological analogue. It was not, however, until the appearance of Oppenheim's case in 1887 that this singular disease began to attract the attention which has been increasingly accorded to it up to the present moment.

Etiologically, little or nothing definite is known about it beyond the fact that it appears to result from the action of some toxic agent upon a congenitally predisposed nervous organism. Its association with tumors of the mediastinum and of the thymus gland has been noteworthy in specific instances. The predominance of the disease in early life is striking, but persons of advanced years are by no means exempt.

Pathology.—Up to the present time the most searching anatomical investigations have failed to reveal any organic changes in the medulla, bulbar nerves, or muscles. Congenital nervous defects and peculiarities have been observed in connection with certain cases, and a certain amount of stress has been laid upon the same as regards their morbid value, but it remains extremely doubtful if such stress has been rightly placed. The disease, in last analysis, appears to be a true neurosis.

Symptomatology.—This comprises the usual dysarthria, dysphagia, and masticatory weakness with their associated palsy of the lips, tongue, palate, and jaw observed in the ordinary types of bulbar paralysis. Added to this is a paralysis of the upper part of the face with imperfect closure of the eyelids. The paralysis also extends to the trunk and extremities, and attacks of dyspnea are frequent. In a certain number of cases the involvement of the eye muscles, notably ptosis, is the earliest and most striking symptom. Atrophy and reaction of degeneration in the affected nerves and muscles are absent throughout the entire course of the disease regardless of its duration.

Jolly in investigating the behavior of the affected nerves and muscles to electrical stimulation observed a peculiarity which he designated "myasthenic reaction." He found that where a tetanizing faradic current was applied (either to nerves or muscles) at intervals of a few seconds, the muscular contraction grew progressively weaker and gradually vanished completely, but that the muscle regained its irritability after a short rest. He further found that if the current were passed through a muscle without interruption for the space of a minute or even less, the muscular contraction gradually died away, but was again obtainable by the same sort of stimulation after a minute's rest.

Analogous phenomena have been observed in voluntary attempts to use the muscles of the jaw or extremities. A patient may take one bite of an article of food and then be totally unable to bring the jaws together with any force, but after resting a while may regain enough strength to chew for a few moments.

The course of the disease is very peculiar. The complete development of symptoms may require many months, although in certain cases the time required has been much briefer. Remissions are common, and the full development of symptoms may be followed by a regression, but so treacherous is the malady that when recovery seems fully established, there may be a fresh outbreak of the most rapid character and the symptom complex again be complete in a startlingly short time. Intercurrent attacks of dyspnea and tachycardia and febrile movements are common.

The disease has on the whole so many peculiarities that differentiation is not difficult. The combination of bulbar symptoms with weakness of the muscles of the trunk and extremities, the frequent involvement of the external ocular muscles (manifested mainly by ptosis), the retention by the affected muscles of their normal volume, the absence of reaction of degeneration in the presence of the peculiar "myasthenic reaction" mentioned above, the characteristic tiring of affected muscles on voluntary motion, the lack of definite sensory and sensorial disturbance, the absence of mental weakness and disease, and the complete lack of any tangible pathologic substratum in the brain, nerves, or muscles unite to form a clinical and anatomical picture that is *sui generis*.

The *prognosis* is always serious. Nevertheless the most alarming cases may end in complete recovery. Recovery is, however, never assured until there has

been a freedom from symptoms for a period of many months. Up to the present time the majority of cases have terminated fatally.

Treatment.—The proper care of this type of bulbar paralysis requires unusual skill. A complete rest treatment, such as is followed in the severest form of neurasthenia, should be carried out in bad cases to the minutest detail. The patient should be allowed to do almost nothing for himself, even to swallowing food, which, by the way, should be selected so as to combine the maximum of nourishment with the least tax upon the digestive organs. Even the use of the stomach tube for artificial feeding is not devoid of danger, as its introduction may induce fatal suffocation. If mastication can be permitted with safety in a given case, care should be taken to allow the patient to rest between mouthfuls.

The drug treatment consists in the administration of tonics. In certain cases the preliminary production of diaphoresis has been beneficial. Against the use of electrical stimulation it cannot be too strongly cautioned. JOSEPH W. COURTNEY.

Poppy.—See *Papaver*.

Porocephalus.—A genus of worm-like arachnids which has from sixteen to twenty-two rings around the body. The adult lives in certain African snakes; the larvæ are found in the liver of the monkey, hedgehog, lion, and sometimes in man. A. S. P.

Porokeratosis.—*Synonyms:* Hyperkeratosis eccentrica, Keratodermia eccentrica, Hyperkeratosis figurata centrifuga atrophicans.

DEFINITION.—Porokeratosis is a rare, chronic, progressive keratodermia in which occurs a characteristic and unique rifted ridge bordering a central atrophic area.

FIG. 4331.—Case of Porokeratosis of Five Years' Standing. The affected area is bounded by the characteristic rifted ridge. The lesion shown here was the only one present in this case. (From Grover W. Wende's collection of photographs of skin diseases.)

In 1887 Maiocchi reported a case, marked by a singular appearance of the skin, which he diagnosed as a form of ichthyosis hystrix. After six years the same case was brought to the notice of Mibelli, who pronounced the lesion exceptional and peculiar, claimed that the pathological process was distinctive, and finally characterized the affection by the name of porokeratosis. Simultaneously with the observation by Mibelli, an article was published by Respighi describing a number of similar cases under the name of hyperkeratosis eccentrica.

Porokeratosis has been especially observed in Italy, particularly in the district of Parma. Cases occurring in the United States have been reported by Hutchins, Gilchrist, and Wende. A few cases have been noted in Germany, France, and England. With the exception of a very few isolated instances, practically all the known cases of porokeratosis were reported within the decade following the appearance of the articles of Mibelli and Respighi.

SYMPTOMS.—The disease is of very slow development; it first appears as a dry, dirty brown, wart-like papule or callous spot, varying in size but invariably surrounded at its base by a collarette of scales. As the lesion develops it takes on decided changes, the periphery gradually extends centrifugally and the central portion becomes slightly depressed. The border resolves itself into a unique non-inflammatory hypertrophy, sharply defined against the outlying sound skin, and forming a continuous or broken ridge; in the middle of this ridge is found a rift somewhat irregularly dividing the same into two lateral halves. All of which constitutes a picture unlike any other known lesion: this has been characterized as a "seam," "dike," or "wall;" it is dirty gray or blackish in color and usually quite pronounced, though in ill-defined cases it may appear simply as a loose rim of epidermis. The center, so long as the lesion is small, consists of a horny, thickened, epidermic patch. As the lesion develops the center may become normal in appearance; sometimes the natural furrows of the skin are erased; again, there is clear evidence of atrophy. The functions of the sweat and sebaceous glands are interrupted; in some areas absence of hair is observed. Epidermic concretions, the size of a millet-seed, are sometimes present, frequently attached to the inner side of the rift, or they may appear at any point within the affected area.

The areas affected by porokeratosis vary in size from one-eighth of an inch in diameter to the covering of the greater portion of an extremity. As a rule, they do not exceed an inch in diameter, and in the majority of cases they are much smaller.

The lesion, always slow in development, at times remains stationary. As they develop, they vary from the primary rounded to elliptic or even rectangular shapes; by confluence they may become polycyclic.

Porokeratosis may be limited to the occurrence of one lesion; or lesions may appear at successive intervals during the life of the patient. All or any part of the skin may be attacked. The favorite regions, however, are the face—especially the nose, forehead, and cheeks—the ears, the neck, the dorsal surfaces of the hands and feet, and the extensor surfaces of the forearms.

Porokeratosis may affect the mucous membrane; the mouth and vagina are the only sites as yet re-

ported. The lesions of the mouth are generally not very numerous, although present in a large number of cases. They consist of small asymmetrical spots varying from the size of a pin to that of a lentil. Like the lesions of the skin, they may be oval, polycyclic, or irregular.

The subjective symptoms are without special importance; only occasionally the patient may complain of either slight or intense pruritus. When the feet are affected the shoes sometimes cause pressure pain.

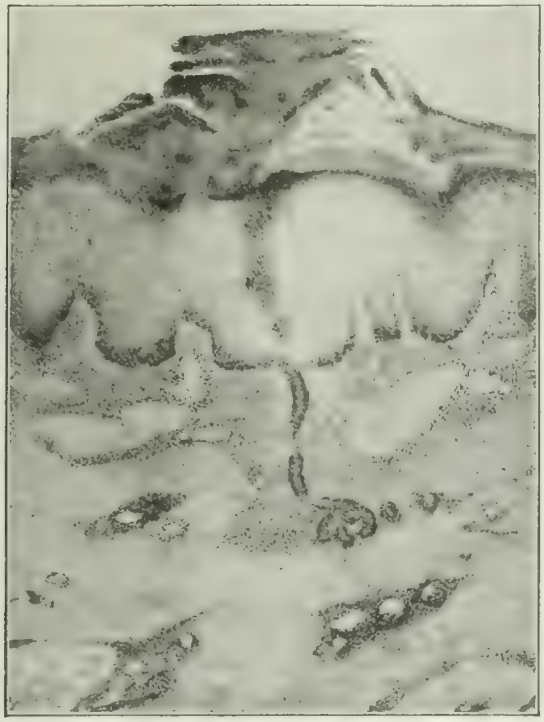

Fig. 4332.—Cross-section of the Characteristic Ridge in a Case of Porokeratosis. In addition to the condition of marked hyperkeratosis, which is revealed in the picture, there may be seen a sweat pore which is obstructed by the presence of a black horny plug that extends down to the level of the acini. (Grover W. Wende.)

Etiology.—The cause of the disease is still a matter of conjecture. Hereditary tendencies are frequently shown. Gilchrist published the histories of a total of eleven cases occurring in four successive generations of one family, while Respighi reports the recurrence of the malady in several generations. Most of the cases occur in laborers. Males suffer more often than females. Sometimes the affection is developed in children; generally, however, it appears in adolescents or adults.

Proof that the affection is parasitic is wanting; although in a series of thirty inoculations by Wende made upon four individuals, one was successful, undoubtedly owing to local irritation upon a susceptible skin. Respighi made experiments in transplantation that proved to be negative. All examinations for microorganisms have been without result.

Pathology.—In the main this disorder is a special form of hyperkeratosis. The margin is composed of a mass of cornified cells which still retain their nuclei; it forms a conical plug corresponding to the interpapillary depression into which the enlarged glandular orifices combine, and which orifices are choked by the horny masses—a condition which strongly resembles lichen spinulosus. The lower horny and the upper rete layers are especially affected, although all parts of the epidermis are involved. A small amount of cellular infiltration and edema is seen in the papillary layer of the cutis immediately underlying the affected epithelium. The derma undergoes a sclerotic degeneration in its upper layers; at first hypertrophied, but in the advanced stage atrophied. The sweat glands are dilated, choked and reveal epithelial proliferation and hyperkeratinization. Epithelial accumulations in the sweat ducts and sebaceous glands, as well as in the hair follicles, have also been observed by Mibelli, Respighi, and Gilchrist.

Diagnosis.—The clinical characteristics of porokeratosis are so unique that a mistake in diagnosis is not likely to occur. The early lesions may be mistaken for those of lichen planus, but lichen planus is generally accompanied by itching, is an inflammatory, self-limited disease and not continuous, and it does not attack several members of the same family. The essential lesions of lichen planus are the characteristic papules, striated on the surface, and of a dark red color; occasionally they are essentially annular, but in that case the rings are limited by a red prominence, not a depression, and one does not see either the rift or the edge of the porokeratosic circles so characteristic of the disease.

Prognosis.—The disease does not affect the general health, and, beyond the possible disfigurement, need not create any anxiety. Sometimes the lesions disappear spontaneously. When located about the joints, especially of the fingers or feet, the affection may cause some pain from pressure and the interference with function.

Treatment.—The same treatment is required as that given to some forms of ichthyosis. The lesions, in the early stages of the disease, are to be removed by salicylic-acid plasters or the use of the curette. Joseph has obtained good results by excision. Gilchrist recommends electrolysis. Both of these modes of treatment were employed in the case illustrating this article, but without favorable results. Undoubtedly this treatment is applicable only to small lesions.

Grover W. Wende.

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Portland, Maine.—The largest city and commercial metropolis of Maine, with a population of 59,000, one hundred and fifteen miles northeast of Boston, is beautifully situated at the head of Casco Bay. Portland is the center of a number of attractive seaside resorts which are easily reached from this city by sea or land. Such are Old Orchard Beach, Scarborough Beach, Prout's Neck, Kennebunkport, Pine Point, Saco Pool, and Wells Beach to the south; and Boothbay, Harpswell, Islesboro, Isle Au Haut, Vinal Haven, Deer Isle, Camden, and Castine to the northeast. Indeed, the whole coast of Maine with its innumerable indentations and many islands affords a great variety of attractive summer resorts with a cool, delightful climate. It is visited at this season by thousands of people from the inland cities of

the North, South, and West. Portland itself and its picturesque surroundings offer very many attractions, and possess a cool summer climate and a steady sea breeze.

There are many fine buildings and churches in the city, a number of parks, notably the Eastern Promenade with a fine view of the city and harbor, and many points of historical interest. The drives are delightful, and excursions by water through the harbor and Casco Bay with its many islands, are numerous and pleasing. Diamond, Peak's, and Cushing Islands are favorite resorts near the city, easily and quickly reached by water. The accommodations, both in Portland and the various other resorts mentioned above, are abundant, good, and of varying prices. The following table represents the climate of Portland and will also convey an idea of the climate of the resorts lying to the north and south. In general, the summer climate is seen to be a cool marine one, with frequent sea breezes, a majority of pleasant days, and a humidity of about seventy per cent. There are often quite sudden and marked changes in temperature, and fogs are not infrequent. Such a climate is a stimulating one and well suited for the overworked, for neurasthenics, and for those suffering from anemia, scrofula, and bone and joint tuberculosis. Convalescents from chronic diseases also do well in this climate. It is too damp and variable for laryngeal and pulmonary cases and those subject to neuralgic affections. Especial mention should be made of the exceptionally fine beach at Old Orchard, the finest in New England, extending for a distance of ten miles and affording most excellent surf bathing. This is a very much frequented resort, and offers accommodations of every kind and description. Hinsdale (vol. iv., Book II., "Health Resorts," "Physiological Therapeutics") says that the climate of Kennebunkport is not excelled on the New England coast. "The south and southwest breezes," he says, "are from the water; a hot land breeze is a rarity, and fogs are not of frequent occurrence." He recommends the climate for neurasthenics and those suffering from insomnia and melancholia.

CLIMATE OF PORTLAND, ME., LATITUDE, 43° 39′, LONGITUDE, 70°, 15′. PERIOD OF OBSERVATION, TWELVE YEARS.

	January.	March.	May.	July.	September.	October.	November.	Spring.	Summer.	Autumn.	Winter.	Year
Temperature, degrees Fahr.:												
Average mean temperature, deg	23.2	32.6	54.8	69.7	60 6	50.4	38.0	43.5	67.2	49.6	25.6	46.5
Average daily range	15.8	14.2	16.2	16.6	14.4	14.2	13.1					
Mean of warmest	31.9	41.2	64.1	79.0	69.5	58.8	46.7					
Mean of coldest	16.1	27.0	47.9	62.4	55.1	44.0	33.6					
Highest or maximum	58.0	65.0	94.0	97.0	94.5	83.0	66.0					
Lowest or minimum	−11.5	− 7.0	34.0	51.0	37.0	28.6	− 6.0					
Humidity:												
Average mean relative, per cent.	72.6	68.4	64.7	70.1	73.6	70.8	70.8	65.3	70.1	71.7	71.8	69.7
Precipitation:												
Average in inches	3.22	3.25	2.94	3.52	3.16	3.66	3.85	8.95	10.40	10.67	9.02	39.04
Wind:												
Prevailing direction	N. W.	N. W.	S.	S. W.	S.	S. W.	N. W.	N. W.	S.	S. W.	N. W.	N. W.
Average hourly velocity in miles.	7.6	9.1	7.8	6 6	6.7	7.3	8.3	8.5	6.4	7.4	8.0	7.6
Weather:												
Average number clear days	9.7	7.2	8.3	8 6	10.2	8.9	9.1	23.2	27.8	28.2	28.5	107.7
Average number fair days	12.0	11.6	11.8	14 2	11.1	11.5	10.6	34.8	40.2	33.2	35.9	144.1
Average number clear and fair days.	21.7	18.8	20.1	22.8	21.3	20.4	19.7	58.0	68 0	61.4	64.4	251.8

Portland, as well as the various resorts about it, can be easily reached from Boston either by rail or by water.

EDWARD O. OTIS.

Portland, Oregon.—This is the largest city in the State of Oregon, with a population of 207,214, and is situated at the head of ship navigation on the Willamette River which flows into the Columbia. It is in no sense a health resort, but it is mentioned

CLIMATE OF PORTLAND, OREGON, LATITUDE, 45° 32′; LONGITUDE, 122° 43′. PERIOD OF OBSERVATION, TWELVE YEARS.

	January.	March.	May.	July.	September.	October.	November	Spring.	Summer.	Autumn	Winter.	Year.
Temperature, degrees Fahr.:												
Mean average temperature, deg.	39.6	47 3	56.0	66 2	60.9	53.0	45.1	51.5	64 2	53.0	41 0	52.4
Average daily range	10.8	16 2	20.5	21.9	20.0	14.2	12.3					
Mean of warmest	45.2	55.8	67.4	76.8	70.7	59.2	51.4					
Mean of coldest	34 4	39.6	46.9	54.9	50.7	45.0	39.1					
Highest or maximum	58.0	76.5	86.0	95.5	90 0	79.0	68.0					
Lowest or minimum	3.0	22.5	33.0	46.0	39.0	31.0	22.5					
Humidity:												
Mean average relative, per cent.	78 4	75.9	64.9	63.7	69.2	77.6	78.4	70.3	65.1	75.1	78 7	72.3
Precipitation:												
Average in inches	7 34	7.27	2.44	0.71	1.62	4.95	7.37	13.19	3.34	13.94	23.72	54.18
Wind:												
Prevailing direction	S.	S.	N. W.	N. W.	N. W.	S.	S.	S.	N. W.	S.	S.	S.
Average hourly velocity in miles.	6 0	5.1	4.8	4 7	4.2	4.1	4.5	4.9	4.5	4.3	5.3	4.7
Weather:												
Average number clear days	3.4	4.4	5.1	15.3	12.4	7.1	4.7	14.7	37.0	24.2	9.6	85.5
Average number fair days	7.0	7.0	9 9	7.4	9.5	9.9	8.8	26.1	26.4	28.2	21.1	111.8
Average number clear and fair days.	10.4	11.4	15.0	22.7	21.9	17.0	13.5	40.8	63.4	52.4	30.7	187.3

here, and a climatic chart is given, for the sake of contrasting the climate of the eastern and western sides of the North American continent. By comparing the charts of Portland, Me., and Portland, Ore., the contrast will be seen. "Portland, Ore., lies nearly two degrees farther north than Portland, Me., yet its mean winter temperature is not less than fifteen and one-half degrees warmer than that of its namesake on the Atlantic coast. It is within one degree of being as warm as that of Norfolk, Va., and is about ten degrees warmer than that of New York City. On the other hand, the summer at Portland, Ore., is slightly cooler than at Portland, Me., and is about seven degrees cooler than that of New York City and almost exactly the same as that of Montreal." "The range of temperature is decidedly less at Portland, Ore., than it is at Portland, Me. The rainfall is much greater, and the relative humidity is higher (especially in winter), and the number of cloudy days is much greater. The great cloudiness of the Oregon winter weather is a feature of the climate not characteristic of any other part of the United States except the Lake region and St. Lawrence Valley district" (Richards). Richards (previous edition of the HANDBOOK) calls attention to the close resemblance between the climatic conditions characteristic of Portland, Ore., and those prevailing along the western coast of the European continent. The temperatures of the Oregon coast, he says, are strongly suggestive of those found throughout northwestern Europe; further, the almost rainless summer with heavy winter rainfall is a feature of climate in which the Oregon coast resembles the Mediterranean basin rather than the more northerly parts of Europe.

EDWARD O. OTIS.

Portsmouth, N. H., and Adjacent Resorts.—This "old town by the sea" is noticed here not only on account of its own attractions, but because in its vicinity are a number of well-known summer marine health resorts: the Isles of Shoals; Rye and Hampton Beaches and Little Boar's Head; York Harbor and Beach; Ogunquit, Kennebunkport and Kennebunk Beach, Passaconaway, Kittery, and Newcastle.

Portsmouth, fifty-seven miles from Boston, is situated a few miles above the mouth of the Piscataqua River, and possesses an excellent harbor. It is the only seaport of New Hampshire, and in the days of wooden shipbuilding was a very prosperous town, as is evident from the stately mansions still remaining there.

The present population is about 11,000 and the town presents a quiet, tranquil aspect quite in contrast to its by-gone activity when ships were launched from its yards and were entering and departing from its spacious harbor. The streets are beautifully shaded, and the old residences of the architecture of seventy-five or a hundred years ago, with their attractive gardens, together with the water views from the decaying wharves, all combine to give this old city a most picturesque appearance. There are also many points of historic interest in and about the city, for it was first settled in 1623. On an island opposite, in the town of Kittery, is the United States navy yard. There are no meteorological observations to be had in regard to Portsmouth, but a fairly accurate idea of the climate may be obtained by striking an average of the climatic data of Boston and Portland, which are on the coast fifty miles east and west of Portsmouth, and which differ but little from each other. Estimating in this manner we have the following figures: Mean average yearly temperature, 47.3° F. Mean average temperature for the four seasons: spring 44.1°, summer 68.1°, autumn 50.3°, winter 26.8°.

The annual mean relative humidity of Portland and that of Boston are almost identical, and that at Portsmouth is, therefore, probably the same, which is 69.6 per cent., varying but little during the year. The average number of clear and fair days is: spring 58.3, summer 65.6, autumn 61, winter 59.6; year, 244.7. The yearly rainfall is 43.6 inches. The prevailing wind is from the southwest and west. All along this coast there may be a few very hot days during the summer, but generally the air is cool and delightful, and the sea breeze is almost a daily occurrence. The average mean temperature for this coast for the four summer months is June 64°, July 68°, August 67°, September 58° F., and the mean average precipitation for these months is June 3.2 inches, July 2.8 inches, August 5.7 inches, September 5 inches. The average relative humidity is about 70 to 75 per cent. The accommodations are good, among them one very excellent first-class hotel. Although Portsmouth is a city, yet it is such a mild and quiet one that it offers many advantages for even a whole summer's sojourn. The society is exceptionally good, to which the adjacent navy yard makes valuable contributions; the air pure and cool; the scenery in the vicinity very attractive, and there are many excursions both by land and water. There are various churches, one the historic old St. John's, a good library, a well-equipped hospital, and excellent physicians. Frequently some of the vessels of the North Atlantic Squadron visit Portsmouth during the summer, and there are always one or more warships at the navy yard.

The water supply of Portsmouth is from springs and driven wells a few miles from the city, and is regarded as of excellent quality. Sewers emptying into tide water are being slowly introduced, although many of the old-time vaults still remain.

The average yearly mortality for the last eight years (1894–1901) is 19.25 per thousand.

An old resident and practitioner of Portsmouth assures the writer that the sanitary condition is good, and that there are very few cases of sickness which can be attributed to unsanitary conditions.

One is referred to the writings of T. B. Aldrich, Lowell, and Mrs. Celia Thaxter for charming accounts of Portsmouth and the Isles of Shoals.

Newcastle.—This small island at the mouth of the Piscataqua River, about two miles from Portsmouth, is a popular summer resort, with a large hotel, boarding-houses, and cottages. The situation of Newcastle is very picturesque, and it has a beautiful and extensive ocean exposure. It is connected with the mainland by bridges, and has frequent communication with Portsmouth by land and water. There are opportunities for golf, tennis, boating, and bathing. There is a military garrison at Fort Constitution. The climate is the same as at Portsmouth, with the exception that being directly on the ocean, it is more peculiarly marine.

Kittery Point, at the mouth of the Piscataqua River, opposite Newcastle, is very attractively situated and is a popular summer resort, affording good accommodations, both in hotels and cottages. It has frequent communication with Portsmouth both by trolley and by boat.

Isles of Shoals.—This group of small, rocky islands lies about nine miles off the coast, and has communication in the summer with Portsmouth several times a day by a comfortable steamer, the voyage occupying about an hour. Appledore is the largest of the group, which consists of eight islands, and contains two hundred and fifty acres. The formation of these islands is granitic, and they present a rugged picturesque appearance, barren, and with very sparse vegetation. Huge, irregular reefs jut out into the ocean, and after a storm the play of the surf is very imposing. Only two of the islands provide accommodations for summer residents, Appledore and Star Island, there being extensive hotels on both islands. The accommodations are rather more elaborate and expensive on the former (Appledore), and there are several

cottage annexes. These islands have been a popular summer resort for many years, owing to the cool, equable marine climate found there, with an absence of dust and flies. Here one can experience all the climatic influences of a sea voyage without the discomforts incident to ship life. They are far enough removed from the mainland to be free from all contaminating influences, and from whatever quarter the wind blows it brings pure air. From a "weather record" for the summers of 1897–98 (June 25th to September 15th) kindly furnished the writer by Dr. J. W. Warren, who has been a summer resident of Appledore for over twenty years, the following data are condensed:

Mean temperature (Fahrenheit scale) from two daily observations at nine and four o'clock. June (25th to 30th) 63.2°, July 65.7°, August 67°, September (1st to 15th) 64.8°. The maximum temperature for this period was: June (25th to 30th) 70°, July 81°, August 78°, September (1st to 15th) 80°. Minimum, June (25th to 30th) 56°, July 56°, August 53°, September (1st to 15th) 56°. The summer temperature is said to be several degrees cooler than it is on the coast. Cold, raw days are infrequent, and the difference in temperature between day and night is slight, so that one can generally sit out in the evening. In general, the variations in the temperature are never as pronounced as on the mainland.

The average number of fair days for the two years was: June (25th to 30th) 4, July 15, August 17, September (1st to 15th) 9. Number of partly cloudy, misty, or foggy days: June (25th to 30th) 2, July 13, August 10, September (1st to 15th) 2. Partly rainy or rainy days: June (25th to 30th) 1, July 1.5, August 1.5, September (1st to 15th) 1.5.

The prevailing summer winds are southwest and south-southwest, and are not generally high. Fogs are not so prevalent as farther east, although they occasionally occur. The average number of rainy days is said to be much less than at Portland or Boston.

Therapeutically this climate has been found to be of great benefit to convalescents and to certain cases of neurasthenia. It is peculiarly valuable for those who, for one reason or another, wish to be much in the open air and at rest, for there are few inducements or opportunities to take exercise. Many years ago the late Dr. H. I. Bowditch considered the summer climate of these islands favorable for early cases of pulmonary tuberculosis, and they surely possess the requisite of pure air. Many cases of hay fever find immunity here. On White Island is a lighthouse, a prominent object from the mainland. There is good sea fishing and sailing about the islands. A steam launch affords frequent communication between Appledore and Star Island.

For much of the above information the writer is indebted to Dr. J. W. Warren.

York Harbor and Beach.—These resorts, on the Maine coast, are about nine miles distant from Portsmouth, and can be reached from the latter place by steam railroad, or by ferry, and a most attractive trolley ride. York Harbor is the principal resort, and enjoys a wide popularity. Cottage life predominates, although there are several good hotels. The coast is bold and rocky, and the York River winds inland for some nine miles, and has a large flow of tide water. The residential portion of the town is built upon ledges with little or no subsoil, so that there is good surface drainage, aided by the natural declivity of the land toward the sea. Further inland are wooded districts and tillage lands. The climate is a particularly stimulating one, favorable for convalescents, for whom a marine climate of this nature, combined with sea bathing, is desired. The air is generally cool and the temperature equable, an extremely hot or cold day in the summer being rare. Fogs are unusual. The following climatic chart was obtained through the kindness of Dr. Seabury W. Allen, a summer resident of York Harbor, as also much of the information contained in this account. The prevailing wind is southwest to southeast during the summer months, and is only exceptionally of sufficient velocity to interfere with canoeing or sailing. There is good sea-bathing here as at most of the other resorts mentioned in this article but the water is rather cold, the average temperature being 64° F.

Thunder storms are frequent in summer, but a continuously rainy day is the exception. The water supply is excellent; it is obtained from an inland lake some five miles distant. The ice, milk, and farm produce are also of good quality. The larger houses and hotels have sewers running into the sea, the smaller ones either connect with one of these sewers or have cesspools of their own.

So far as known there have been no cases of illness attributable to imperfect drainage. Indeed, this resort enjoys almost complete immunity from zymotic and infectious diseases. Gastrointestinal disorders, especially in children, are rare. Such a climate, or indeed any cool marine one, is obviously not suitable for patients suffering from rheumatism, bronchial and pulmonary affections.

York Beach, situated a few miles to the eastward of York Harbor, possesses essentially the same characteristics as the latter, with the exception of the drainage. Here, on account of an extended swamp, lying behind the beach shingle, and which is imperfectly drained, there is always more or less stagnant surface water, and for this reason this locality is not so desirable as a place of summer residence.

Several miles beyond York Beach and to the northward is the Passaconaway Inn, on a rocky promontory, affording good accommodations, and still farther along the coast is the extensive Ogunquit Beach, reaching toward Wells.

Kennebunkport, Kennebunk Beach, Biddeford Pool, and Old Orchard Beach lie between Wells and Portland. Their climatic features resemble closely

Climate of York Harbor—Prepared by Dr. Seabury W. Allen.

	June.	July.	August.	September.	October.
Temperature, degrees Fahr.:					
Average or normal	62.3°	69.9°	65.8°	58.4 } °For three	
Highest or maximum	92.3	95.5	87.3	79.3 } years,	
Lowest or minimum	45.0	51.6	48.3	39.6 } 1892–1894	
Precipitation:					
Mean annual precipitation for twenty-five years, 40 to 50 inches.					
Mean monthly average rainfall (April to September) twenty-five years, 3.4 inches.					
Average number of days in which rain fell (for three years).	11	9	7	9	
Average daily temperature (for nine years)	8 A.M.–67 8 P.M.–68	8 A.M.–67 8 P.M.–67	8 A.M.–65 8 P.M.–70	8 A.M.–56 8 P.M.–57	8 A.M.–45 8 P.M.–46

those of York Harbor. Kennebunkport and Kennebunk Beach are at the mouth of the Kennebunk River and are reached by a five-mile branch from the Portland division of the Boston and Main railroad. All these places are thronged with summer visitors, Kennebunk Beach being particularly popular with Canadians. Old Orchard Beach and Kennebunkport have remarkable beaches, of hard sand and gentle declivity and especially free from undertow. The water sometimes reaches 70° F. (record of July 15, 1914) but is usually in summer between 60° and 65° F. Old Orchard is a favorite place for excursionists while at Kennebunkport and Biddeford Pool cottage life dominates.

Rye Beach.—This well-known and favorite summer resort is eight miles distant from Portsmouth by electric road, and is also easily reached from Boston by rail to North Hampton and thence by trolley. The air is warmer than on the Maine coast, but is fresh and cool, with an almost daily sea breeze. Moreover, the humidity (about seventy per cent.) is considerably less than at many other marine resorts. The majority of summer days are clear or fair, and the rainfall at that season is moderate. The general healthfulness of this resort is noteworthy, and children especially thrive here. The rapidity with which delicate and sickly children improve in this climate is often quite remarkable. It is also favorable for the aged and delicate persons and convalescents from various diseases. The surf bathing is good, although the water is cold, averaging about 60° to 65° F. during July and August.

The drives are very delightful, over good country roads, and through pleasant pastoral scenery. An ocean boulevard, constructed by the state, extends along the whole coast of New Hampshire affords an exceedingly attractive drive of about eighteen miles from the Piscataqua River, on the north, to Hampton River on the south.

There are well-kept golf grounds with an attractive club-house, and a picturesque stone Episcopal church near the water, "St. Andrew's by the Sea." The sanitary conditions are generally good, and all the hotels and large boarding-houses have sewers running to the sea. The water supply is from springs, artesian and surface wells. The accommodations are excellent, though rather expensive, and there are many social attractions. Cottage life here as well as at the neighboring Little Boar's Head has become quite an important feature.

Little Boar's Head, situated about a mile south of Rye Beach, possesses the same characteristics as the latter. The name is derived from the bluff upon which it is situated. The views over the marshes and toward the sea are particularly charming, The accommodations and class of visitors are quite like those at Rye Beach. Indeed, both from its contiguity and identity of interests, Little Boar's Head can be regarded as a portion of Rye Beach. It is reached by trolley from Portsmouth or from Boston by railroad and trolley.

Hampton Beach.—Although not so fashionable as Rye Beach, this is a much-frequented resort, with several hotels of moderate price and fair accommodations, and many small cottages stretching along the beach. There is a long, hard, sandy beach extending for some miles, and affording excellent surf bathing. In the rear of the beach are extensive marshes. There are many attractive drives in the vicinity, although the wooded and cultivated land does not approach the water so closely as at Rye Beach.

This is a favorite resort for excursions, and consequently might not be so attractive to the permanent guest. It is reached by electric road from Portsmouth and Exeter, and is within three miles of the steam railway. Across the Hampton River next to Hampton Beach is the thickly settled summer resort of Salisbury Beach of much the same characteristics as that of Hampton Beach. EDWARD O. OTIS.

Porto Rico.—Porto Rico (*Spanish,* Puerto Rico), aboriginal name Borinquen, in size the fourth island of the West Indies, is situated between latitudes 17° 50′ and 18° 30′ north, and longitudes 65° 30′ and 67° 15′ west, Greenwich. On the north is the Atlantic Ocean, on the south the Caribbean Sea, on the west Mona passage separates the island from Hayti, and on the east lie the Virgin Islands and Saint Thomas. Belonging to Porto Rico are the adjacent small islands of Vieques, fertile, and Culebra, nearly barren, on the east coast, and Mona, a guano deposit, on the west coast. Vieques is the largest of the three, being about twenty-one miles long and six miles wide. Porto Rico is about 1,000 miles southeast of Florida, and about 1,500 miles from New York City. The shape of the island is that of an elongated quadrangle, its long axis running east and west. The greatest length of the island is 108 miles and its average breadth is thirty-seven miles. The area is 3,435 square miles, or about 1,000 square miles greater than that of the state of Delaware and 1,500 square miles less than that of Connecticut. In appearance Porto Rico is an agglomeration of hills and mountains channelled with innumerable steep and narrow valleys. Along the north littoral, the hills and mountains abut more or less abruptly on the ocean, with but here and there an intervening strip of flat or gently sloping shore. The southern shore has a considerable coastal plain, relatively speaking. Notwithstanding the striking unevenness of the island, there is a definite orographic system traced as a sinuous crest from near the southwestern corner eastwardly, and about one-third nearer the southern coast than the northern. In the eastern part of the island this crest bends sharply and terminates near the northeast extremity of the island in the peak, El Yunque, 3,750 feet above sea-level, the highest point in Porto Rico. The general elevation of this crest ranges from 2,000 to 3,000 feet above sea-level, with here and there a pass somewhat lower or a peak somewhat higher. From this general crest the mountains and hills decline coastward. The coastward fall is much greater toward the south as a consequence of the proximity of the mountain crest to the southern coast. This crest divides the island into practically two watersheds, the larger one draining north and west, the smaller draining south and east. Flowing down these two sheds, rapidly and often precipitously, are more than 1300 named streams. But few are navigable, and then only for a few miles. The coast, unlike that of Cuba, has but few fringing reefs to interfere with the close approach of vessels to the shore. There are a number of good natural harbors. San Juan, on the north, is the most important commercially. It now has a depth of thirty feet. Ponce Playa, the seaport of the city of Ponce, on the south coast, has a depth of twenty-nine feet. Other ports that may be entered by the average ocean-going vessels are Arecibo, Aguadilla, Mayaguez, Guanica, Arrayo, and Fajardo. When it is considered that the total coast line is not much more than 300 miles, Porto Rico appears well provided with harbors. Viques, the small islet off the east coast, has two excellent harbors.

Geology.—Though one of the earliest colonized islands of the New World, practically nothing was known of the geology and mineral resources of Porto Rico till after its cession to the United States. The early Spanish settlers worked some placer gold, and some is still to be found in the rivers of the northeast part of the island. Mercury, magnetic iron ore, copper, coal, lignite, salt, and several other minerals are found, but not in quantities commercially important. Brick-clay and limestone are abundant. The soil along the coast is corallaceous, inland it is a

sandy to a clayey loam quite rich in alluvium. Several thermal and mineral springs, and one or two caves of interesting formation and beauty are known.

Fauna.—The indigenous mammalian fauna has practically disappeared with the exception of a few species of rodents, of which the only peculiar one is the somewhat squirrel-like agouti (common also to all the other West Indies). A number of bats are found. The curious marine mammal, the manatee, frequents the shoal waters of the coast. Fish, both fresh- and salt-water varieties, are plentiful. Noxious reptiles are scarce and no venomous snakes are found. Insect pests are not as plentiful as in other tropical countries. The usual domestic animals thrive well, and good beef is to be had throughout the island.

Flora.—Vegetable life flourishes even to the tops of the highest peaks. However, it is now only on the more inaccessible mountain slopes and tops that considerable remnants of the once large indigenous forests are found. Some of the native woods possess properties that are peculiarly suitable for certain purposes, but their scarcity precludes their general use. Intelligent reforestation would seem to offer returns of commerical value. Among the many native trees, there have been described a beautiful talauma with immense white odorous flowers and silvery leaves, a hertella with crimson flowers, an unknown tree with orange-like foliage and large purple flowers, and most conspicuous of all, the *Cocoloba macrophylla*, with its great purple spikes more than a yard long. Of woods common to other of the West Indies, there are found hard and soft Spanish cedar, sandalwood, and ebony. Tree ferns are numerous and of large size. The absence of epiphytes is in striking contrast to their abundance in the forests of the neighboring islands. Coffee of excellent quality, sugar cane, yams, oranges, cocoanuts, and many of the other tropical fruits are cultivated and yield well. A species of rice, requiring no irrigation, is found growing upon the highlands, and forms one of the staple foods of the laboring class. An excellent grass, *Hymenachne striatum*, covers the lowland pastures, and on it is fattened the beef for which Porto Rico is esteemed by its neighboring islands.

Climate.—The dominant characteristics of Porto Rican climate are those general to insular tropical regions, that is, the temperature is uniformly high and subject to relatively small annual variations between the warmest and coldest periods of the year; and due to insularity, the diurnal temperature range is quite regular; the rainfall regimen follows the general rule of tropical islands, namely, frequent and abundant on windward exposures, increasing with altitude, less frequent and scant on leeward exposures, even to the extent of aridity wherever the lee may be protected by high mountains. Though somewhat nearer the equator than Cuba, Porto Rico is not correspondingly warmer. On the contrary its temperature, taken as a whole, is slightly more comfortable. This is due to the situation of the island farther out in the ocean, and at the windward angle of the Antillean system. This position, combined with its slightly more southern latitude, gives Porto Rico the unobstructed flow of the northeast trades at all seasons of the year. Porto Rico, again compared with Cuba, owes somewhat of its more agreeable temperature to its smaller size, giving it a nearer approximation to the true marine air temperature of its latitude.

The records of the full-order U. S. Weather Bureau station established at San Juan in 1898, with those of the subordinate stations subsequently established throughout the island, give excellent data for determining the essential details of Porto Rico climate, However, it will only be feasible to give here the general characteristics of the principle climatic elements, temperature, rainfall, wind, and clouds.

Temperature.—A record of temperature was kept by the Jefatura de Obras Publicas, prior to American occupation of the island, but it does not present on its face that evidence of accuracy that well-kept meteorological records exhibit. The annual average temperature for the entire island is 76°, as determined from the records of the U. S. Weather Bureau. The average temperature of the warmest month, August, is 79°, and that of the coolest month, January, is 73°. The highest temperatures authentically recorded are 103°, 101° and 100°; these temperatures occurred only on so many occasions and at as many places in a period of ten years. Along the immediate sea coast the average temperature for January is 75° and for August, 81°. In the interior the temperature is somewhat lower in January and may or may not be somewhat higher in August, depending upon elevation and local exposure. For example, Coamo, an interior station, 250 feet above sea-level, has a mean January temperature of 74° and a mean August temperature of 84°, while Aibonito, inland and 2,000 feet above the sea, has an average January temperature of 67° and an average August temperature of but 76°. The diurnal range is much influenced by location with respect to sea coast, and altitude: at San Juan, the average daily range is 11°; at Aibonito, 19°, and at several other inland and elevated stations the daily ranges are from 19° to 25°. Compared with the extensive ranges of temperate zone climates, these ranges are not so very striking, yet it would be a mistake to ignore them, as experience has shown that where the heat dissipating agencies of the organism are long accustomed to regularity of demands made upon them slight changes in either direction can be extremely uncomfortable; such is the consensus of those long resident in tropical countries.

The hottest season of the year is from July to October, inclusive, with an average temperature of 78° to 79°. The coolest season is from December to March, inclusive, with an average temperature of 73° to 74°.

Rainfall.—The average yearly rainfall for the island is 77 inches as determined from the records of forty-four stations during a period of twelve years. In this same period the greatest annual average was 94 inches, and the smallest annual average was 64 inches. These average values are of significance only when taken in consideration with the general climatic factors influencing rainfall in tropical regions. The orographic features of Porto Rico and its situation with respect to the northeast trade winds give the island two general rainfall divisions and watersheds—one of abundant rainfall and one of scant rainfall. These two divisions are separated by the general east and west mountain ridge that extends from one end of the island to the other. The rainfall is much greater on the northern watershed than on the southern, and much greater on the northeastern part of the first-named shed. Generally speaking, the rainfall is everywhere greater on northeast exposures. On the southern watershed there are many localities where the rainfall is insufficient for the tropical vegetation and barren tracts are not uncommon. Irrigation is necessary in many localities on this shed. The average annual rainfall along the southern coast is but 45 inches, while that along the northern coast is 65 inches. In the interior of the northern watershed, in the mountains, exposed to the trade winds the average annual rainfall exceeds 100 inches.

The greatest amount of rain falls from May to November. The months of January, February, and March are comparatively dry, February noticeably so at San Juan. The frequency with which rain occurs is shown in the following table:

The rains are generally of short duration, seldom exceeding ten to twenty minutes in downpour—though several showers may occur within a day. The downpour is sudden and usually heavy, and accompanied often with thunder and lightning.

Station.	Location.	Average annual number of days with rain.
San Juan	N. coast	211
Fajardo	E. coast	187
Mayaguez	W. coast	186
Ponce	S. coast	80
Aibonito	Inland N. slope	158
Barros	Inland N. slope	157
Cayey	Inland N. slope	169
Lares	Inland N. slope	139
Coamo	Inland S. slope	86

Sunshine.—Notwithstanding the frequency of rainy days over the greater part of the island, the amount of sunshine is abundant. The following table shows the average annual number of clear, partly cloudy, and cloudy days for a period of five years:

Station.	Annual average of days.		
	Clear.	Partly cloudy.	Cloudy.
San Juan	139	158	68
Ponce	125	168	72
Barros	220	108	37
Cayey	224	82	59

The usual cloud regimen is clear skies in the morning, cloudy in the afternoon, and clearing and clear at night.

Humidity.—The humidity, both relative and absolute, is high. So long though as the air is in motion the high humidity is not uncomfortable.

Wind.—The prevailing winds are remarkably constant from the east or between northeast and east. The velocity is steady and averages eleven miles an hour. It is subject to a regular diurnal range, rising gradually to a maximum at the hottest part of the day and subsiding from that time to a minimum at the coolest part of the day, just about sunrise. This regularity and steadiness of the wind cannot be overestimated in its relation to the comfortable habitability of Porto Rico.

Storms.—Though visited August 8, 1899, by one of the most destructive storms of recent years, the island is well to the east of the usual tracks of West Indian hurricanes. Of severe storms of the hurricane type, such as was that of August, Porto Rico has experienced but two others in a period of forty years. Thunder storms, though of almost daily occurrence and accompanied by great electrical display, are not destructive, and one soon becomes used to their apparent violence.

History.—Porto Rico was discovered by Columbus in 1493. The first settlement was made by a party of Spaniards under the leadership of Ponce de Leon, at Caparra, A.D. 1510, but it was shortly afterward abandoned. San Juan was founded by the same leader in 1511. The town was sacked by the English under Drake in 1595, and again under the Earl of Cumberland in 1598. Since then it has successfully withstood the assaults of the Dutch in 1615, the English in 1678 and in 1797, and the United States in 1898. On July 25, 1898, the island was invaded by the United States forces, who landed without opposition at Guanica on the southern coast. Only a feeble resistance was subsequently encountered. The Spanish formally evacuated the island October 18, 1898. By the treaty of Paris, December 11, 1898, Porto Rico was ceded to the United States. A territorial government was provided for the island by what is popularly known as the "Foraker Act" passed by the Congress of the United States in 1900. This act provides a Governor and an Executive Council, appointed by the President of the United States. A legislative assembly is also provided, consisting of two parts, one elective and constituting the lower house, and the other part, the appointive executive council, which constitutes the upper house of the assembly. All laws enacted by the legislative assembly must be submitted to the United States Congress for final approval. The first civilian governor under this act was Charles H. Allen, appointed May, 1900. Between 1898 and1900 the island was governed by the military, under the direction of the U. S. War Department. A census taken by direction of the War Department, 1899, gave a total population of 953,243 inhabitants. The census of 1910 gave a total population of 1,118,012, an increase of 17.3 per cent. in eleven years. Unlike most, if not all, the other West Indian islands, Porto Rico has a larger white than black population. In 1899 there were 589,426 whites and 363,817 blacks. The density of population is also great, averaging 325.5 persons to the square mile, a density ten times as great as that of the United States proper, and more than three times as great as that of the New England States. The greater part of the population is rural. The distribution in 1910 was, urban 224,620, rural 893,392. According to color and race, of the total population 65 per cent. were white, 30 per cent. mulatto, 4.5 per cent. black. Only 1.5 per cent. were foreign born. The population of the largest cities in 1899 was: San Juan 32,048, Ponce and its port 27,952, Mayaguez 15,187, and Arecibo 8,008. In 1910, the population of San Juan was 48,716, of Ponce 35,005 and of Mayaguez 16,563. The ratio of illiteracy was and is high, but 23 per cent. of the population over ten years of age being able to read in 1899, and even yet not much over 30 per cent. of the same age population are literate. However great efforts have been made and are making to improve this unfortunate condition. The present outlook is most hopeful for a more rapid advance in educational progress. The school enrolement (1914) is more than 50 per cent. of the school population. The number of public schools is 4,330. A government university has been established, the University of Porto, at Rio Piedras.

Agriculture is the chief occupation, employing about sixty-three per cent. of the working population. The most important products are coffee, sugar, pineapples, and tobacco. The value of the exports of these several products in 1914 were, sugar, $20,240,315; tobacco, over $9,000,000; coffee, over $8,000,000; and pineapples, over $1,000,000. The total value of exports from July, 1898, to December, 1899, was $11,621,049. The imports during the same period amounted to $12,654,542. In 1901 the exports were $8,588,967, and in 1914, $43,102,762. Imports of the corresponding years were $8,918,136, and $32,568,368, respectively. The chief imports in 1914 were, rice $7,554,409, flour, $1,608,504, meats, $3,707,516, cotton goods, $4,634,136, steel and iron $2,731,496, leather, $1,439,986. Transportation facilities before American occupation were poor. There existed but 137 miles of railroad, and with the exception of the excellent military road from San Juan to Ponce, and a few connecting branches, there were no common roads at all. Since then the good road mileage has been increased till there are now more than 600 miles of improved roads with good bridges wherever bridges are required. The railroad system has been extended so as to connect all the important cities, virtually encircling the island, with spurs running into the interior.

Telegraph and telephone lines have been extended throughout the island. Several large irrigation dams have been recently completed, namely, at Guayabal, Corile, and Patillas. The dams have an irrigating capacity of 24,000 acres, and bring under cultivation an immensely fertile soil.

The sanitary conditions were equally in keeping with the general indifference shown in other improvements.

Few, very few, houses had any efficient sewage disposal systems. In many the systems were even worse than none, being in their ultimate workings actually pernicious. Since American occupation, improved sanitary methods and measures have greatly reduced the death rate from all diseases. The average death rate prior to 1898 appears to have been about 30 per 1,000; the average death rate during the last decade was less than 25 per 1,000, and in 1913 it reached the unusually low rate of 18.6 per 1,000. The chief causes of death in 1913 were tuberculosis, with a total of more than 1,600 deaths, malaria, with over 1,000, and anemia and infantile tetanus, with more than 600 and 500 deaths, respectively. Only 150 deaths were due to typhoid. The work of the U. S. Army Medical corps, since continued under civilian government, in eradicating smallpox and in minimizing and pointing the way to the eradication of hook-worm disease, is deserving of special commendation and note. Smallpox was, prior to 1899, one of the major causes of mortality, averaging annually 623 deaths. It is now, happily, no longer a factor of importance, owing to the thorough vaccination of the entire population that was carried out by the United States military authorities. The large mortality from anemia due to the general infection of the soil by hook-worm has been greatly reduced by the sanitary and therapeutic measures instituted shortly after American occupation and continued to date under civilian administration.

W. F. R. Phillips.

Post, Alfred Charles.—Born in New York City, Jan. 13, 1806. He studied medicine under his uncle, Dr. Wright Post, a noted surgeon of New York, and received the degree of Doctor of Medicine from the College of Physicians and Surgeons in 1827. During the following two years he resided at Paris, Berlin, Vienna, and London, for further clinical study, and then began the practice of his profession in his native city. From 1831 to 1835 he was Demonstrator of Anatomy to the College of Physicians and Surgeons, and from 1836 to 1852 he was one of the Attending Surgeons of the New York Hospital. From 1851 to 1875 he was Professor of Surgery in the Medical Department of the University of New York. He died at his home in New York on Feb. 7, 1886.

Dr. Post was regarded as one of the leading surgeons of America, and his operations were noted for precision and dexterity. He also showed mechanical ingenuity in devising instruments and appliances, and in the latter part of his life labored much in plastic surgery. He made comparatively few contributions to medical literature, and of these only the following may here receive special mention: "On Stricture of the Urethra," *N. Y. Med. Journal;* "Care of Blepharoplasty," *N. Y. Med. Gazette;* "On Club-foot," *The Medical Record;* "Treatment of Stone in the Bladder," *N. Y. Med. Times;* and "Contractions of Palmar Fascia," *Archives of Clinical Surgery.* A. H. B.

Post, Wright.—Born at Hempstead, Nassau County, New York, Feb. 19, 1766. He began the study of medicine in the office of Dr. Richard Bayley, a prominent surgeon of New York. In 1784 he went to London and became the house pupil of Mr. Sheldon. Dr. Stephen Smith, from whose biographical sketch of Dr. Post in "American Practice of Surgery" this brief notice is borrowed, says that he became thoroughly familiar with the teachings of John Hunter, and was undoubtedly there when that surgeon performed his first operation of ligating the femoral artery for aneurysm, in 1785. "In 1786 he returned to New York and gave lectures on anatomy. In 1792 he was appointed Professor of Surgery in the medical department of Columbia, formerly King's College. From 1796 to 1807, when the College of Physicians and Surgeons was organized, Dr. Post taught anatomy and surgery, apparently without a rival, in Columbia College. He was the first Professor of Anatomy and Surgery in the College of Physicians and Surgeons, but in 1811 the chair was divided, at his special solicitation, and he retained the chair of anatomy, teaching surgery only clinically . . In 1821 he was elected to the office of President of the College of Physicians and Surgeons, a position which he held until 1826, when he resigned. He died in 1828, at the age of sixty-two. A. H. B.

Potassium.—I. General Properties.—In its physiological relations potassium is the most individual of the alkali metals, producing effects sufficiently pronounced to be seen characteristically in the case of all its compounds that are capable of absorption. Such effects are: Locally, potassic compounds are slightly irritant. In the intestines, potassic salts tend to increase the secretion of fluid. Constitutionally, the prominent effects are certain derangements of function and other effects that find their simplest explanation in the assumption that potassium quickens the rate of oxidation within the organism as it does in laboratory experiments. The derangements of function are, first, an enfeeblement of the heart's action, passing, in poisonous dosage, to permanent arrest in diastole. The effect seems to be due to a directly paralyzing influence upon the musculature of the organ itself. Secondly, but requiring relatively larger dosage, there follows general motor paralysis, voluntary and reflex. This effect is proportionately much more strongly marked in cold-blooded than in warm-blooded animals, and, in therapeutic dosage in man, is practically not seen at all. The effects commonly assigned to a quickening of oxidation are an increase in the solid excreta of the kidneys, with a proportionate increase in the volume of the urine, and a diminution in the amount of uric acid excreted, with a simultaneous increase of urea and appearance of calcium oxalate. In large doses, long continued, potassic compounds prove noxious to nutrition, the blood becoming thin and unduly fluid, newly formed and lowly vitalized tissues, such as cheesy deposits, tending to liquefy, and health and strength generally to suffer.

II. The Compounds of Potassium Used in Medicine.—The compounds of potassium official in the United States Pharmacopœia divide, for purposes of study, into two groups—the one embracing compounds whose effects are either derived from the potassium or are *sui generis* to the salt, and the other such as owe their effects mainly to the acid radical of their composition. The members of the former group, which alone will be discussed in this place, are the *hydroxide, carbonate, bicarbonate, citrate, acetate, bitartrate, potassium and sodium tartrate, sulphate, nitrate,* and *chlorate.* The second category comprises the *hypophosphite, bromide, iodide, dichromate, cyanide, ferrocyanide, permanganate, arsenite* (in the preparation, *liquor potassii arsenitis*), *potassio-aluminum sulphate* (alum). For discussion of these compounds see, severally, *Hypophosphites, Bromides, Iodides, Sulphides, Chromium, Cyanides, Ferrocyanides, Manganese, Arsenic,* and *Aluminum.*

Potassium Hydroxide: KOH. This is the compound which was formerly known as *Potassa* and *caustic potash* It is obtained first in aqueous solution by precipitating with lime a solution of acid potassium carbonate. Such aqueous solution, when rapidly boiled down, yields a fluid of oily consistence—simply the hydroxide melted by the heat—which, poured into cylindrical paper moulds, hardens on cooling into the cylindrical sticks in which form potassium hydroxide is commonly met with. Potassium hydroxide thus obtained is a white, hard substance, having a faint

alkaline odor and a very harsh, caustic taste. It is exceedingly deliquescent, and readily soluble in water and alcohol.

Beside the stick form, potassa is official in five per cent. aqueous solution under the title *Liquor Potassii Hydroxidi*, Solution of Potassium Hydroxide. This solution is made as just described, and is a clear, colorless liquid, odorless, but with the acrid, caustic taste of potassa. It should be kept in green glass bottles, glass stoppered, and the stoppers should be coated with vaseline or a thin layer of melted paraffin. Specific gravity about 1.036.

Potassium hydroxide produces physiological effects which spring in part from an intense affinity for water, in part from its powerful alkalinity, and in part from its operation as a compound of potassium. Locally, in concentrated application, it is intensely caustic. A moistened stick swept even lightly over a tender surface produces speedy corrosion, which extends finally beyond the area of original application, the tissues breaking down widely into a brownish, slimy, pultaceous material. Taken internally, therefore, in strong solution, potassium hydroxide is a corrosive poison. In such poisoning, the acrid, alkaline taste of the potion is followed immediately by severe pain in the pharynx, esophagus, and epigastric region. These symptoms are in turn speedily succeeded by violent vomiting, where the ejecta have the greasy aspect and pultaceous consistency of tissues corroded by potassium hydroxide, and prove strongly alkaline to test paper. The mucous membrane of the lips, mouth, and throat may be bright red from irritation, if the solution swallowed were not overstrong, or may, in the case of strong potions, show direct corrosion, being covered by a brownish film having a greasy or soapy feel. Loss of voice and extreme difficulty of swallowing are exceedingly common, but intestinal symptoms are generally wanting. Constitutionally, the symptoms are those of shock, from the suddenness and severity of the corrosion. In survival from serious grades of the poisoning, stricture of the esophagus is a very common sequel. In the treatment, the only peculiar feature is to give harmless acids to neutralize the alkali, but since the damage is generally already fully done before the physician arrives, this chemical neutralization rarely avails for much. Vinegar and lemon juice are the acids most available. Locally applied, in non-corrosive strength, potassium hydroxide operates as a powerful and harsh alkali. Acids are neutralized, grease becomes saponified, epithelial tissues swell and soften, and acid secretions, such as the gastric juice and the sweat, tend to be called forth. Upon the skin, solutions of potassium hydroxide cleanse from dirt or the crusts of dried secretion and epithelium resulting from skin disease. Taken internally, the remedy excites appetite and increases the flow of the gastric juice, or in cases of fermentation of the food, neutralizes acidity and so relieves the heartburn and nausea which such acidity excites. Constitutionally, medicinal doses of potassium hydroxide produce the effects of all potassium compounds, and also tend to neutralize acidity in tissues, to diminish the acidity of the urine, or even to make it alkaline. This compound is of special efficacy in the diatheses leading, severally, to rheumatism and gout, and in urticaria, psoriasis, eczema, acne, and recurring boils.

The medical uses of potassium hydroxide are for the purposes above detailed, yet it is not much used internally, and for direct local alkaline action the carbonates, and for constitutional alkalizing, the citrates and tartrates, are preferable.

To *cauterize* with potassium hydroxide the adjacent parts should be protected by adhesive plaster, and the doomed area, if covered by skin, should then be rubbed with a moistened stick of the caustic until discoloration appears. If the part be a mucous membrane or raw tissue, a single light sweep of the caustic is sufficient for even a profound cauterization. In no case should the agent be used where an exact limitation of the caustic effect is essential, as where the part to be destroyed is in close contiguity to important, or large, blood-vessels or organs. To render the corrosion of potassium hydroxide less spreading, a mixture of equal parts of potassium hydroxide and quicklime was devised, and was formerly official in the United States Pharmacopœia, under the title *Potassa cum Calce*, Potassa with Lime. This mixture, commonly known as *Vienna caustic*, is a grayish-white, deliquescent powder, soluble in hydrochloric acid. It is less diffusive in its action than potassium hydroxide by reason of the peculiar action of the lime of its constitution. For use the powder is made into a paste with a little alcohol.

For a caustic lotion, the solution of the Pharmacopœia is to be prescribed, diluted with several volumes of water. For internal giving, the same solution is employable, in doses ranging from ♏x.–℥j. (0.65–4.00) greatly diluted with some syrupy or mucilaginous fluid. But potassium hydroxide, as an internal remedy, is most objectionable for any but a very temporary medication.

Potassium Carbonate: K_2CO_3. The salt is official in the United States Pharmacopœia under the title *Potassii Carbonas*, Potassium Carbonate. It is a white, granular powder, very deliquescent, odorless, having a strongly alkaline taste, and an alkaline reaction. It is readily soluble in water, but is insoluble in alcohol. Potassium carbonate is so deliquescent that unless carefully put up in well-stoppered bottles it will eventually transform itself into an oily fluid, by dissolving in moisture attracted from the atmosphere.

Physiologically, potassium carbonate is simply a weakened potassium hydroxide, yet not so weak but that, in strong solution, it may prove a corrosive poison. Its use is mainly in ointment or in aqueous solution as a strong alkaline potassium application in skin diseases. Ointments of the carbonate are made of a strength ranging from two to ten per cent. Solutions of the salt for service as lotions range in strength from one-half to one per cent.

Potassium Bicarbonate: $KHCO_3$. The salt is official in the United States Pharmacopœia under the title, *Potassii Bicarbonas*, Potassium Bicarbonate. It occurs in colorless, transparent, prismatic crystals, and differs from the normal carbonate in being permanent in the air. It is odorless, and of a slightly alkaline taste and reaction. It is soluble in 3.2 parts of cold water and is decomposed by boiling water. It is practically insoluble in alcohol. It should be kept in well-stoppered bottles.

Physiologically, the bicarbonate is similar to the carbonate, but weaker. The taste is mild, though mawkish; the alkalinity feeble, and the salt is hardly capable of being corrosive. The uses are, locally, as an alkaline application in skin disease, in preparations such as are described above and, internally, as a stomachic or constitutional alkali. But for stomachic purposes the sodium salts are more agreeable, and for constitutional alkalies the potassium citrates and tartrates. If given internally, the dose ranges from gr. xv. to ℥i. (1.0–4.0).

Potassium Citrate: $K_3C_6H_5O_7 + H_2O$. This salt, formerly known as *Salt of Riverius*, is official in the United States Pharmacopœia under the title *Potassii Citras*, Potassium Citrate. It is a deliquescent salt occurring in transparent prismatic crystals or as a granular powder. It is odorless with a slightly alkaline and cooling taste. It dissolves readily in water, but slightly only in alcohol. Potassium citrate is a not disagreeable tasting, cooling salt, which is devoid of all local harsh effect, and yet after absorption seems to undergo decomposition as regards its acid radical, becoming converted into a carbonate. Such secondarily formed carbonate thereupon exerts the usual action of an alkaline potassium compound, as detailed under potassium hydroxide above. Potassium citrate

is thus available as a gentle diuretic, diaphoretic, and cardiac sedative in fevers, and also as an agreeable and yet efficient agent for constitutional alkalizing. It may be given freely in doses of gr. xv. to xxx. (1.0–2.0) in water or in effervescing water, sweetened or aromatized to taste. In order to obtain the salt in effervescing solution, in which condition it is more grateful to a fevered stomach, the following preparations are official in the United States Pharmacopœia: *Potassii Citras Effervescens*, Effervescent Potassium Citrate. This preparation is a powder consisting of a dry mixture of citric acid, tartaric acid, potassium citrate and potassium bicarbonate. One or two teaspoonfuls make a dose, to be taken in water and drunk during effervescence. Such effervescent solution takes the place of the old, so-called "neutral mixture," or "mixture of citrate of potassium," once official. Such mixture was simply fresh lemon juice, strained, and neutralized with potassium bicarbonate. *Liquor Potassii Citratis*, Solution of Potassium Citrate: This is a simple aqueous solution of the salt effected by bringing together in water six per cent. of citric acid and eight per cent. of potassium bicarbonate. It contains nine per cent. of potassium citrate, and should be made fresh when wanted. But the effervescing draught made from the "effervescent citrate" is a better way of getting the same solution.

Potassium Acetate: $KC_2H_3O_2$. The salt is official as *Potassii Acetas*, Potassium Acetate. This is an exceedingly deliquescent salt, having a warming, mildly pungent, salty taste. Very soluble in water and in alcohol. It must be kept in well-stoppered bottles. Potassium acetate is generally similar in properties to the citrate, undergoing, like that salt, conversion into a carbonate after absorption, and so operating constitutionally as a potassium alkali. Potassium acetate may be used for the same purpose and in the same doses as the citrate.

Potassium and Sodium Tartrate: $KNaC_4H_4O_6 + 4H_2O$. This well-known salt, commonly called Rochelle or Seignette's salt, is official in the United States Pharmacopœia under the title *Potassii et Sodii Tartras*, Potassium and Sodium Tartrate. This salt occurs in colorless, rhombic crystals, or as a white powder. It is odorless, with a cooling, saline taste, and effloresces slightly in dry air. It dissolves readily in water, but is almost insoluble in alcohol. This salt is decomposed by acids, with the production of a crystalline precipitate of acid potassium tartrate ("bitartrate").

Rochelle salt is mild in flavor and local action, agrees well with even a sensitive stomach, and differs from the citrate and acetate in being of low, rather than high diffusion power. Hence in full dose it is purgative, but as compared with the average of saline purges ranks among the milder. In non-purgative doses, especially if given well diluted, it is absorbed, changes to carbonate after the manner of the citrate and acetate, and then exerts, as efficiently as other salts, the specific action of alkaline potassium compounds. From its mildness it is preferred by many to other potassium preparations as a constitutional alkali in rheumatism, lithemia, etc. For constitutional action as an alkali or as a diuretic the salt is to be given in comparatively small but frequently repeated doses, not to exceed, as a rule, ʒj. (4.00) at a time. As a purge, the dose will range, according to the intensity of the effect desired, from ʒij. to ʒi. (8.0 to 30.0) in water, plain or aromatized. A favorite mode of administration is in effervescent solution, as obtained by use of the official *Pulvis Effervescens Compositus*, Compound Effervescing Powder. This is the well-known *Seidlitz powder*, and consists of two parts, one a powder in blue paper, made up of about gr. xl. (2.6) of acid sodium carbonate and about ʒij. (8.0) of Rochelle salt, and the other a smaller powder in white paper, consisting of about gr. xxxv. (2.25) of tartaric acid. Each portion is to be dissolved separately in about ʒij. (60.0) of iced water, sweetened and aromatized if so desired, and the solution of the acid then to be added, half at a time, to that of the salts, and the potion drunk during the effervescence which immediately occurs. The reaction upon mixing the solutions is, of course, the decomposition of the sodium bicarbonate by the tartaric acid, with the formation of a sodium tartrate and the evolution of carbon-dioxide gas. A single "powder" is a medium purgative dose.

Potassium Bitartrate: $KHC_4H_4O_6$.—This well-known salt, the *cremor tartari* or *cream of tartar* of common parlance, is official in the United States Pharmacopœia under the title *Potassii Bitartras*, Potassium Bitartrate. The salt is permanent in the air, and has an agreeable, subacid taste. It is peculiar in being comparatively insoluble in cold water (201 parts), although much more soluble in boiling water (16.7 parts). It dissolves sparingly only in alcohol. The solubility in water can be increased till the salt dissolves in one part, by the addition of borax, two parts to five of the tartrate. Commercial cream of tartar always contains more or less calcium tartrate, which salt is a normal constituent of crude tartar; other adulterations are chalk, gypsum, clay, sand, or flour. Purchase of the article in crystals affords the surest way to avoid these sophistications.

Cream of tartar is a cooling, acidulous salt, agreeing well with delicate stomachs. Like Rochelle salt, it is of low diffusion power and is therefore cathartic, and in its purgative action is characterized by the copiousness of the watery dejections it determines. For this reason it is a favorite ingredient of cathartic mixtures intended for carrying off a dropsical effusion, such as the compound powder of jalap of the United States Pharmacopœia. In non-purgative dosage the salt is refrigerant and diuretic—perhaps more generally diuretic than any other potassic compound, but, unlike the other potassium salts of organic acids, it does *not* appear to suffer the usual conversion in the blood into a carbonate. The uses of the present salt are therefore restricted to its application as a purge, a diuretic, of a grateful, cooling saline in feverishness. The doses are substantially the same as those of Rochelle salt for the same several purposes. The powdered cream of tartar may be suspended in water or mixed with molasses for giving as a purgative, or, for use as a fever draught, may be dissolved in boiling water, and the solution, when cold, given sweetened with sugar. The old-fashioned, so-called *imperial* draught is made by dissolving one per cent. of cream of tartar in boiling water, adding one per cent. of sliced lemon and eight of white sugar. *Cream of tartar whey*, so called, consists of one and a half per cent. of the salt in milk.

Potassium Sulphate: K_2SO_4. The salt is official in the United States Pharmacopœia under the title *Potassii Sulphas*, Potassium Sulphate. It is a permanent salt, occurring either in transparent, colorless rhombic crystals, or as a white powder. It dissolves in nine parts of water at 25° C. (77° F.) and in four parts of boiling water. It is insoluble in alcohol. Potassium sulphate is, like all sulphates, comparatively harsh, and in large concentrated dose has caused fatal irritant poisoning. It is of low diffusion power, therefore purgative, and its medical use has been as a saline cathartic. It is, however, little used, because of its occasional harshness. The pharmacopœial dose is thirty grains (2.0), to be given in solution, well diluted. This is the salt formerly called *vitriolated tartar* and *sal de duobus*.

Potassium Nitrate: KNO_3. This salt, the well-known substance *niter*, or *saltpeter*, is official in the United States Pharmacopœia under the title *Potassii Nitras*, Potassium Nitrate. This is a permanent salt, occurring in colorless, transparent, six-sided rhombic crystals, or in a crystalline powder. It is odorless, with a cooling pungent taste. It dissolves in 3.6 parts of water at 25° C. (77° F.), and in 0.4 part of

boiling water. It is almost insoluble in alcohol. Under the name of *sal prunelle* or *crystal mineral*, niter is also to be found in the shops in small circular cakes, moulded from the fused salt. Commercial refined saltpeter is the quality of the salt to be employed in medicine, and an article in small crystals is preferable to one in large, since large crystals are apt to contain some water, mechanically entangled in the process of crystallization.

Potassium nitrate, like the sulphate, is a powerful salt in local operation, but, unlike the sulphate, is of high diffusion power, so that even a large dose will be comparatively quickly absorbed. Taken internally it is therefore doubly potent, and even poisonous, a large dose exciting severe irritant poisoning. The salt undergoes no decomposition in the system, and is therefore incapable of exerting any *alkaline* effects, either local or constitutional. In medicinal doses niter produces the antifebrile effects of the potassium salts generally, being cooling and grateful to the stomach, and tending, after absorption, to quiet a bounding heart and at the same time to prove gently diuretic and diaphoretic. Being of high diffusion power, it does not purge except in considerable dose. A peculiar property of niter is that, mixed with fresh venous blood, it turns the blood bright red and impairs its coagulability; but in spite of much theorizing, the fact does not lead to any special therapeusis. Medicinally niter is nowadays rarely used internally, except as an ingredient of fever draughts or of diuretic mixtures. The single dose of niter should not exceed gr. xxx (2.00 grm.), and the salt is best given in dilute solution. Considerable single amounts, especially if in concentrated condition, are dangerous, but so rapid are the absorption and elimination of the nitrate that, by means of small and frequent doses, properly diluted for the taking, a very large quantity—from ʒ i. or ij. (30 to 62 grm.)—can be passed through the system in the course of a single day without injury. A special therapeutic application of saltpeter is the inhalation, for the relief of spasmodic asthma, of the fumes arising from its combustion. As usual in antispasmodic medication, some cases find relief from the agent and others do not, or even suffer aggravation thereby. For the application, white unsized paper, free from wool, is steeped in a twenty-five-per-cent. aqueous solution of niter and allowed to dry. A piece is then burned, and the patient, with the face as near as can be borne without undue irritation, inhales the white fumes that are given off. Such prepared paper was once official in the United States Pharmacopœia under the title *Charta Potassii Nitratis*, Nitrate of Potassium Paper. It is sometimes called *asthma paper*. Toxicologically niter is of some importance, cases of poisoning by the salt not infrequently occurring. An ounce, swallowed at a draught, has proved fatal in a number of instances. Taken, as it commonly is in such cases, in pretty strong solution in mistake for purgative salts, it produces symptoms of severe gastrointestinal irritation—burning pain in the stomach, violent vomiting and purging, the dejecta being sometimes bloody, and general collapse. Special symptoms are urinary suppression, with strangury, tenesmus, and bloody urine, and aphonia. These may or may not occur. Death may take place in two hours after the swallowing of the poison. There is no chemical antidote to niter, so that the treatment of a case of poisoning must be conducted simply on general medical principles.

For potassium chlorate and its toxicology, see *Chlorates*.

EDWARD CURTIS.
R. J. E. SCOTT.

Pott, Percival.—Born in London, England, Jan. 6, 1714. At an early period he manifested a strong leaning toward surgery, and his guardian therefore felt justified in entering him as a pupil at St. Bartholomew's Hospital. The faithful and enthusiastic manner in which he performed all the duties of this position warranted the prediction that he would attain eminence in his profession. He began the practice of medicine in 1736, and already as early as 1749 he had won for himself the position of one of the leading surgeons on the staff of St. Bartholomew's Hospital. In 1764 he was made a member of the Royal Society of London. He died in that city on Dec. 22, 1788.

A particular form of fracture of the ankle which Mr. Pott sustained through a fall from his horse in 1756 is known as Pott's fracture, and is described in his book, "Some few Remarks upon Fractures and Dislocations," published in 1768. "Pott's disease," or angular curvature of the spine was described in a work entitled "Remarks on that Kind of Palsy of the Lower Limbs which is Frequently Found to Accompany a Curvature of the Spine" (1779). Among his other writings the most noteworthy are: "A Treatise on Ruptures" (1756), "Observations on the Nature and Consequences of those Injuries to which the Head is Liable from External Violence" (1768), and "Chirurgical Observations" (1775). A. H. B.

Pott's Disease.—See *Spine, Diseases of the.*

Poupart, François.—Born at Mans, France, 1661. His early education was received from the fathers of the Oratory in Mans and he evinced even at that time an especial fondness for study in the humanities and philosophy. He continued his studies at the Jardin du Roi, making a specialty of anatomy and surgery, and passed the examination in surgery at the Hotel Dieu in Paris with credit. It was at this time that he announced that while he had a thorough command of the theory of his chosen specialty, from actual experience he had no idea how even to bleed a man. He was at once given the opportunity to perfect his knowledge in one of the hospitals of Paris and three years later received his doctor's degree at Reims. In 1699 he was admitted to the Academy of Science as a pupil of the celebrated Mery. He died October 31, 1709.

Poupart's writings show him to have been a man with a broad love of the sciences. He contributed to the *Journal des Savants* and to the Journal of the Academy of Sciences. Among his best known articles are those on hermaphrodite insects, a "Dissertation on the Leech," "Observations on Mussels;" entering another field, "A Treatise on the Apparition of Spirits." His masterpiece, however, was his work "Complete Surgery." Poupart's name will ever be remembered through association with the ligament described by and named after him, although it is insisted by some authorities that his description was neither new nor exact. E. L. J.

Pravaz, Charles Gabriel.—Born in France in 1791, resided in the city of Lyons, and died in 1853. His only claim to distinction is to be found in the fact that he invented a syringe which is the type of the hypodermic syringe of today. A. H. B.

Presbyopia—Pr—from πρέσβυς, old, and ὤψ, eye; Fr., *presbytie*, from πρεσβύτης, an old-sighted person—is "the condition in which, as the result of the increase of years, the range of accommodation is diminished, and the vision of near objects interfered with" (Donders). The range of accommodation diminishes year by year, from about 15 dioptries at the earliest age (ten years) at which accurate observations have been made, to about 1 dioptrie at the age of sixty-five or seventy; at forty it amounts to something less than 5 dioptries, and at forty-five to about 3.5 dioptries.

Of the 15 dioptries of accommodation which the child of ten years is able to bring into exercise, from two-thirds to three-fourths (10 to 11 dioptries) may be lost without greatly incommoding an emmetrope in ordinary near vision. In emmetropia the distance (P_2) of the binocular near-point (p_2) is the reciprocal of the number of dioptries representing the binocular range of accommodation; hence, with a binocular range of accommodation of 5 dioptries, $P_2 = \frac{1}{5}$ meter (20 centimeters), at which distance the smallest print in ordinary use is easily deciphered by eyes of average visual acuteness; when the binocular range of accommodation is reduced to 4 dioptries, $P_2 = \frac{1}{4}$ meter (25 centimeters), at which distance ordinary newspaper print may still be read easily; with the loss of another dioptrie of accommodation (leaving but 3 dioptries available), $P_2 = \frac{1}{3}$ meter (33.3 centimeters), and the reading of fine print becomes difficult, except under the conditions of good illumination and perfect acuteness of vision. These several values of P_2 correspond, in emmetropia, to ages ranging from about thirty-eight to about forty-seven years, and comparatively few emmetropes attain the latter age without seeking aid from convex glasses in reading or other fine work; the adoption of convex glasses by an emmetrope under forty is generally determined either by the exceptionally exacting nature of the work in which he habitually employs his eyes, or by the fact that his acuteness of vision is somewhat below the normal. When at the age of from fifty to fifty-five years the range of accommodation has become reduced to 2 dioptries, $P_2 = \frac{1}{2}$ meter (50 centimeters), and the book must then be held at arm's length, at which distance only the larger sizes of print can be read; but, even with this range of accommodation, a public speaker may be able to read fluently from a plainly written manuscript lying before him upon a reading-desk or table.

The diminution of the range of accommodation with advancing years is a strictly physiological change, and is directly related to the progressive hardening of the crystalline lens, in consequence of which it becomes less and less capable of undergoing the change in curvature required for the adjustment of the eye for near vision. As this hardening of the crystalline occurs in all eyes alike, irrespective of their refractive condition as determined by the relation of the curvature of the refractive surfaces to the length of the axis of the eyeball, it would seem to be scientifically correct to define presbyopia as the loss of accommodative power incident to advancing years. Immemorial usage has, however, associated the name with the particular condition in which, as a result of increasing age, near vision becomes indistinct while distant vision remains either absolutely or relatively unimpaired. As thus defined, presbyopia is an incident in the life-history of all emmetropes and hypermetropes, and also of myopes whenever the myopia is of low grade—3 dioptries or less. In myopia of higher grades, 4 dioptries or more, the distance of the far-point remains within $\frac{1}{4}$ meter (25 centimeters) of the eyes; so that, even with total loss of accommodation, it may still be possible to read fine print without the aid of glasses.

The striking contrast between the vision of myopes, who see only near objects distinctly, and that of presbyopes, who see distant objects clearly, while near objects appear confused, was very early recognized, and, in the absence of any definite theory of accommodation presbyopia was, for more than 2,000 years, regarded as the opposite condition to myopia. Hypermetropia, the true opposite of myopia, remained confounded with presbyopia until after the middle of the nineteenth century, when the demonstration of a change in the form of the crystalline lens in accommodation by Cramer, and, independently, by Helmholtz, and the masterly analysis of the phenomena of accommodation in its relation to the several anomalies of refraction, by Donders, dispelled the cloud of obscurity in which the whole subject had been so long enveloped, and through which only occasional glimpses of the truth had been previously enjoyed by a few exceptionally acute investigators.

Premonitory signs of presbyopia may often be detected in emmetropes as early as the thirty-sixth year; exceptionally fine print, such as No. 1 of Jaeger's scale, being no longer read with the same perfect fluency as in youth, especially if the illumination is defective. Within the next five years the newspaper print loses a little in sharpness of definition, and the finest needlework becomes difficult and perhaps deteriorates somewhat in quality. If the acuteness of vision is normal, and the print not too fine, relief from the increasing strain in accommodation is obtained by holding the book or work a little farther from the eyes; but if vision is subnormal, or if the print is bad or very fine, a stronger illumination may be demanded, without increasing the reading distance. By the age of forty-five the disability has generally increased to the point that only fairly large print can be read with ease by ordinary artificial light, and a more powerful lamp is procured or the book is held nearer to the light; about this time the need of help from glasses commonly suggests itself.

A hypermetrope habitually wearing neutralizing (convex) glasses, or a myope wearing neutralizing (concave) glasses, experiences the disabilities of presbyopic vision at about the same age, and in about the same degree, as the emmetrope; thus, between the ages of forty and forty-five, the hypermetrope discovers that his convex glasses are no longer quite sufficient in reading, and similarly, the myope discovers that his concave glasses have become something of a hindrance in near vision, although in both cases the neutralizing (convex or concave) glasses continue to serve perfectly for distant vision. A change to stronger convex glasses by the hypermetrope, or to weaker concave glasses (or, perhaps, the temporary removal of his glasses) by the myope, is the remedy which now suggests itself, and which is, sooner or later, adopted. With a change of glasses reading again becomes easy, but with a corresponding falling off in the distinctness of distant vision. For this reason, an elderly emmetrope either removes his glasses or looks over them when not engaged in near work, and a presbyopic ametrope ordinarily requires two pairs of glasses, the one pair (neutralizing) for distance, the other pair (stronger convex or weaker concave) for reading and other near work; the inconvenience attending the use of two pairs of glasses may be obviated in many cases, by wearing so-called bifocal glasses, in which both corrections are mounted in a single setting before each eye.

A hypermetrope, not wearing convex glasses, experiences the disabilities of presbyopia at an earlier age than the emmetrope, after having, perhaps, passed through a more or less protracted stage of suffering from asthenopia (see *Asthenopia*). In myopia, on the other hand, if of low grade, the reading power with the unaided eyes is retained to a more advanced age than in emmetropia; in the higher grades of myopia it is retained indefinitely.

As a result of the very gradual increase in the resistance which must be overcome in order to effect such degree of accommodative adjustment as is still possible in presbyopia, the relation of the accommodation to the convergence undergoes a notable change; the binocular accommodation (A_2) associated with convergence for the habitual reading distance becoming at length nearly equal to the absolute accommodation (A). In other words, the binocular near-point (p_2) comes more and more nearly to coincide with the absolute near-point (p). Following closely upon the acceptance of convex glasses in near work, the distance (P_2) of the binocular near-point (p_2) undergoes a rapid increase, so that such reading power as may have been retained up to the time of the adoption of the glasses is

speedily lost, and reading without glasses becomes impossible. Hence the common experience of presbyopes, that having once formed the habit of using convex glasses, their continued use becomes imperative; and this whether the glasses have been adopted somewhat prematurely, or only after the need of them has become urgent. The too early use of convex glasses is, therefore, to be deprecated, as entailing the disabilities of presbyopic vision several years, perhaps, before the normal age; on the other hand, as there is a positive limit to the range of accommodation at any given age, the use of convex glasses cannot, as a rule, be deferred by an emmetrope much beyond the forty-fifth year, unless he be content to forego the use of the eyes in reading ordinary print or in other fine work.

The total disuse of the accommodation for a considerable period, as in the case of protracted and exhausting illness, may lead to the premature development of presbyopic symptoms, which are apt to be interpreted as an indication for the immediate adoption of convex glasses. If glasses are used in such a case, they should be of the least power compatible with the use of the eyes under favorable conditions of illumination, and the patient should be encouraged in the hope that, as the accommodative power increases with use, the glasses may be laid aside. In cases of this kind it is often possible to bring the accommodation again into effective use by the instillation, once or twice daily for a few weeks, of a weak solution of pilocarpine, and thus to put off the use of glasses for perhaps several years.

In addition to the impairment of the accommodation, which is the essential characteristic of presbyopia, the refraction undergoes, in the course of time, a slight but positive diminution, so that ultimately an emmetrope becomes slightly hypermetropic (H. *acquisita*—see *Hypermetropia*), a hypermetrope somewhat more hypermetropic, and a myope somewhat less myopic; a very low grade of myopia may thus give place to emmetropia, or may even pass through emmetropia to hypermetropia of low grade. A low grade of hypermetropia, which late in life necessarily becomes absolute (H. *absoluta*), is, in fact, the ultimate normal condition of all emmetropes, so that in advanced age weak convex glasses come to be required for perfect vision at a distance; hypermetropes similarly require a moderate increase in the power of their convex glasses, and myopes require a corresponding diminution in the power of their concave glasses. This falling off in the refraction is ordinarily scarcely to be detected at the age of forty-five; at sixty it may amount to perhaps 0.5 dioptrie, at seventy or seventy-five to 1 dioptrie, and at eighty to 2 dioptries or more.

The TREATMENT of presbyopia consists essentially in the palliation of the disability by the use of such convex glasses as are needed to supplement the failing accommodation. A person originally emmetropic may, at the age of seventy, require convex glasses of as much as 5 dioptries, in order to read fairly good print at a distance of from 25 to 30 centimeters; and if the acuteness of vision is below the normal, it may be necessary to use glasses of 6 or 7, or even 8 dioptries, in order to admit of reading at some shorter distance. In the case of a person originally hypermetropic, the measure of the required glasses will be increased by a quantity equal to the grade of the hypermetropia; in myopia the measure of the glasses will be similarly diminished.

The convex glasses first given to a presbyopic emmetrope of from forty to forty-five years of age, should ordinarily not much exceed 1 dioptrie, and in some cases even weaker glasses may be more acceptable to the patient. These glasses should be used at first for only such work as is performed with difficulty without glasses, in order that the habit of using the accommodation may not be needlessly or prematurely abandoned, and they should not be exchanged for stronger glasses so long as they continue to afford the needed assistance. Subsequent changes should always be made with reference to the glasses already in use, adding perhaps 0.5 dioptrie at each change, and it is often advisable to retain the old glasses for a time for reading by daylight, reserving the stronger glasses for more exacting work. It follows that a presbyope should always preserve a record of the power of the glasses which he is using, in order that, in replacing a lost pair, he may not be reduced to the necessity of selecting new glasses at random, or after hasty and generally imperfect tests made by a shopman whose knowledge very probably may be limited to the trick of selling his wares.

A presbyope, using glasses perfectly suited to his condition, is able to use his eyes in near work freely and without fatigue; glasses of insufficient strength fall short of affording the full measure of relief, and glasses of excessive strength compel the holding of the book at too short a distance, thus imposing needless work upon the recti interni muscles and so possibly giving rise to muscular asthenopia.

The clinical investigation of any case of presbyopia involves, first of all, the careful testing of the eyes in respect of the acuity of vision and for the estimation of any hypermetropia, myopia, or astigmatism that may be present (see these titles). As has been already explained, the measure of any hypermetropia that may be detected must be added to, and the measure of any myopia subtracted from, the value of the glasses ordinarily required by an emmetrope of corresponding age, in order to arrive at an approximation to the glasses to be given for reading. These tests are best conducted at a range of at least five meters, and only after the satisfactory determination of the refraction should a trial of reading glasses, chosen with reference to this determination, be made. The final tests are made in reading fine print. If astigmatism is present, it should, as a rule, be accurately corrected by having one surface of the glass ground to the appropriate cylindrical curvature (see *Astigmatism*).

A rapid falling off in near vision, necessitating frequent and considerable additions to the power of the reading-glasses used by a presbyope, should be regarded with especial solicitude as indicating the possible beginning of glaucoma. In view of the recognized danger of precipitating an acute glaucomatous outbreak, the routine employment of mydriatics in the investigation of the refraction of presbyopes is to be especially deprecated.

Repeated changes from weaker to stronger glasses, attended with a shortening of the reading distance after each change, point to a falling off in the acuteness of vision, oftenest from failure in the perceptive power of the retina, or of the conductivity of the optic nerve.

A marked diminution in the apparent grade of presbyopia is occasionally observed late in life as a result of the development of a myopic state of the refraction; this change, which is popularly known as "second sight," is a not infrequent symptom of incipient cataract. JOHN GREEN.

Pringle, John.—Born at Stitchel, in Roxburghshire, England, April 10, 1707. He received the degree of Doctor of Medicine from the University of Leyden, in Holland. He settled in Edinburgh, Scotland, as a practising physician, but he also (after 1734) acted as Professor of Moral Philosophy in the University. From 1742 to 1749 his professional work appears to have been done largely in connection with the British military forces in the Low Countries. In the latter year he settled in London and was made physician-in-ordinary to the Duke of Cumberland. In 1766 he was made a baronet. Of his published writings the following three are of special importance: "Observations on the Nature and Cure of Hospital and Jail Fevers," 1750; "Observations on the Dis-

eases of the Army in Camp and Garrison," London, 1752; and "Six discourses delivered by Sir John Pringle, Bart., when President of the Royal Society, on occasion of six annual assignments of Sir Godfrey Copley's Medal," etc., London, 1783. The second of these books, according to the Encyclopedia Britannica, entitles Sir John Pringle to be regarded as the founder of modern military medicine. His death occurred on Jan. 18, 1782. A monument to his memory has been erected in Westminster Abbey.

A. H. B.

Proamnion.—This convenient term was introduced by Ed. van Beneden to designate that part of the *area embryonalis* at the sides and in front of the head of the developing embryo which remains without mesoderm for a considerable period, so that the ectoderm and entoderm are brought, in the region of the proamnion, into immediate contact. (See article *Amnion.*) We find that it had been observed in the chick by Remak, His, and Kölliker. Strahl was the first to direct special attention to it. It has since been observed by various writers; van Beneden and Julin have described it in the rabbit, Heape in the mole, Selenka in the opossum, and its exact history has been admirably worked out in the chick by Ravn, and in many birds and reptiles by Schauinsland. The proamnion, then, has been observed in representatives of the classes Reptilia, Aves, and Mammalia. There is also an homologous area in the embryos of fishes and amphibia. It will be remembered that the mesoderm grows out in all directions from the primitive streak. In a chick of about twenty-seven hours, the front edge of the mesoderm is a somewhat irregular transverse line, which crosses the germinal area about at the front border of the head. (See article *Area Embryonalis*, Fig. 295.) As the mesoderm expands, it does not grow forward in the median line, but does grow forward at the sides of the *area pellucida* in front of the head of the embryo. A space is thus enclosed between the mesoderm on each side; this space later becomes the proamnion; it contains no mesoderm. Later on, the lateral portions of the mesoderm approach the median line again, some distance in front of the head, so that now the proamniotic area is completely surrounded by mesoderm. We see, as the next phase of development, the head amniotic fold arising in such a position that the proamnion is embraced between the arc of this fold and the head of the embryo; the proamnion, therefore, constitutes the floor of the pit formed by the upgrowth of the head amnion. In the chick the proamnion never acquires any considerable development, but gradually disappears by encroachments of the mesoderm upon all sides, as has been well described by Ravn.

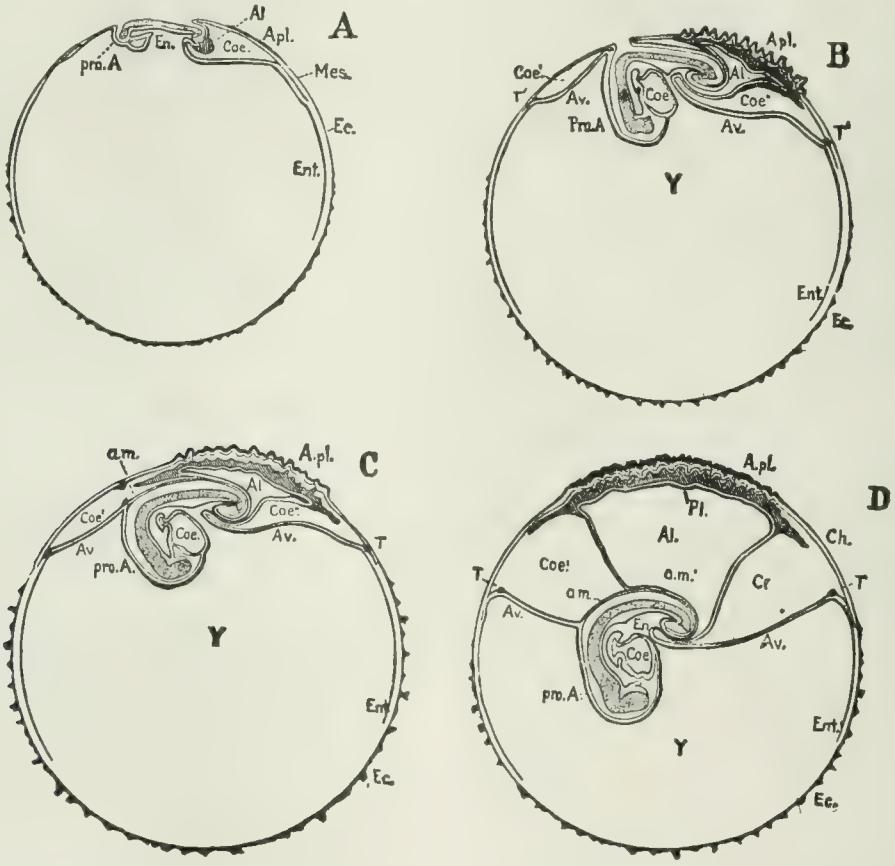

Fig. 4333.—Diagram of the Development of the Fetal Adnexa in the Rabbit. (After van Beneden and Julin.) *A*, *B*, *C*, *D*, Successive stages; *pro.A*, proamnion; *Av*, area vasculosa; *Coe*, cœlom; *Coe'*, *Coe''*, extraembryonic portion of the cœlom; *En*, entodermic cavity of the embryo; *Enb*, extraembryonic entoderm; *Ec*, ectoderm; *Mes*, mesoderm; *Apl*, area placentalis; *Al*, allantois; *T*, terminal sinus of the area vasculosa; *Y*, yolk sac; *am*, amnion; *am'*, portion of the amnion united with the wall of the allantois; *Ch*, chorion.

In the majority of mammals, which have an em-

bryonic shield spread out upon the surface of the blastocyst, there is usually a well-marked proamnion; but in the ruminants it is nearly or quite absent.

In the rabbit, according to van Beneden and Julin, whose observations have been confirmed to a certain extent by Kölliker and Heape, the rôle of the proamnion is more considerable. The history of the proamnion, as given by van Beneden, may be followed easily by the aid of the accompanying diagrams (Fig. 4333), copied from van Beneden. In A, the proamnion, *pro.A*, is very small, and the allantois, *Al*, is just growing out. In B, the embryo, which for greater clearness has been shaded with stippling, has grown very much, and the anterior half of its body is bent down at a sharp angle into the yolk sac. The embryo, however, remains separated from the cavity *Y*, of the yolk sac, by the proamnion, which forms as it were a hood, *pro.A*, over the anterior extremity of the embryo. The amnion proper is as yet developed only over the posterior end of the embryo. For the further history of the amnion see *Amnion*, vol. i. of this Handbook. The proamnion, as can be seen in C and D, retains its importance as a fetal covering for a considerable period, during which the amnion *am*, and allantois *Al*, are rapidly pursuing their development. After the stage shown in Fig. 4333, D, by the expansion of the cavity marked *Coe'*, the roof of the yolk sac is depressed, and at the same time, the mesoderm grows into the proamnion, which thus becomes merged into the true amnion.

In both the dog and the cat the mesoderm is continuous at first in front of the head region, but soon disappears from this area, to return later. Thus the proamnion in these animals is a secondary formation; not primary as in the chick. According to Strahl (1902) this is true also of the rabbit.

Charles Sedgwick Minot.
Revised by R. P. B.

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Professional Neuroses.—See *Neuroses, Occupational.*

Progeria.—This may be defined as a condition of premature senility. The word is derived from the Greek, πρόγηρος, meaning prematurely old, and was first used by Hastings Gilford in 1904 to connote a disease that he had described in a boy seven years previously. A similar case had been reported in 1886 by Jonathan Hutchinson. In 1910 M. Variot and M. Pironneau described a third case in a girl under the title "Le Nanisme, Type Sénile (Progeria de Gilford)." Progeria occurs only in instances of delayed or arrested growth, more particularly in association with that type of infantilism to which the name "ateleiosis" has been applied. (See *Infantilism* and *Ateleiosis.*) In ateleiosis there is an unmixed infantilism, whereas in progeria infantilism and senilism are combined in the same patient. The progerian passes from a delayed childhood into a premature old age. The cause of this remarkable transformation is unknown. Gilford points out that progeria in all of its features presents a contrast with acromegaly. Those parts of the skeleton which are overgrown in acromegaly are undergrown in progeria. Arthur Keith has made a special study of this contrast in the skeleton of a progerian recently added to the Museum of the Royal College of Surgeons, England. On the basis of this study he concludes that if the changes in acromegaly are to be attributed to a stimulus or hormone proceeding from the pituitary, then the condition in progeria can be best explained by an absence or marked diminution of that stimulus.

Alexander Spingarn.

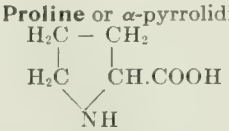
Proglottid.—A ripe "segment" of a tapeworm which represents a complete flatworm, budded off from the scolex or so-called "head." It has no digestive system but possesses a complete set of reproductive organs. When shed a proglottid has the uterus full of eggs, which are set free through a special birth pore or by the rupture of the body wall. See *Cestoda.*

A. S. P.

Prolamins is the term applied to the group of proteins designated "*alcohol-soluble proteins.*" The name arises from the fact that these substances yield upon hydrolysis unusually large amounts of proline and ammonia. Zein of maize hordein of barley and gliadin of wheat and rye are typical prolamins.

F. P. U.

Proline or α-pyrrolidine-carboxylic acid



is a decomposition product of protein which was first obtained upon hydrolysis of casein. The prolamins or alcohol-soluble proteins are particularly rich in proline.

F. P. U.

Prostate, The.—The prostate gland (Gr. προστάτης, from προ and ἵστημι, I stand) derives its name from its position at the entrance to the bladder.

Anatomy.—The prostate is a sexual organ partly muscular and partly glandular located at the neck of the bladder and in front of the second part of the rectum. In shape it has been likened to a Spanish chestnut. In the upright position of the body it lies just below the bladder and behind the symphysis pubis. The base of this heart-shaped gland is in contact with the bladder and vesiculæ seminales, while the apex rests upon the posterior layer of the deep perineal fascia; the anterior surface looks toward the pubis, and the posterior surface rests upon the anterior rectal wall.

The urethra, as it leaves the bladder (pars prostatica urethræ), traverses the prostate from near the middle of its base to its apex, and rather more than one-half of the gland lies behind the canal.

The average measurements according to Lowsley are as follows: width 4.1 cm., length 3.4 cm. and thickness 2.4 cm. During the sixth decade the maximum size is reached, but the increase over the preceding figures is only a matter of a few millimeters. In persons over sixty there is again a very slight decrease in size. Slight longitudinal furrows along its anterior and posterior surfaces show an indistinct tendency toward a division into two lateral lobes, although the two halves are structurally continuous with each other.

In this connection it is worthy of note that in some animals the prostate consists of two separate lobes.

Recent work has shown definitely that developmentally the prostate consists of a posterior, median, and two lateral lobes, together with the occasional persistence of an anterior lobe which ordinarily disappears in fetal life, and the presence at times of a group of glands just below the neck of the bladder and within the grasp of the sphincter, the subcervical group of Albarran. The posterior lobe is that portion which forms the posterior surface of the gland and is wholly behind the ejaculatory ducts. The middle lobe lies in front of the ejaculatory ducts and behind and above the verumontanum. The lateral lobes form the sides of the urethra and generally fuse on their anterior aspect, thus forming the roof.

The substance of the prostate is made up mainly of three tissues: (1) Glands; (2) unstriped muscular fibers; and (3) fibrous tissue.

The glands are of the acinous variety, and are most abundant in the lateral portions of the organ, their ducts coalescing and opening along the floor of the urethra. The muscular fibers are disposed in circular bands which are continuous at the junction of the bladder with the circular fibers of that viscus. Hyrtl also describes a system of these fibers radiating from the caput gallinaginis. The fibrous tissue forms a firm enveloping capsule which sends off-shoots through the substance of the gland.

Just below the point of entry of the urethra the two ejaculatory ducts enter the prostate, one on each side, and, running forward through its substance and converging, they enter the floor of the urethra.

The prostatic urethra (pars prostatica urethræ) is slightly narrower where it enters and leaves the gland than it is within it. The hollowed floor of this portion of the canal is called the sinus prostaticus, and is divided into two equal furrows by a longitudinal ridge (verumontanum), the end of which farthest from the bladder is composed of erectile tissue, and is capable of considerable dilatation into a little round prominence which, with the verumontanum running back from it, presents a fancied resemblance to the head of a snipe—hence its name *caput gallinaginis*.

On the top of this little eminence is the opening of a minute sac—the utricle or sinus pocularis—which is thought to be the analogue of the uterine cavity in the female. Close to the edge of this sinus, and sometimes within it, are the orifices of the ejaculatory ducts. Along the sides of the verumontanum open the prostatic glands proper, to the number of from twenty to thirty.

The prostate is enclosed in a tough fibrous capsule which is a part of the pelvic fascia. Besides its attachments to the bladder and deep perineal fascia, it is further held anteriorly by the puboprostatic ligaments, and posteriorly by the rectovesical fascia. Its slight mobility is provided for by the levatores prostatæ—muscular bundles, really parts of the levator ani—which, arising from the posterior surface of the pubis, are inserted along the lateral borders of the gland.

Its blood supply is derived from the internal pudic, the vesical and hemorrhoidal arteries, and the veins which form a plexus around the gland empty through the hypogastric vein. The nerves are branches of the hypogastric plexus of the sympathetic.

Physiology.—The prostate is a sexual gland. After birth it remains in a quiescent state up to puberty, when it begins to increase in size and development. It attains its full growth at about the twenty-fifth year.

The secretion of the glands, which are especially active during sexual excitement, is a slightly turbid fluid of feebly alkaline reaction, with a specific gravity of 1.010.

It is especially rich in chloride of sodium (one per cent.), and, as solutions of this salt are known to excite the spermatozoa to movement, its presence in the prostatic fluid is thought by some to perpetuate their activity. Probably the most important function of this secretion is in producing coagulation of the secretion of the seminal vesicles.

The prostate, further, in its character as a muscular organ, acts as an involuntary sphincter of the bladder. As the urine accumulates a point is finally reached at which the tension of the detrusor urinæ muscle pulls open the rings of involuntary fibers around the neck of the bladder and allows the urine to enter the pars prostatica urethræ. Its presence there causes an urgent desire to urinate, and the escape of the water is then prevented only by the compressor urethræ muscle, which is the voluntary urinary sphincter. If this muscle does not relax and allow urination to be completed, the prostate closes down and forces the contained urine back into the bladder, where it stays until the further increased tension brings on another "besoin d'uriner."

Malformations.—The prostate may be wholly wanting, in connection with a general lack of development of the urinary organs.

In exstrophy of the bladder there is no roof over the prostate and the gland ducts may be seen opening through the mucous membrane at this spot and microscopic examination of the tissue shows that the prostate is present.

Injuries and Wounds.—The deep-seated position of the prostate makes it little liable to injury from without. In severe crushes of the pelvis with fracture about the pubis, it may be wounded. In perineal lithotomy it is always incised, and often somewhat contused by the extraction of the stone. If the crushing and laceration of the parts have not been serious, healing usually takes place kindly.

Injury of the prostate occasionally results from the passage of instruments through the urethra. This occurs most commonly in cases of hypertrophy, in which the irregular enlargement of parts of the gland has made the canal tortuous.

A specimen in the museum of the Harvard Medical School shows a very much enlarged middle lobe which so obstructed the entrance of the catheter that the instrument had been forced directly through it and had entered the bladder beyond.

The knowledge that such injuries are possible should lead to their avoidance. Much force is never needed in the passage of an instrument which is properly guided, but a thorough understanding of the nature of the possible obstacles, and considerable patience and care in overcoming them, are necessary to success in these cases.

Inflammation of the Prostate.—Acute prostatitis is commonly the result of the extension of an inflammation from adjacent parts.

A gonorrheal urethritis is by far the most usual exciting cause. In this case the inflammation runs back along the urethra to the prostate. That this is not the usual course of a gonorrhea is due to the protection afforded by the constrictor urethræ muscle. This sphincter, surrounding the membranous urethra, prevents the discharge from penetrating to the prostate and bladder, and usually protects these deeper parts from participation in anterior inflammations. Occasionally the passage of an instrument, or the forcing of an injection through the constrictor, may convey infective discharges past this natural barrier.

A non-specific urethritis or an inflammation of the bladder may, in similar manner, extend to the prostate. The passage of instruments, the application of caustics, the use of strong injections, the presence of calculi in the bladder or prostate, accidental injuries, or operations may be the exciting cause of an acute prostatitis, although, from any of these causes it is comparatively rare.

Among other causes cited as occasionally giving rise to prostatitis may be mentioned sexual abuses, acrid irritating conditions of the urine, the use of stimulating diuretics such as cantharides and turpentine, the abuse of stimulants, and the presence of inflammation in the rectum. These conditions are never competent to excite an acute prostatitis in a healthy state of the gland, but only act to aggravate an already existing inflammation, or make the tissue move susceptible to infection afterward.

A stricture of the urethra greatly aggravates any deep inflammation of that canal, and makes its extension to the prostate much more liable to occur.

Pathology.—In acute inflammation the prostate is much congested, with great swelling and edema, which extend to the surrounding parts. The prostate itself may be enlarged to three or four times its natural size, and even with this degree of inflammation, resolution and a return to a comparatively normal condition are possible.

If, however, the inflammation runs a more acute course, it may lead to the formation of abscesses which, starting as minute points of pus, may gradually enlarge and coalesce until, in an extreme case, the whole organ may be reduced to one abscess cavity.

Spontaneous opening may take place backward into the rectum, into the urethra, or into the bladder, and the pus may even occasionally find its way down through the ischiorectal fossa, or into the perineum, and point externally. Rarely, the abscess may open into the peritoneal cavity, or into an adherent coil of intestine.

Symptomatology.—The prominent symptoms are pain deep in the perineum and in the rectum, with tenesmus of the bladder and the rectum. Urination is very frequent, and is accompanied by great pain, especially during the passage of the last few drops of water, which are frequently colored with blood.

Accompanying these local symptoms there is usually considerable fever, which may or may not be ushered in by a chill. There is also often severe pain in the back, loins, and thighs.

As the inflammation increases the pains become even more severe, the urine in its passage scalds intensely, the pressure and throbbing pain in the rectum become very distressing, and defecation, which is constantly desired, is, when it happens, a new source of suffering.

The stream of urine becomes small and hard to start, owing both to the swelling of the prostate and to the spasmodic contraction of the constrictor urethræ muscle, and finally complete retention may result.

If a gonorrheal discharge previously existed, it may disappear at the onset of prostatic inflammation, or it may be changed into a slight mucous discharge.

There is usually a good deal of tenderness in the perineum, and sometimes also close above the symphysis pubis. A rectal examination is difficult on account of the extreme sensitiveness of the parts, accompanied by spasm of the sphincter muscle.

If the inflammation gives rise to an abscess, its formation is often heralded by rigors with high fever. If the abscess breaks into the urethra or bladder, there may be a sudden escape of pus in the urine, with an improvement of the general symptoms.

If the pus cavity attains any considerable size, its character may be made out through the rectum, where it is to be felt first as a hard, boggy swelling, which later softens and gives evidence of fluctuation.

If the abscess extends into the loose cellular tissue along the rectum, pyemic symptoms may develop, and in case of rupture into the peritoneal cavity the characteristic symptoms of peritonitis will come on abruptly, with a speedily fatal issue.

Treatment.—Absolute rest is the first and most important measure when acute inflammation of the prostate makes its appearance.

The patient should keep in a horizontal position with the hips somewhat raised.

If severe pain is present—especially if frequent spasms of the bladder are aggravating the inflamed gland—opiates should be given; and it is to be borne in mind that these, by inducing rest from spasm, exert a really curative effect. Morphine and atropine subcutaneously, or opium and belladonna suppositories, may be administered under these circumstances.

All irritations from instrumentation, injections, or stimulating diuretics should be avoided.

The bowels should be kept gently open by aperients, if necessary, and this point should be carefully looked after when opiates are being used.

The urine should be rendered as unirritating as possible by the use of sandalwood oil, diluents, and alkaline diuretics, and nourishment should be given in a bland, unstimulating form. Farinaceous gruels, milk, and light broths may form the bulk of the diet. Alcohol should be entirely avoided in the acute stage of the disease.

Locally, all possible measures for limiting the severity of the inflammation should be employed. In an early stage of the disease, leeches applied to the perineum may be of considerable service. From six to eight should be put on along the raphe and close to the anus. The bleeding may be encouraged, especially in plethoric persons, until from fourteen to sixteen ounces have been withdrawn.

Hot applications, either by fomentations or by hot-water bottles, to the perineum and over the pubes, are useful in diminishing pain and spasm, and probably assist somewhat in limiting the inflammation. Hot hip-baths or packs are recommended for this same purpose; but the exertion and the unfavorable position required for the first of these add so much to the pelvic congestion as greatly to diminish the otherwise favorable effect of the heat. If used, they should not be prolonged for more than five or eight minutes, as the maximum effect on the surface is produced in that time.

If retention of urine occurs, it must be relieved by the careful introduction of a small, soft catheter (Nos. 12–14 French scale).

Sometimes, when there is a spasmodic stricture at the compressor urethræ, a soft catheter will not pass, and a stiff instrument must be used, requiring, of course, the greatest gentleness of manipulation.

When the retention persists and requires repeated catheterization, an instrument tied into the bladder (*sonde à demeure*) will often cause less irritation than does its frequent introduction.

The possibility of abscess formation is always to be kept in mind, and the condition of the gland should be watched by rectal examinations. If fluctuation is made out, the abscess should be opened at once. This is best done through the perineum since by this route the possibility of a urethrorectal fistula may be avoided and the prolonged suppuration much shortened. All danger of concealed hemorrhage as well as the uncertainty of working under uncomfortable conditions is done away with.

When the abscess communicates with the rectum thorough irrigation of the bowel should be carried out, and an antiseptic, free from poisonous properties, should be selected, on account of the absorptive power of the rectal mucous membrane.

If the disease ends in resolution, care should be taken that the recovery is complete, for an acute inflammation may, if neglected, leave a chronic condition which is sometimes extremely hard to relieve.

Chronic Prostatitis.—Chronic inflammation of the prostate may, as has been said, follow an acute attack. It may, however, on the other hand, originate as a chronic or subacute affection.

What has been said in regard to the etiology of acute, will for the most part apply to chronic pros-

tatitis; but while the former is never the result of sexual errors, these are not infrequently the starting-point of a chronic inflammation of the gland in that the congestion thus caused makes a fertile soil for the entrance of bacteria; irregular sexual habits in themselves, however, never cause prostatitis; and it is to be noticed that the imperfect sexual indulgence of masturbation, or partial intercourse, is much more productive of prostatic trouble than is the normal excitement of proper coition. This is probably due to the unrelieved congestion of the gland, left after these unnatural practices. Outside of chronic gonorrheal prostatitis, a low-grade infection of the colon bacillus is the most common source of trouble. The infection may be primary in the prostate, or it may be the last stronghold of an earlier general infection of the urinary tract.

Pathology.—A chronically inflamed prostate is usually somewhat enlarged, but may be natural or diminished in size. The gland is less firm than in health, and its texture is more open and spongy. Upon section the cut surface is red or dusky in hue, and moister than normal. Little points of suppuration may exist, but are usually few and small.

The mucous membrane has an increased vascularity and may be thinned, particularly if the prostatic urethra is dilated in consequence of an anterior stricture. It may, on the other hand, be thick and spongy, denuded partly of epithelium, or much roughened with spots of ulceration; sometimes, in cases of long standing, it is pigmented. The sinus pocularis and dilated gland ducts about it may contain pus. Sometimes an abscess cavity exists in communication with the urethra.

Symptomatology.—Patients with chronic prostatic inflammation are troubled with increased frequency of micturition, which in a mild case may be scarcely noticeable, but is often very troublesome—occurring sometimes with intervals of less than an hour.

There is sometimes pain of a dull, heavy character, referred to the perineum and lower rectum. There may also be considerable pain low down in the back, with twinges shooting into the thighs and testicles. A slight, persistent urethral discharge, often most marked in the morning, may be the only symptom. In some cases the symptoms may be almost entirely of a sexual character, such as are often spoken of as sexual neurasthenia.

The bladder, when full, may make its condition known by a feeling of discomfort or actual pain, with intensely urgent call to urinate. The passage of urine may be accompanied by slight scalding sensations, and there may be a twinge at the end of micturition, when the bladder shuts down upon the sensitive prostate. Occasionally tenderness in the perineum may be felt upon deep pressure.

The urine may be cloudy and contain, more or less abundantly, clumps of muco-pus mixed with epithelial cells. These are little accumulations of secretion washed out of the dilated gland ducts, and differ from the loose threads of mucus so common in chronic urethritis in being smaller, more coherent, and rounded in form. When the urine is passed in two portions, the first part is apt to be more cloudy and to contain these clumps of mucus more abundantly than the second part. Not infrequently, however, even when the inflammation is confined to the prostate, the pus is distributed throughout the urine and both portions are cloudy. The reason for this has been very clearly stated by Ultzmann, and is as follows: The internal sphincter of involuntary fibers surrounding the vesical orifice of the urethra is comparatively feeble, while the compressor urethræ muscle, just in front of the prostate and surrounding the membranous urethra, is strong and competent, and, being under the control of the will, it forms the voluntary sphincter of the bladder.

As discharges collect in the prostate they cannot force their way forward past the constrictor, but readily escape backward into the bladder, where they diffuse themselves through the urine. Even in these cases, however, when the urine is universally cloudy, the first portion will still be somewhat more cloudy than that which follows, and will contain many more of the mucous prostatic clumps. The urine in mild cases may be clear with a moderate number of "prostatic plugs" which settle rapidly to the bottom of the urine glass.

The urine, when examined microscopically, will often be found to contain, besides the pus, a considerable number of blood cells, and occasionally also a few spermatozoa. The blood may not infrequently be perceived to come at the end of micturition, when the bladder closes down upon and squeezes the congested prostate.

A chemical examination frequently shows the presence of a little albumin, often in larger quantity than the pus and blood would account for. In other respects the urine is usually normal.

If the character of the stream is noticed, it will often be found that its force is decidedly diminished, and that after the completion of urination a few drops dribble away. Sometimes partial or total retention may oocur.

This interference with urination is to be partly accounted for by the swelling of the prostatic mucous membrane, but is often largely dependent on a spasmodic contraction of the constrictor urethræ muscle; and if under these circumstances a sound is passed, it will meet with decided resistance when it reaches the voluntary sphincter. This spasmodic stricture may be so close as greatly to aggravate the difficulty and pain of micturition, for, as the bladder forces the urine into the prostatic urethra, if its further escape is prevented, the undue pressure in this sensitive part is productive of very great suffering. Usually the spasm of the constrictor is finally overcome by the accumulating intravesical pressure, and urination, beginning first by drops, presently comes with more or less freedom.

As we have said, the constrictor muscle hinders prostatic secretions from escaping anteriorly and appearing as a urethral discharge. A very slight gleet in the morning is not infrequently observed. Sometimes also in these cases a glairy discharge of prostatic mucus is pressed out and escapes while the patient is at stool; especially is this the case when the bowels are constipated and much straining is required. This is commonly interpreted by the patient as an escape of semen, and he becomes convinced that he is a victim of spermatorrhea.

Usually the microscope fails to find spermatozoa in this discharge, which consists mainly of mucus, with sometimes a little admixture of pus and blood.

Besides the local symptoms and manifestations that have been described, we see in these prostatic cases often marked changes in the general condition of our patients. They are nervous and hysterical, or may be depressed and despondent, with often a hypochondriacal overestimate of the gravity of their trouble. Sometimes a true neurasthenic condition may be induced in a case of long standing. Digestive disturbances and palpitation of the heart may occur.

Physical Signs.—An examination of the prostate through the rectum shows it sometimes slightly enlarged, but often normal or diminished in size. In consistency it is usually somewhat softer than in health though it may be hard; there are often differences of consistency in the same organ almost amounting to nodularity. The sensitiveness is generally very marked.

If the urethra is explored with an instrument it is commonly very sensitive, but may be anesthetic; the latter condition being noticed usually in old cases. The urethra should be carefully examined for a possible stricture, and it is to be remembered that the con-

strictor muscle will often be found to make a spasmodic contraction just behind the triangular ligament. The passage of the sound through the prostatic urethra is almost always painful, and may excite an intense desire to urinate, or an ejaculation of semen.

Diagnosis.—The disease which we are considering is peculiar to young and middle-aged men, and is to be kept distinctly separate from hypertrophy of the prostate, which occurs only in the old. Inflammatory symptoms, it is true, are not uncommon in this latter affection, and will be discussed later.

Tuberculosis of the prostate may occasionally offer slight resemblance to chronic prostatitis but as a rule the diagnosis is not difficult as the marked nodularity of the vesicles and prostate in tuberculosis is characteristic. Moreover it is to be borne in mind that tuberculosis of the prostate is rarely if ever primary in that organ but is secondary to either urinary (renal) or genital (epididymal) tuberculosis. If there is no lesion of the epididymis and guinea pig tests are positive, renal tuberculosis is to be suspected and searched for.

The discrimination between prostatitis and deep urethritis after gonorrhea is impossible and for practical purposes unnecessary as the presence of one implies sooner or later the other, and the treatment in either case is the same.

The formation of Böttcher's crystals upon the addition of a drop of a one-per-cent. solution of phosphate of ammonia to a drop of the secretion shows beyond question that it contains prostatic fluid.

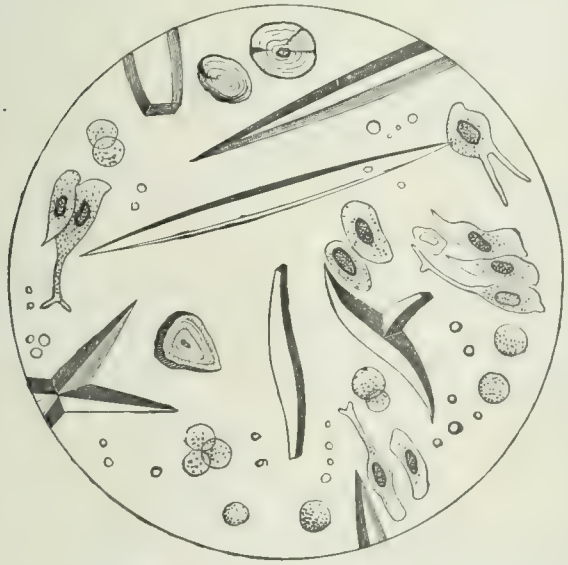


Fig. 4334.—Sediment from Prostatic Discharge, Containing Pus and Epithelial Cells, Granules, Amyloid Bodies, and Bottcher's Crystals.

This reaction should be conducted on a microscope slide, under a cover-glass, and within an hour, usually, crystals such as are shown in Fig. 4334 make their appearance. They are composed of a phosphate formed from a base which exists in prostatic fluid, and which is supposed to impart to it its peculiar odor. Unfortunately, the mixture of urine with the secretion prevents the formation of these crystals, and so limits very much their diagnostic usefulness.

Treatment should be addressed to both the general and the local condition.

The general treatment should be tonic, especially in the cases in which much nervous depression exists.

A generous, stimulating diet, with moderate exercise in the open air, and with cold sponge baths in the morning, when the patient's strength will admit of them, are to be advised.

The laws of sexual hygiene should be carefully explained to the patient, and the importance of their observance made plain to him.

Drugs are of little or no value in most cases. Bromides may be helpful in quieting sexual excitement. Sandalwood oil may be useful for its soothing effect, and if the urine is highly acid, potassium citrate and a generous intake of water are indicated.

Various local measures of treatment may be expected to contribute to the cure. When there is much pain in the prostate and rectum, hot injections into the bowel may help to palliate it, and to reduce the congestion in the same manner that hot douches act upon the female pelvic organs.

The most important local treatment, however, is that applied directly to the prostate itself, and consists in the passage of sounds, massage of the prostate through the rectum, and in applications and injections into the prostatic urethra.

The use of sounds in chronic inflammation of the prostate has long been recognized as of advantage, and the benefit from them has been variously explained. Some surgeons think that they should be used cold, and ascribe their efficiency to the astringent action of the cold. Others consider that their pressure within the prostate exerts some beneficial influence by forcing the blood out of the gland. While some good may perhaps be attained in either or both of these ways, it is probable that the stretching of the constrictor urethræ muscle, and the consequent relief from spasmodic contraction of the same, will account, in a large measure, for the good results that follow their use. As has been said above, this sphincter is not infrequently put in a spasmodic state of contraction by the proximity of the prostatic inflammation, and in this state of stricture, it has a tendency to aggravate the deep inflammation, just as an organic stricture tends to increase and perpetuate a urethritis posterior to it. It can be readily understood, therefore, that the relief of this spasmodic contraction would act favorably upon the inflammation behind it.

As large a sound as will pass comfortably through the urethra should be used, and it should be introduced with the greatest gentleness. A sound passed roughly down through the anterior urethra will sometimes find the constrictor tightly closed against it, when, had more care been exercised, the urethra would not have resented its introduction, and it would have readily passed the moderately contracted sphincter.

If the spasmodic stricture is a tight one, it will sometimes be found necessary to precede the introduction of the sound by the passage of a French, olive-pointed, conical bougie; which, insinuating its point through the obstruction, readily dilates it and prepares the way for the larger instrument.

When excessive irritability or an access of inflammation make the application of cold to the prostate desirable, it may best be accomplished by the use of the cold sound. This is a hollow instrument, which after its introduction can be chilled down by passing a stream of water through it. It should usually be kept in place for about five minutes.

We now come to speak of local applications to the prostatic urethra, and in these we recognize the most efficient means at our command for subduing chronic inflammation of this part.

The cases which are particularly suited to this form of treatment are those in which prostatic clumps are present in the urine, with or without a purulent secretion; in short, in which the mucous membrane is distinctly affected. Medication may be conveyed to the pars prostatica urethræ either by the injection of a few drops of a strong solution, or by irrigation with considerable quantities of a weak solution.

The application of soluble drugs to the prostatic ure-

thra is probably best accomplished by the injection of solutions.

The constrictor muscle, situated just in front of the prostate, prevents the penetration of an ordinary urethral injection, and special instruments are therefore needed for medication in the urethra posterior to it. Figs. 4335 and 4336 represent such catheters for prostatic medication.

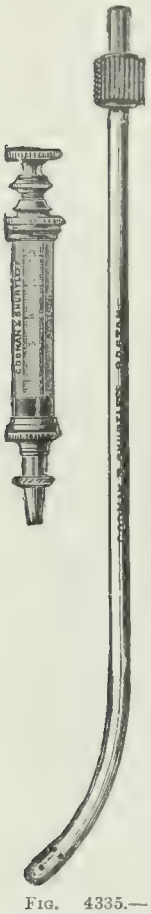


Fig. 4335.—Ultzmann's Prostatic Syringe A capillary tube and graduated syringe for the introduction of strong solutions. The curve of this and of the irrigating catheter is modified from Ultzmann's instruments. See text.

The curve shown in these instruments has advantages both in the ease of introduction, and in the readiness with which the location of the point can be determined from the position of the handle.

When the instrument is vertical (the patient being of course, in the horizontal position), the point necessarily rests just in front of the triangular ligament; now, upon bringing it down to an angle of forty-five degrees, and at the same time advancing it slightly, the point slips on through the constrictor muscle, but never passes beyond the prostate unless a special effort is made to push it on toward the bladder. (Fig. 4337.) Fluid injected through the catheter, when in this position, cannot pass forward through the constrictor, but washes out the prostate and escapes backward into the bladder.

Of the various drugs used for prostatic application, nitrate of silver is perhaps the most valuable.

Two or three minims of a one- to two-per-cent. solution should be thrown into the prostatic urethra through the capillary catheter (Fig. 4335).

Some pain of a burning character, with often considerable tenesmus, follows the application; but this usually passes off in the course of an hour or two. The injection should be repeated every four or five days, and its effect may sometimes be heightened by the previous passage of a sound. As convalescence is established, the intervals in the treatment should be gradually lengthened.

Irrigation of the prostatic urethra may often be practised with great benefit. In case there is much irritability of the neck of the bladder, with considerable mucopurulent secretion, a soothing antiseptic wash is of use. A two-per-cent. solution of borax or boracic acid, with the addition of a little glycerin, is a good injection for this purpose.

If the use of an astringent wash seems indicated, any of the mixtures useful in gonorrhea may be tried. Perhaps a one-per-cent. solution of acetate of zinc is as good as any. The irrigating fluid, after washing out the prostate, flows back into the bladder, as has been said, and from there it may either be withdrawn by slightly advancing the catheter, or it may be passed by the natural efforts.

While the above-mentioned procedures are addressed to the urethral aspect of the prostate, further relief may be afforded by massage of the rectal face of the prostate. This is done by the forefinger introduced into the rectum, and should aim at expressing the contents of the prostate. The amount of pressure which may be safely used will depend on the acuteness of the inflammation, of which the tenderness will prove a safe guide. Massage should not be given at too short intervals, and is often wisely made to alternate with the other local measures above outlined.

In all prostatic massage it must be remembered that the vesicles may be, and often are, more diseased than the prostate itself, and the emptying of these by the finger tip should be aimed at. In any case the most sensitive or the most nodular part is the most diseased and special attention should be directed there.

After any manipulation or treatment of the prostate the patient should keep quiet, if possible recumbent, until all serious discomfort passes away, and should avoid any exposure to chill or fatigue for several hours.

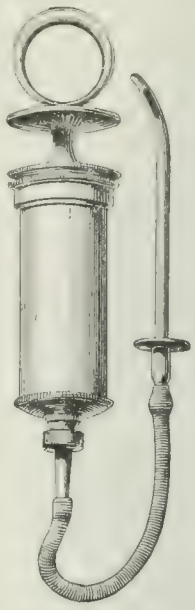


Fig. 4336.—Irrigating Catheter. (After Ultzmann.)

Obstructing Prostate.—An obstructing prostate may be either enlarged or contracted. This latter condition is probably due in most cases to previous inflammation with resulting sclerosis and contraction which obstructs first, by stiffening the neck of the bladder and thus raising and stiffening the internal urethral orifice, and second, by an actual stricture of the internal orifice. This condition is relatively uncommon as compared with the so-called hypertrophy which is the condition commonly met with and hereafter described.

Hypertrophy of the Prostate.—*Etiology.*—The one thing which seems to be essential to the existence of hypertrophy, or adenomatous enlargement of the prostate is the advanced age of the patients. Hypertrophy of the prostate is practically unknown before the age of forty-five, whereas after that it is extremely

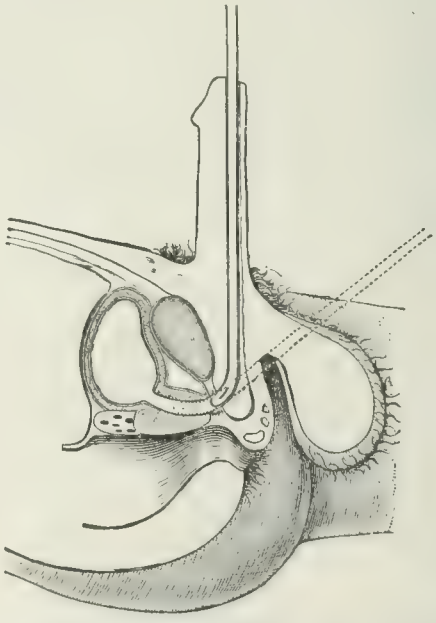


Fig. 4337.—Diagram showing that if a short-beaked instrument is held with the handle vertical, the point rests just at the triangular ligament. The dotted figure shows how the point slips through the constrictor muscle when the handle is brought to an angle of forty-five degrees with the axis of the body.

common up to the age of about seventy-five after which it again becomes relatively uncommon.

Stone in the bladder, stricture of the urethra, irritation by the frequent use of instruments, sedentary habits, gouty or rheumatic diathesis, and exposure to cold and damp, have all been cited by surgical writers as predisposing circumstances; but none of these conditions has ever been positively shown to stand in a causative relation to the disease.

On the other hand, it has been shown by Cabot and Smith that the presence of a previous inflammatory prostatitis prevents later hypertrophy; a stricture, and hypertrophy of the prostate are never present together.

There is no doubt that, when prostatic hypertrophy exists, any of these conditions may greatly aggravate its symptoms; and besides those already named we may mention excesses in drink or in venery, prolonged voluntary retention, and the recumbent posture as familiar causes of increased prostatic congestion.

Hypertrophy of the prostate, so called, is not an hypertrophy in the true sense of the word; the functioning glands do not increase in number. It is an enlargement due to the growth within the substance of the organ of adenomatous new growths. These may be present in great numbers, none very large, or one adenomatous mass may fill a lobe. Between these adenoma there is an increase in the interstitial tissue of the organ and also a blocking of gland ducts with distortion of the glands. This often leads to small cysts in the gland substance.

As the normal size of a particular prostate can never be known, it may be hard to say, even on post-mortem examination, whether a given specimen is enlarged or not. For approximate determination, however, a prostate weighing six drams may be regarded as normal in size, and anything over that is to be considered hypertrophied.

Upon section of an adenomatous prostate these various conditions will show in varying degrees in proportion as one condition or another dominates. The cut surface bulges irregularly above the cut capsule. If the adenomatous masses make up most of the organ they will bulge out still more and show as various-sized nodules, hard to the touch and glistening yellowish white in color. There may be many small, or one or two large ones. These nodules may be fewer in number and the distorted and engorged ducts and acini may be more prominent. In this case the surface is soft and exudes a milky fluid. Several small cysts may be cut. If the interstitial increase be more prominent the surface is harder and drier.

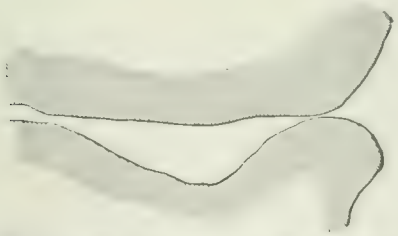


Fig. 4338.—Diagram to Show the Shape of the Urethra in a Vertical Section through a Prostate with an Enlarged Middle Lobe.

The two lateral and the median lobes are affected simultaneously, but not by any means necessarily to the same degree. The posterior lobe is never involved in this adenomatous change. The anterior lobe and occasionally the subcervical group are involved in the process.

The shape of the prostatic urethra—a matter of the first clinical and surgical importance—depends largely upon the partial or general character of the hypertrophy. If the enlargement is pretty evenly distributed throughout the organ, the urethra is in the first place considerably lengthened, sometimes measuring even seven centimeters. When the hypertrophy is partial the elongation is less, though it is still marked.

Furthermore, in cases of general hypertrophy, as the lateral lobes enlarge they compress the urethra from the sides, until it becomes a slit-like canal with tolerably firm walls in close apposition. As the lateral diameter is thus diminished, the anteroposterior diameter is correspondingly increased.

Fig. 4339.—Diagram of a Horizontal Section through the same Organ, showing how the Urethra divides and goes on either side of the Middle Lobe.

It will be readily seen that, as long as the enlargement is symmetrical, the direction of the urethra is not materially altered; but, on the other hand, it is equally evident that, if the hypertrophy is partial, and not evenly distributed, the unequal pressure from one side or the other of the canal will cause lateral deviations, and that, if the anterior or so-called middle lobe is unduly enlarged, the posterior portion of the urethral floor will be raised, causing a deviation upward or toward the pubis. (See Fig. 4338.)

The projection upward of this lobe may make the internal urethral opening crescentic in shape, and if the middle coalesces with either of the lateral lobes, this orifice is pushed over toward the opposite side. (Figs. 4339 and 4340.)

Sometimes the anterior lobe grows out into the bladder as a distinct tumor, which may be attached by a broad base, or may stand off in a pedunculated polypoid form.

Besides the changes in the prostate itself, there are other alterations in associated organs which we must consider in connection with this disease, as they are instrumental in producing many of the symptoms which we shall have to study.

As the prostate enlarges the internal meatus is raised and a pocket is formed in the bladder just behind the enlarged gland. The bladder wall also becomes thickened, partly in consequence of hypertrophy of the muscular coat, owing to the increased resistance against which it has to work, and partly owing to a sclerosis of the interstitial fibrous tissue, like that which has occurred in the prostate.

Fig. 4340. Diagram of a Horizontal Section through a Prostate in which the right lobe, *A*, is moderately enlarged, the left lobe, *B*, somewhat less so, while the middle lobe, *C*, is much enlarged and is joined to the left lobe, causing a deviation of the vesical end of the urethra to the right.

Interlacing muscular bands often stand out from the vesical wall under these circumstances, forming trabeculæ between which there are not infrequently, considerable pouches of mucous membrane.

The walls of the ureters and pelves of the kidneys may also be somewhat thickened, and the interstitial renal tissue undergoes frequently a hyperplasia.

As a later result of the prostatic obstruction the

bladder, ureters, and pelves of the kidneys may become greatly distended.

Guyon and Lannois have laid particular stress upon the fact, already hinted at and partly understood by earlier writers, that coincident with these changes in the urinary tract a general sclerosis, affecting specially the walls of the blood-vessels, is going on throughout the body.

When from any cause inflammation of the bladder, ureters, or kidneys has associated itself with hypertrophy of the prostate, we have the familiar pathological appearances of cystitis, pyelitis, and pyelonephritis engrafted upon the organs already seriously altered by the prostatic obstruction.

Natural History.—The progress of the disease is slow. The organs affected are not of vital importance, and the changes in them may reach a very advanced state before they seriously threaten life.

Guyon has divided the history of the disease into three periods: *First*, that of congestion, affecting mainly the prostate, but also in less degree the bladder and kidneys. *Secondly*, that of partial retention of urine. And, *thirdly*, that of distention of the bladder with usually secondary changes in the kidneys.

This somewhat empirical division gives us perhaps as good a framework as any for the classification of the clinical phenomena.

In the first stage, that of congestion, we have some enlargement of the prostate and functional disturbances, especially in the matter of urination. This condition may persist for a long time, and in certain cases, in which for any reason the caliber of the urethra is not greatly interfered with, it may exist almost indefinitely without showing any tendency to pass on to the second stage, that of retention.

Usually, however, sooner or later the obstruction to the passage of the urine becomes greater than the force of the bladder can overcome, and a state of habitual partial retention is the result.

When this condition comes on slowly, the accumulation of residual urine may be very insidious, and escape the observation of patient and physician alike; on the other hand, an increase in the prostatic obstruction may occur suddenly, and the unexpected complete stoppage of the urine may be the first announcement of trouble.

When the retention of the second stage of the disease develops gradually, and is not discovered and treated the point may be finally reached where the bladder has completely lost its tone and is so distended that the urine escapes almost constantly by an overflow (retention with incontinence). This same condition of things may follow also an acute retention which has not been relieved by catheterization and in which nature has finally established a leakage.

The third stage of the disease is now entered upon, and if nothing is done for such a case the distention of the bladder becomes extreme, and a secondary dilatation of the ureter and of the pelves of the kidneys takes place. This is soon followed by atrophy of the secreting portion of the kidney, and an increase of its interstitial tissue (interstitial nephritis).

The secondary changes in the heart and blood-vessels usually associated with chronic nephritis, are likely to make themselves noticed at this time, if they have not already done so, and the disease becomes a constant and serious menace to life.

It is in this advanced stage of the disease that inflammatory processes, starting in the bladder, rapidly extend backward to the kidneys, and uremic symptoms presently usher in the closing scene.

Symptomatology.—From what has been said in regard to the history and progress of the disease, it will be seen that the symptoms of the first stage are mainly dependent upon the condition of congestion in the prostate, bladder, and kidneys. And as this congestion is most considerable in the prostate, the most noticeable symptoms caused by it are disturbances of micturition and of sensation, due to the irritated state of the neck of the bladder.

In the second and third stages we have, in addition, a series of symptoms due to the mechanical obstruction to micturition, and to the changes in the bladder and other organs consequent upon this obstruction.

We shall have finally to consider the symptoms arising from various morbid conditions likely to appear as complications in the course of prostatic disease.

The first appearance of symptoms usually announces a morbid condition which has already been coming on for some time. When the enlargement takes place in such direction as not to encroach seriously on the caliber of the urethra, it may reach very considerable proportions before it causes any inconvenience to the patient.

One of the first symptoms to be noticed is an increased frequency of micturition, which is specially marked at night or early in the morning. Guyon regards this as evidence of congestion, which is aggravated during recumbency and sleep. He calls attention also to the frequent existence of erections in these patients, on waking, as further evidence of an increased congestion of the prostate during sleep.

Pain is ordinarily not very noticeable in the early stages of the disease, although a dull aching or heavy dragging sensation in the perineum, rectum, and behind the pubis is not uncommon.

If attention is paid to the manner in which urination is accomplished, it will be found that early in the disease the stream is slow to start and diminished in force. This is due largely to a loss of power in the bladder, but is to be partly explained by the swelling in the prostate, and by a spasmodic contraction and stammering action of the constrictor muscle.

The diminution in the force of the stream in a prostatic patient differs from that seen in cases of stricture, in that, while a strictured patient can, by voluntary effort, increase the force of his stream, a man with enlarged prostate cannot do so.

Second Period. The symptoms which have their origin in congestion continue during this period, and are, indeed, intensified. Added to them we have other symptoms due to the retention, which is the characteristic condition of this stage of the disease.

The retention may be complete or incomplete.

Complete retention may be acute and appear suddenly or it may be preceded by a period of partial retention which always develops slowly.

The symptoms which accompany a complete retention are easy of recognition, and a physical examination reveals the bladder distended above the pubis. Incomplete retention, on the other hand, comes on very insidiously, and is often overlooked for a long period, at just the time when recognition and treatment of the condition are of great importance.

Although, as has been said, partial retention comes on quietly, still a careful examination of the symptoms will usually elicit evidence of a changed condition of things, at or soon after the time when the bladder begins to fail of emptying itself. The feeling of weight behind the pubis is likely to be increased, and the frequency of micturition, which during the first stage was decidedly more pronounced at night, begins to be almost equally noticed in the daytime. The intervals between the acts of urination become short, and the call is imperative. In short, the bladder being always partly full, it takes but a small additional quantity to distend it to its full capacity.

The only positive means of determining the conditions of the bladder is by a physical examination, and this should be made in every doubtful case.

Sometimes the bladder shows extraordinary tolerance, and the distention becomes so extreme as to cause incontinence from overflow, before the patient feels obliged to call upon a physician; and sometimes also, unfortunately, before the medical attendant recognizes the nature of the difficulty.

This incontinence is evidence of a very great degree of distention, and shows that the disease has entered upon its third stage. Usually, before it appears, the disease has already extended backward and has begun to affect the kidneys.

There is one symptom which may appear and give evidence that the disease has reached the third stage, before incontinence begins. This is polyuria. If the quantity of urine in the twenty-four hours is measured, it will be found considerably to exceed the normal.

Pain, which was an insignificant symptom in the first stage, may assume considerable importance in the second and third stages.

Beside the discomfort in the perineum, and back due to the congested and irritated prostate, there is also considerable pain before and during micturition, caused by the distention of the bladder and its unavailing or partially successful attempts to empty itself. The passage of the urine through the prostate is also sometimes painful, and this is especially the case when the occurrence of inflammation has rendered the urine pungently alkaline and has made the parts particularly sensitive.

The examination of the urine may give negative results during the early stages of prostatic disease; but when the congestion of the kidneys is considerable there are usually albumin and a few casts. During the last stage of the disease, when polyuria has established itself, the specific gravity is low (1.003–1.006) and there is generally a small amount of albumin, although this may not be present. A few casts will generally be found at this time, too, but they may be absent even when the kidneys are extensively diseased. It is often remarkable how little evidence a urinalysis gives of extensive damage to the kidneys.

In the presence of inflammatory complications the character of the urine is greatly changed, as we shall see later.

In addition to the more local symptoms which we have been considering, there are also certain general disturbances which are likely to appear in advanced prostatic disease. These are of two kinds, digestive and febrile.

Obstinate indigestion in an old man, especially if accompanied by nausea, should always lead us to take the condition of the prostate into consideration. These patients are also very liable to a low feverish condition, with extremely dry mouth and tongue, and this may announce the extension of inflammation from the bladder back into the kidneys.

We now come to the consideration of the complications which are likely to arise in prostatic cases, and of the symptoms, or variations in symptoms, to which they give rise.

They are cystitis, pyelitis (pyelonephritis), going on to serious renal destruction and renal insufficiency and uremia, hematuria, and stone in the bladder.

Cystitis is so common in prostatic hypertrophy that it may be looked upon almost as a necessary result. It sometimes appears without apparent cause, sometimes in consequence of excesses in drink, or from exposure to cold, and in this case the infection probably comes from the rectum or through the blood. Far more commonly, however, it follows as a consequence of the use of the catheter or other instrument, and when it is once established it is rarely got rid of—but may, as we shall see, by appropriate treatment, be kept within very reasonable bounds. When the inflammation of the bladder is at all acute, the pain and frequency of micturition are greatly increased. If the prostate shares in the inflammation, a great weight and bearing-down pain in the rectum may be felt, with a frequent urgent desire for defecation.

The urine becomes thick from the admixture of pus and mucus, which often settles at the bottom of the vessel in a thick, ropy mass. Presently, in the majority of cases, it undergoes alkaline fermentation, becomes ammoniacal, and has a strong pungent, often fetid odor. The sediment now contains, besides the pus, prostatic cells and abundant crystals of triple phosphates, often associated with finely granular amorphous phosphates.

If the inflammation extends from the bladder back through the ureters to the kidneys, the resulting pyelitis or pyelonephritis makes itself known by pain in the back, high fever, more or less diminution or even suppression of urine, and uremic symptoms.

This course of things is especially liable to occur late in the disease, when neglect of catheterization has allowed the ureters to become greatly distended. Under these circumstances, any exposure to cold or instrumentation may be sufficient to start the fatal access of inflammation.

Occasionally, when the use of the catheter has been neglected after the time when it should have been begun, the final entrance upon the catheter life, instead of being a conservative measure, gives the final push toward a fatal issue. The existence of polyuria, with urine of a low specific gravity, should always lead us to fear this result.

Stone in the bladder not infrequently occurs in prostatic patients as a consequence of cystitis, in which case the stone is of the soft phosphatic variety; or a stone composed of uric acid, oxalate of lime, or cystin may form, and owe its origin primarily to a constitutional condition. In either case the prostatic hypertrophy may be regarded as partly responsible for the formation of the calculus.

In the first case, that of the phosphatic stone, the obstruction, by causing the cystitis and fermentation of the urine, stands in a pretty close causative relation to the calculus. In the second case, in which the deposit of crystals from the urine is due to a constitutional tendency, the obstruction at the prostate may be the condition which decides whether a stone shall form or not. For, when the bladder is completely emptied at each urination, the crystals as they form are thrown out and do no harm, whereas when there has been formed behind the prostate a pocket in which there is always residual urine, the sand collects there and soon agglomerates itself into a concretion.

When a stone forms behind an enlarged prostate the pain is usually much increased, and is less amenable to treatment. It is referred often to the glans penis, and is greatly aggravated by motion, especially by riding in a jolting vehicle. It is commonly less marked at night or during rest.

Hematuria in case of stone is very likely to appear after exercise or riding, while prostatic hemorrhage from congestion seems to be independent of any jarring of the bladder—in fact, is rather more likely to come at night, when recumbency favors prostatic congestion.

The sudden stoppage of the stream in the midst of urination, by the rolling of the stone against the opening of the urethra, is less likely to occur in case of an enlarged prostate than in a healthy bladder, owing to the lodgment of the stone behind the prostate, below the urethral orifice.

If the presence of the stone affects the frequency of micturition, it tends to increase it rather in the daytime, when motion causes the stone to move about, than at night, when it is at rest.

Hematuria, as has been said, may result from the congestion of the prostate with or without ulceration, or from the presence of a stone. In this case the bleeding may be terminal, though this is not necessarily the case. We may also have hemorrhage of considerable amount and duration, following the use of instruments; and, lastly, the too sudden emptying of an overdistended bladder may lead to an attack of hematuria, from the capillary oozing from the vesical wall. Sometimes clots of large size may form in the bladder, and cause much pain and discomfort before they are broken up and expelled.

Physical Examination.—After it has been decided from the symptoms that there is a probability that prostatic hypertrophy exists, a thorough examination should be made of the prostate and bladder.

The objects of this investigation are to ascertain the stage at which the disease has arrived, to learn the amount of obstruction and the configuration of the prostatic urethra, and to discover any complicating conditions which may exist.

The patient should first empty the bladder, so far as possible by the natural efforts, and the hypogastrium should then be explored by palpation and percussion, to see whether enough distention of the bladder remains to be detected in this region. The normal variations in the position of the bladder and intestines render this examination often unsatisfactory, especially when the abdominal wall is thick or rigid.

The examiner should then explore with the forefinger the rectum. This is best done with the patient standing with legs slightly apart and knees straight, bending over a table or chair.

If the prostate is enlarged it will be felt pressing down the anterior rectal wall. Its size, shape, and consistency should be noticed. The relative enlargement of the lateral lobes can usually be well made out, and nodular projections are sometimes felt, caused by irregularities in the hypertrophy of different parts of the gland. Rectal examination, unfortunately, gives little or no information in regard to the condition of the third lobe, which is so often the cause of a serious obstruction to the flow of urine. Incidentally, the degree of tenderness to palpation will be discovered.

The condition of the prostate itself having been determined, the examining finger should be carried up along the posterior vesical wall, if that be possible, and the condition of the bladder should be learned. In this investigation the bimanual manipulation between the finger in the rectum and the hand above the pubes, so commonly practised in examinations of the female pelvic organs, is useful, and by it the amount of distention of the bladder can often be most accurately made out. A short-beaked sound should be passed, and as it runs through the prostate deviations of the urethra will often be shown, by the feeling of resistance on one side or the other and by the turning of the handle. The sound in entering the bladder may sometimes be felt to slip up over a bar, or may turn to one side around a prominent third lobe. After a proper search has been made for a possible stone, the sound should be depressed until it lies in the axis of the body, and then withdrawn until the concave side of the beak comes against the neck of the bladder; it may then be rotated, and, as the beak sweeps the vesical face of the prostate, any irregular outgrowths or projections will be felt to arrest its movements. If the sound has been felt to ride over an obstruction at the neck of the bladder and if, after it is in, it rotates freely, this points to a bar rather than to a globular enlargement of the third lobe, which last would arrest the beak of the sound in rotation. As the instrument is withdrawn slowly through the prostate, the deviations due to projections into the urethra are often felt even more plainly than during introduction. Finally, the urine may be withdrawn with a catheter and the exact amount of residuum thus discovered. This will be found to vary much at different times, and depends somewhat upon the amount of urine which the bladder contained before the last urination.

When the bladder is full and the urine consequently rushes out with some force in a considerable stream, it will often be found that there is much less water left in the bladder than is the case when urination is attempted before complete distention has been reached.

Diagnosis.—The conditions with which enlarged prostate is likely to be confounded are stricture of the urethra, stone in the bladder, atony of the bladder, cystitis, cancer of the prostate, and tumor of the bladder.

The physical examination, if thoroughly made, usually enables us to eliminate the first two of these conditions and if enlargement of the prostate with residual urine is found we may, in the absence of other discoverable cause, decide that an existing cystitis is dependent upon the prostatic trouble. It may, however, be impossible to demonstrate the absence of stone behind an enlarged prostate except by a thorough examination under ether with the cystoscope.

It has been pretty clearly demonstrated that cancer of the prostate always begins in the posterior lobe. Accordingly the finger in the rectum should recognize its presence fairly early. Rectal palpation with an instrument in the urethra may demonstrate a pathological thickening of this portion of the gland which should always make one suspicious. The onset of the process may be so insidious that its presence is not known until the pain of a spinal metastasis forces a diagnosis or until the cause of an obstinate sciatic rheumatism or other so-called rheumatic pain is searched for.

Tuberculosis, as has been already stated, is rarely if ever a primary disease, so that when it is believed or proved to be present the primary focus should be looked for.

A tumor of the bladder may give rise to hemorrhages and difficulties of micturition which simulate those caused by enlargement of the prostate. Also a tumor may be present in the bladder behind an enlarged prostate, and so complicate the symptoms.

The hemorrhage from a tumor is ordinarily very much greater than that from a congested prostate. But this is not always the case, and it must be remembered that hematuria in any case and especially in a man over forty-five may be very serious and a careful investigation should be undertaken at once. Cystoscopic examination is the final court of appeal in any case of this kind.

After definitely settling the diagnosis of prostatic hypertrophy, it is always important to go further and to decide in what stage the disease is, as we shall see that treatment should vary according to the varying conditions.

The steps to this decision have been sufficiently indicated above.

Treatment.—As has been described, the disease under consideration consists essentially in a tendency to congestion of the prostate, bladder, and kidneys, with an accompanying hypertrophy and sclerosis.

For convenience we have divided it into three stages: First, of congestion, with functional disturbances; second, of single retention; and, third, of retention with distention, often incontinence, and perhaps involvement of the kidneys.

First, we will consider those measures of treatment, hygienic and medical, which are applicable to all stages of the disease. Anything which has a tendency to increase the congestion should be carefully avoided. A chill of the surface should be especially guarded against. The patient should wear flannels next the skin, and should carefully avoid draughts or long exposure to chilly and damp air. The feet should be kept dry and warm, and if the patient gets up at night to pass water, use the catheter, or for other purpose, he should cover his feet and legs warmly. Neglect of these precautions may at any time bring on an attack of retention, of cystitis, or even of pyelonephritis.

Excesses in eating and drinking are to be avoided. Large quantities of rich or highly seasoned food must not be indulged in, and wine and beer are for the most part better left alone. This caution should be understood to apply only to overeating, as a sufficient quantity of nourishing food is of importance. If the patient has been in the habit of taking a stimulant, a

little light claret or some whiskey and water may be allowed with meals.

Especial warning should be given against holding the water over the ordinary time, particularly if any call to pass it is felt. An attack of complete retention or of cystitis may result from disregard of this rule. Venereal excesses are, of course, to be avoided.

The effect of sedentary habits and of horizontal decubitus in increasing the passive congestion must be borne in mind, and moderate gentle exercise is to be advised. The patient will do well, when engaged in any occupation that keeps him long in one position, to take an occasional turn through the room; and at night or in the morning, when he gets up for the purpose of emptying his bladder, a short walk about his chamber will often materially assist him in making his urination thorough and satisfactory.

Constipation should be carefully guarded against. In prescribing for this condition, the violently acting drugs, which produce more or less congestion of the pelvic organs, should not be used. The greatest assistance will often be obtained from rectal injections. These are especially useful when the mechanical obstruction of the prostate, pressing as it does upon the rectum, is largely responsible for the failure of the bowels to act. Cold injections are usually to be avoided, though they may sometimes render good service in helping to restore the functions of an atonic bladder. Hot injections (112°–115° F.) will sometimes assist in reducing congestion.

The functions of the skin should be stimulated as far as possible. Rubbing and massage are to be employed to this end, and baths also serve a useful purpose if care is taken against a subsequent chill. A hot bath ending with a sponge off in cold water, and vigorous friction with a rough towel, may be of real benefit, by bringing the blood to the skin and so relieving internal congestion.

In selecting a climate for a prostatic patient, preference should be given to dry inland localities, where sudden changes of temperature are less likely to occur than on the seacoast. Sometimes, however, when the general condition is depressed and a stimulating climate is desirable, the seaside may be tried, special precautions being taken against surface chills.

General medication directed against the disease itself has but little to offer.

Of the medication required in the various morbid conditions which may from time to time need correction, we shall speak in considering the treatment of the various periods.

Local treatment may be divided into palliative and operative.

Palliative Treatment.—Treatment in the first period is almost wholly hygienic and medical.

In the absence of complications, and before there is any retention, the less instrumentation the better, as it only aggravates the congestion, and introduces the danger of infection from dirty instruments.

If the urine is irritating from too great acidity, an alkaline diuretic, such as citrate or acetate of potash, is indicated. Also a balsam, as sandalwood oil, either alone or with the citrate, may be of great benefit.

Second Period.—When the stage of partial retention has set in and the patient passes water, but is not able to empty his bladder completely, then operation should be at once considered. It is certain that no safer time will ever come; on the contrary more obstruction with infection and increasing damage to the kidneys is constantly increasing the risk; moreover the possibility of a return to the first stage by the use of palliative measures is only slight and if accomplished is never permanent as the disease is always and surely progressive. In other words, operation is the choice from this time on unless from some condition other than urinary, the patient is unable to undergo the operation.

So important is this that every patient who is seen in the first stage may be warned that the time will probably come when operation is the lesser of two dangers, and as his symptoms or lack of symptoms are no guide, he should occasionally present himself for examination. If now the patient refuses operation or for some other reason it is considered out of the question, palliative treatment must be resorted to. This means the use of the catheter regularly, in proportion to the amount of residual urine, for the rest of the patient's life, together with one of the formaldehyde splitting compounds as a urinary antiseptic (unless it prove too irritating, when sandalwood oil is to be used). It is a wise rule to observe, never to insert a catheter where a residual is suspected without first making the urine aseptic.

It will sometimes be found that, after a short systematic use of the catheter, the bladder will recover itself and again become able fully to expel its contents. Thus the disease may occasionally be moved back from the second period into the first though never permanently.

When complete retention comes on suddenly the catheter is indispensable, but in this case again its use may perhaps later be given up.

When entering upon the use of the catheter, we may often learn whether it is really needed by noticing the effect upon the symptoms. If these are relieved or ameliorated, we are evidently on the right track.

It is to be remembered, however, that not infrequently, on commencing catheterization, a cystitis develops itself, owing either to the too sudden evacuation of a distended bladder, to the introduction of dirt upon the catheter, or simply to the irritation from the constant use of instruments. It is important that the aggravation of symptoms caused by this inflammatory onset shall not lead the patient or doctor to infer that the catheter is doing harm and should be given up, for it is by continuing its use that the attack of cystitis may be most quickly and surely relieved.

Let us now consider how and with what instruments the catheterization is to be carried out.

As has been described, the walls of the urethra are pressed together and may be somewhat deviated by the inequalities of the lateral lobes. The posterior part of the urethral floor is also often raised by the projection of the third lobe. Our object is to reach the bladder through this sinuous passage with the least possible amount of irritation. If a soft, red rubber catheter will find its way into the bladder, it is, by all odds, the best instrument to use. It requires no skill for its direction, and can do no damage to the urethral walls—a point of great importance, as it enables us to entrust its use to an unskilful patient.

When, owing to the narrowness or tortuousness of the urethra, the rubber catheter will not pass, we must resort to a stiffer instrument, and must adapt its form in reference to the difficulties which it has to overcome.

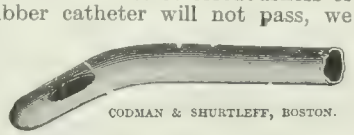


Fig. 4341.—Elbowed Catheter. (Sonde coudée of Mercier.)

The obstructions which it will meet project from the lateral walls and floor of the canal, and our effort must be to carry the point of the instrument along the upper or anterior wall.

Mercier devised for this purpose a flexible webbing catheter with the point sharply turned up (sonde coudée), so that it might ride over the obstructions on the floor. For those cases in which the hypertrophy of the third lobe was very pronounced, he used a catheter with a second bend, designed to lift its point still higher. (Figs. 4341 and 4342.)

In introducing these instruments, care should be taken that the point be kept turned toward the roof of the canal, and after it has passed the triangular liga-

ment the penis should be depressed as much as possible between the thighs, so that the catheter may be pushed straight upward in the axis of the body.

The English gum-elastic catheter may often be used with advantage, either with or without its wire stylet. If it is introduced without a stylet it is a good plan to exaggerate the curve of the instrument, as has been suggested by Thompson. When used thus it should be introduced cold and carried as rapidly as possible through the anterior urethra, for as it warms it

Fig. 4342.—Double-Elbowed Catheter. (Sonde bicoudée.)

becomes flexible and loses its form. By passing it rapidly but carefully, its curve often carries it over the obstructing third lobe.

If it meets an obstruction and, warming in the urethra, becomes flexible, the forefinger in the rectum should be used to lift the point of the catheter into the prostate, while at the same time the handle should be brought down to the axis of the body, and the instrument, which is then practically straight, should be pushed steadily into the bladder. This should be

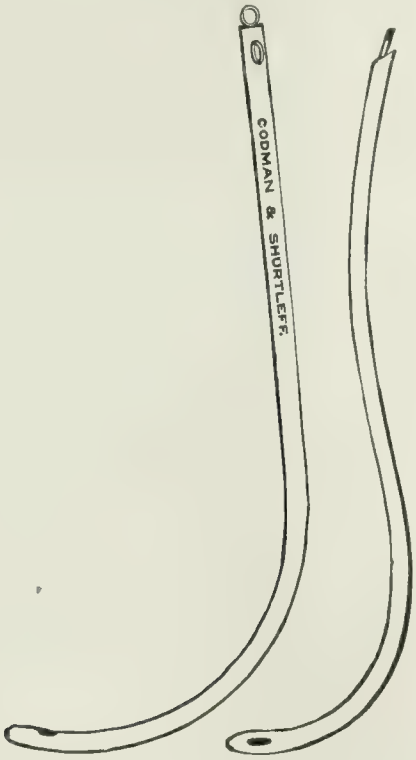


Fig. 4343.—Silver Catheters of Curve Appropriate for Use through an Enlarged Prostate.

done without the exercise of much force, as the point, when properly guided, slips along quite easily and when it catches there is danger of its making a false passage if pushed.

If the gum-elastic catheter is introduced with a stylet it should be curved into the form of a prostatic silver catheter. (Fig. 4343.) Sometimes, when the point catches it may be lifted over the obstruction by the simple maneuver of slowly withdrawing the wire while slightly advancing the instrument. This curls the point upward and often enables it to ride over the obstacle.

Occasionally, when other flexible instruments fail, the French conical bougie catheter will succeed in worming its way through the canal. It should be used with great caution, as its comparatively sharp point may catch in and perforate the mucous membrane.

Failing with other instruments, we may have recourse to a metallic catheter of large curve.

The beak of this instrument should be long enough to reach easily through the enlarged prostate, which may be one inch and a half longer than in the normal state. If the curve is too short the point does not reach the bladder, but being engaged in the prostate, runs considerable risk of making a false passage when the handle of the instrument is depressed.

The forefinger in the rectum may give great assistance in guiding the passage of this catheter.

In using any instrument in a urethra with false passages it is a good plan always to withdraw for a considerable distance when the point is caught, and then to try to pass the pocket by carrying the beak down first one wall and then another until the right passage is found. Ordinarily the false passages exist in the floor of the urethra; but this rule has many exceptions.

If, in a case of complete retention, after careful and thorough attempts we do not succeed in reaching the bladder, recourse must be had to puncture with trocar or aspirating needle.

This was formerly done through the rectum with curved trocar, but as this method cannot be used antiseptically the suprapubic puncture is to be preferred. This may be done with a fine needle introduced close above the pubis, and, if necessary, may be repeated two or three times daily for a considerable time. Usually, however, drawing off the urine in this way is followed by such a subsidence of the swelling as presently to allow the introduction of the catheter.

The evacuation of a distended bladder, whether by catheter or by aspiration, should be performed slowly and carefully. When the distention is extreme, the bladder should not be wholly emptied at one time, for if the internal pressure is too suddenly relieved we are likely to have a great congestion of the vesical mucous membrane, with the escape of blood into the urine, followed often by considerable inflammation.

The greatest care should likewise be taken in the matter of thorough antiseptic cleanliness, as the introduction of germs into the bladder may start a fermentation of the urine with cystitis. It is of course important, whenever a catheter is entrusted to a patient, that careful instructions should be given to him in regard to this.

Catheterization having been commenced, how often should it be repeated?

In the cases of partial retention with moderate residuum, the use of the catheter each night before retiring is usually sufficient. As the disease progresses, however, a point is presently reached when the bladder habitually holds from six to eight ounces of residual urine, and the calls to urinate are consequently pretty frequent. Under these circumstances the regular use of the catheter is required.

If now the patient can get along comfortably while using the catheter four times a day, he is fortunate, and may live for twenty or more years with his artificial urination. Not infrequently catheterization will be required six, seven, or even more times in the twenty-four hours. Especially is this the case when cystitis is present. The water should always be drawn when the desire to micturate is urgent and persistent.

When catheterization is required so often as to become a decided source of irritation, and if the bladder is so irritable as to be constantly liable to painful contractions, it will be found best to tie in the catheter for a time (sonde à demeure). Usually in a few days,

after the bladder has had a rest, the catheter can be again left out and the patient can resume regular catheterization.

During the time while the patient is becoming accustomed to the use of the catheter and the bladder is acquiring a tolerance of instrumentation, it is wise to give some urinary antiseptic almost as a routine measure. Of the antiseptics now at our command urotropin and sandal oil are the most useful. Urotropin may be given in doses of five to eight grains two or three times a day, and is a most useful drug, but it will occasionally act as an irritant, especially in the presence of ulceration of the prostate, and in these cases sandal oil is to be preferred. Sandal oil is a more soothing drug, and is especially useful where the tendency to irritability of the bladder exists.

Third Period. In this stage of the disease, systematic emptying of the bladder is as urgently called for as at any earlier time. The serious changes, however, which are likely to have occurred in the urêters and kidneys, with the condition of passive congestion which exists throughout the urinary tract, make the use of the catheter a matter of considerable danger.

In these cases the patient's condition of comparative health—troubled, it is true, by frequent and often partly involuntary micturition, but not debarred from ordinary occupations—makes a striking contrast with the state of things which may rapidly develop upon entering on the "catheter life." For a slight added irritation to the bladder may be suddenly followed by a pyelonephritis, or even more abruptly by renal congestion with suppression, uremia, and death.

These dangers are alarming and imminent enough to make us hesitate, but what is to be hoped from allowing the disease to take its course? Nothing, but a certainly fatal issue, which is likely to come in a few weeks or months, and which may be precipitated at any time by an exposure to cold, by fatigue, or by a slight indiscretion in diet.

On the other hand, when catheterization is successfully established, the disease may be moved back from the third to the second stage, and the patient who was in such danger may be put in a state of comparative security.

The precautions to be observed in accustoming the patient to the catheter are the same that are required in the second stage of the disease, but they are now even much more important.

Especially should the sudden emptying of a distended bladder be guarded against. It may often require two or three weeks of catheterization before the bladder acquires such tolerance that it may safely be left empty.

During the preliminary period the catheter should always be passed with the patient horizontal, to guard against the too rapid flow of water; afterward, when the complete emptying of the bladder is desired, the vertical position is the best for this operation.

Operative Treatment.—It is impossible in the space at our command here to do more than suggest the outlines of operative treatment and of the more important procedures.

Radical operations aim at a cure; that is, at the complete restoration of the function of urination and that with as little risk to life as possible and with as little damage to other structures and functions as may be. While they often fall far short of this ideal, yet the majority of cases are practically cured. Perhaps the main reason why operative treatment has not been more generally successful is to be found in the age of the patients, for in the majority of cases we have to deal with men between fifty and eighty years of age, and it is obvious that severe operations become more dangerous with advancing years.

Operation during First Stage.—As the symptoms of the first stage are largely those of engorgement and irritability, comparatively few patients will be seen at this time, and as it is obviously impossible to decide definitely how long a time may elapse before a patient reaches the second stage, or whether this stage will be reached at all, it is seldom that patients in the first stage are to be advised that an operation should be done. Of course, it must be admitted that the earlier such operations are done, the better, if they are to be done at all, but the progress of this disease is so variable that sound conservatism will rarely be found in favor of operation at this time.

Operation in the Second Stage.—The second stage of prostatic enlargement is, as will be remembered, that of beginning obstruction. At this time, the bladder will usually be in good, or, at least, fair condition, and comparatively little damage will have been done to other parts of the urinary tract. This time is, therefore, in most cases the time of election for radical operative procedures. The patient is usually not too advanced in age, his blood-vessels are probably in good condition, and the bladder and kidneys have not been irreparably damaged. If, however, a patient, though in the second stage, be found to have evidences of a chronic nephritis, a damaged heart, or sclerotic arteries, the outlook will be correspondingly less favorable.

Operation during the Third Stage.—The third stage being that of complete obstruction accompanied as a rule by more or less damage to the kidney will be an unfavorable time for radical operation. The mortality at this time is greater than in the second stage, and there is little hope of restoring completely, or even in great measure, the function of the bladder. These patients may sometimes, however, by careful catheterization or drainage of the bladder, be so improved that an operation can later be resorted to with reasonable hope of success. Hitherto the rule has been to resort to radical operations only in the more difficult and desperate cases. As a result of this practice the mortality of such operations has been high.

The ideal time to choose for interference is as soon as it is sure that the obstruction is progressive and is going on to more and more retention and damage. Could most of the operations be done at this early date, the mortality would doubtless be much lower.

Unfortunately, patients at this stage of the disease are usually too comfortable to be willing to face the risks of operation.

The Various Operative Procedures.—The prostate may be attacked by two routes, the perineal or the suprapubic. If the lower route be chosen two quite distinct methods of attack still remain: 1. The intraurethral method of enucleation. 2. The transprostatic method.

1. *The intraurethral method* is the older and was in fact the original prostatectomy done by this route. Of this there are two types: (*a*) The older employs the median perineal incision which opens the membranous urethra and proceeds directly to the enucleation of the lobes by means of the finger introduced into the prostatic urethra. (*b*) The other, which is practically the method of Proust, employs the curved prerectal incision, avoids the membranous urethra and makes its attack directly upon the prostate either by a median incision on the posterior surface or by enucleation with the finger introduced directly into the apex of the prostate.

This (the intraurethral) method successfully removes the obstruction by directly attacking the hypertrophied portion through the urethra at a point where the tumor is covered only by mucous membrane and where the line of cleavage can readily be found. It attacks the tumor in a manner very similar to that employed in the suprapubic operation.

With the older median incision there was considerable danger of destroying both sphincters of the bladder. With the newer operation employing a prerectal incision with the external sphincter is avoided and the danger of incontinence is practically eliminated. The nature of the operation is such that in

many hands fistulæ will occur, the commonest the urinary and occasionally the rectal. In the vast majority of cases they close in a few weeks but they may persist. Because of the nature of the operation it may be safely concluded that the function of potency is likely to be adversely affected.

The mortality of these operations in good hands is low.

2. *The transprostatic method* consists essentially in making a somewhat oblique incision in each posterior lobe (the so-called capsule) and through these under the direct guidance of the eye enucleating the prostatic tumor. The very great danger and even probability is that in the hands of most operators at least, some portions of the tumor will be left behind to continue growth; in other words the tumor is not completely removed. The mortality is low and other postoperative complications are not more common than in the other perineal operations.

Suprapubic Prostatectomy.—This operation removes the obstruction with more certainty than any other method because the attack is made directly on that portion of the prostate chiefly involved. It avoids entirely damage to other organs, damage to the rectum and sphincters being practically unknown. In the preservation of potency it is unquestionably superior to any other operation. The only fistula which can occur is that communicating directly with the bladder and this will happen only in case of failure to remove the obstruction which in the presence of hypertrophy can hardly occur. The mortality of this operation however is higher than that following the perineal operation, and must average about twelve to fifteen per cent.

To sum up: the suprapubic route is more likely to result in a cure but has a higher mortality; the perineal route is less likely to result in a perfect cure but has a smaller mortality.

The Chetwood Operation.—This is applicable to cases of fibrous prostate or prostatic bar and consists in burning through the obstruction with a galvanocautery. A perineal incision is made, the urethra opened and the instrument introduced into the bladder. With a finger in the rectum to act as a guide one median or a V-shaped groove is burned in the obstruction.

It is important to remember that the careful selection of the operation best suited to each case is of the first importance, and it is, therefore, often wise to examine the bladder carefully with the cystoscope before deciding which operation should be undertaken, or whether any operation is likely to give permanent relief.

Orchidectomy and Vasectomy.—The subjects of operative treatment of prostatic hypertrophy can hardly be dismissed without making mention of two operations which have been advocated for the relief of the condition.

The operation of double orchidectomy, which was ably advocated by White, had many advocates at the time of its introduction. In some cases it appeared to give very marked relief in cases of congested prostates, but this relief was but temporary, and in the most favorable cases never resulted in radical cure. It was followed in a few instances by very marked mental symptoms, amounting in certain cases to insanity, and this, together with the frequency of total failure to relieve the symptoms, has made it an operation which is never to be advised, and the interest in it at present is entirely historical.

Vasectomy.—This operation, which consists of the ligation and division of both vasa efferentia in the region of the external inguinal ring, was strongly advocated by Mr. Harrison. It was hoped that it would have a result equally favorable with that of orchidectomy, but without its unfortunate results. This hope has never been justified, and the operation seems to be valuable largely for the relief of those cases in which recurrent attacks of acute epididymitis are a serious cause of discomfort to the patient. It can be done if desired under local anesthesia, and its technical details present no difficulty.

Treatment of Complications.—Cystitis, which is the most common complication of prostatic hypertrophy, is to be treated according to the rules laid down under *Bladder, Diseases of*, in vol. i. of this Handbook. When it occurs in the first stage of the disease, general treatment is first to be thoroughly tried, and local treatment through a catheter is to be resorted to only when simpler measures fail. In the second and third stages, when partial retention exists, the systematic evacuation and irrigation of the bladder is the most efficient means of treatment at our command.

Nephritis, or pyelonephritis, must be treated on general principles. Mustard poultices over the lower dorsal and lumbar regions are indicated during the acute stage, with, afterward, careful rubbing and friction to keep up the action of the skin; a bland, nonstimulating, but nutritious diet in abundant quantity; and regulation of the bowels. If uremia threatens, pilocarpine and hot-air baths may be used to promote elimination, and to relieve the congestion of the kidneys.

A stone in the bladder can usually be removed readily by litholapaxy through an enlarged prostate, unless it is of great size and hardness, or unless the careless use of instruments has produced false passages. The pocket behind the prostate often holds a small stone concealed, and makes it hard to seize, in which case the hips may be raised so that the stone rolls back toward the fundus, where it is easily found and crushed.

When micturition is very difficult, it may sometimes be thought wise to remove small stones by perineal incision, in the hope of at the same time relieving the obstruction.

When litholapaxy is impossible on account of the size and hardness of the stone, it is usually necessary to resort to the suprapubic incision. But in the presence of an obstructing prostate a suprapubic cystotomy wound heals with great difficulty and it may be necessary to remove the obstruction to heal the bladder.

Atrophy of the prostate may occur as the result of mechanical pressure, or of destruction of portions of the organ by inflammation. It may also appear in the course of an exhausting disease, or as a consequence of old age. It gives rise to no symptoms and calls for no treatment.

Tumors of the Prostate.—These may be classified as follows:

Cysts	Retention cysts.
	Hydatids.
Myoma	Adenomyoma—the
Adenoma	so-called hypertrophy.
Sarcoma	Round cell.
	Spindle cell.
	Lymphosarcoma.
Carcinoma	Scirrhus.
	Colloid.

Retention cysts formed from dilated gland acini occur in many old prostates. They are always small, and give rise to no inconvenience. Their contents are sometimes inspissated, forming little concretions.

Hydatid cysts of the prostate are so rare that Thompson could, in 1883, learn of but one; and even in that case it is doubtful whether the cyst started in the prostate or near it. When discovered they should be at once emptied.

Pure myoma is very rare; adenoma is somewhat less so, but adenomyoma is the most common of prostatic growths, inasmuch as we, to-day, recognize that all cases of so-called hypertrophy are adenomyomas.

Sarcoma is occasionally observed in the prostate, where it may start primarily, or to which it may

transplant itself from the testicle or elsewhere. It usually appears early, but may develop late in life.

Carcinoma is more common than sarcoma, and appears ordinarily after middle life. It may assume a scirrhus or a colloid type. As has been demonstrated by Geraghty, it is practically always primary in the posterior lobe.

In either of these last two malignant forms of growth there may be a good deal of pain and considerable hemorrhages, especially after instrumentation.

In carcinoma the neighboring lymphatic glands are likely to be early involved.

Any cyst or tumor of the prostate may give rise to symptoms of obstruction. The difficulty of micturition may reach a point at which some operation for its relief will be required. This consists in making a suprapubic opening into which permanent drainage is established. This has a tendency by putting the bladder at rest to lessen congestion and thus slow the progress of the growth. Attempt at removal should rarely be undertaken for once outside the capsule of the prostate the cancer is likely to spread with amazing rapidity. The simple act of drainage will generally give a longer time of life in greater comfort.

Tuberculosis of the prostate occurs only secondarily to tuberculous conditions in other parts of the genito-urinary tract. As patients with genito-urinary tuberculosis usually die when the disease is far advanced, it is rarely possible to decide at autopsy where the disease originated; and as the organs are many of them deep-seated and beyond the reach of physical examination, it is likewise impossible during life to be sure that the prostate was primarily affected.

On the other hand, this gland is situated at the junction of the genital and urinary passages, is as it were at the crossroads through which any tuberculous material from the kidneys or testicles must go in its passage from the body. This situation makes it peculiarly liable to secondary infection, and, as a fact, it is almost always sooner or later involved.

The tubercles may appear as little isolated gray granules, scattered throughout the tissue of the organ, or they may be agglomerated into masses which, if they reach a moderate size, ordinarily become cheesy in the center and finally break down into abscesses. Sometimes almost the whole prostate is thus destroyed, and its place is occupied by an abscess which usually communicates with the urethra and bladder. It may break through into the rectum, forming a recto-vesical or a urethral fistula directly through the prostate.

The *symptoms* are those of a chronic prostatitis (see above) with a special tendency to hemorrhage. They may be associated with evidences of tuberculosis elsewhere.

Physical examination by the rectum may reveal little or no alteration in the gland. Ordinarily, however, inequalities are felt which may give it a distinctly nodular character. This may be associated with enlargement, or the prostate may preserve almost its normal size.

The ejaculatory ducts and the vesiculæ seminales should be felt for, and if the disease has affected them, they may be found as thickened, resistant, cord-like bodies. This is especially to be observed when the disease started in the testicle and worked its way up to the prostate.

Not infrequently a little shot-like mass is felt between the rectum and the prostate, or it may be a little behind and to one side of the gland. It is not attached to the prostate, rectal wall, or seminal vesicles, but is loose in the tissues between them.

Dr. Bryson, of St. Louis, thought that in one case, in which he had an autopsy, he made it out to be a cheesy mass within a vein. Possibly it is sometimes an infected lymphatic gland.

The testicles, epididymides, and vasa deferentia should also be examined, and the urine should be investigated for evidences of kidney complication and for tubercle bacilli. These last are very difficult of detection in the urine, and their apparent absence does not argue against tuberculosis. When unmistakably present they are conclusive confirmatory evidence. In all cases of doubt the urinary sediment should be inoculated into a guinea-pig.

The physical investigation should also include the examination of the lungs, which may share in the tuberculous process.

Diagnosis.—The disease may be confounded with chronic prostatitis or cystitis, with stone or tumor in the bladder, or with pyelitis when accompanied by frequent micturition.

While a careful consideration of the symptoms and inherited tendencies of the patient may enable us to form a probably correct idea of the condition, it is only by a careful physical examination that we can reach a positive diagnosis.

Besides the examination described above, an exploration of the bladder, under ether if necessary, will be needed for the detection or elimination of stone and of tumor of the bladder.

There will be a certain number of cases in which a diagnosis is at first impossible, and in which the true interpretation of the condition can be reached only when time has developed characteristic symptoms.

Treatment.—Most important is the constitutional treatment with cod-liver oil, hypophosphites, and iodides. A healthy out-of-door life, with moderate exercise and good food, is to be enjoined.

Thompson advises against local treatment, and it is certainly important to avoid rough manipulation.

In the early stages of the disease, however, gentle local measures may serve rather to allay than to excite irritation, and should be tried.

Irrigation of the prostate and bladder may be of service. Occasionally the passage of a sound is useful by removing the contraction of the constrictor muscle. The pain and frequency of micturition may sometimes be much relieved by these means. The use of sandalwood oil is nearly always very soothing; and ascending doses of tuberculin are to be tried as it occasionally is of great benefit.

While the prognosis is necessarily grave, and the permanence of improvement is always doubtful, still these cases are not always hopeless if seen early.

Prostatic Calculi.—In the ducts and dilated tubules of the prostatic glands are found not infrequently little yellowish or brownish bodies, composed of an organic substance allied to protein.

These, if they increase beyond a moderate size, begin to have earthy salts deposited in and around them, and finally become prostatic calculi, which may reach the size of a walnut or even of a larger object.

These calculi are usually multiple, and are facetted from mutual attrition. They are hard, take a high polish like porcelain, and are white or light brown in color.

Chemically, they are composed almost wholly of phosphate, with a slight admixture of carbonate of lime, and are to be distinguished from urinary calculi by the fact that they do not contain any of the triple phosphate of magnesia and lime, which is so large a constituent of vesical calculi.

When prostatic calculi are made out they may be removed by a median or lateral perineal incision. The operation is usually one of no serious danger, as the bladder is not opened.

Hugh Cabot.
Edward L. Young, Jr.

Prostigmata.—A suborder of mites, Acarina, in which there is a soft skin strengthened by special sclerites and, excepting in aquatic species, a pair of

stigmata close to or above the first legs. The following families are included: *Thrombididæ, Tetranchidæ, Cheyletidæ, Eupopidæ, Tarsonemidæ.* These all contain species which attack man. See *Arachnida.*

A. S. P.

Prostitution.—This may be defined as sexual promiscuity for mercenary ends. It is derived from the Latin verb *prostituere,* to expose publicly. It should be clearly differentiated from concubinage or other extralegal sexual relations in which love or passion function as the prime motive. The regular practice of prostitution is wholly mercenary and indiscriminately promiscuous.

Prostitution has existed in all civilized countries, though it is far from certain that, as such, it existed to any extent among primitive peoples. It has always been subject to regulation or repression by law or custom. By reason of the natural monogamous tendency of man—so clearly demonstrated by Westermarck and others—prostitution must be considered as an excrescence of society. Being a manifestation of the sexual function without product it is distinctly antisocial, and being the main factor in the spread of venereal disease it is certainly unhygienic. For these and other reasons it is properly a subject for scientific attention, for only through painstaking observation and research can the prostitution problem intelligently be met.

History.—The earliest form of prostitution with which we are definitely familiar appears to have been associated with religion. For example in Babylon, as recorded by Herodotus, every woman must come once in her life to the temple of Mylitta and give herself to the first man who threw a coin in her lap, in worship of the goddess. In Egypt, Phoenicia, Assyria, Chaldea, Canaan, and Persia, the worship of Isis, Moloch, Baal, Astarte, and other deities consisted of wild sexual orgies; the temples were centers of vice. In Greece, the Temple of Aphrodite at Corinth had over a thousand *hierodules* dedicated to the service of the goddess. Athenaeus mentions the importance attached, in any national calamity, to the prayers of the Corinthian prostitutes. In ancient India there was a connection between religion and prostitution—evidences of which still survive.

The Jews.—Among the Jews the Mosaic law was intended to preserve purity of race and religion. Prostitution itself was not forbidden, but it was to be confined to foreign women. There is ample evidence in the Old Testament that prostitution was prevalent in Palestine; the women were forbidden to enter Jerusalem and places of worship; there is some evidence of distinctive dress.

Greece.—Prostitution in Greece, however, came to take on an economic character and in this rôle was recognized by Solon, who is reputed to have established the first brothel, for the benefit of the youth of Athens. The ascription of inaugurating state regulated prostitution to Solon is very frequent, but the authority for the statement is not usually known. This exists in the work of a Greek-speaking Egyptian of Naucratis, a rhetorician and grammarian, who flourished about the end of the second and the beginning of the third century A.D. His principal work which has come down to us is the *Deipnosophistæ* translated as the Deipnosophists and probably meaning "dinner-table philosophers." It consists of a clumsy arrangement of quotations from various authors most of whose works have not been otherwise preserved. It is the chief source of our knowledge regarding the intimate morals and customs of the Greeks. The first edition in book form was issued by the Aldine Press in 1524. The passage[1] to which reference is made is as follows:

"And Philemon, in his Brothers, relates that Solon at first, on account of the unbridled passions of the young, made a law that women might be brought to be prostituted at brothels; as Nicander of Colophon also states, in the third book of his History of the Affairs of Colophon—saying that he first erected a temple to the Public Venus with the money which was earned by the women who were prostituted at these brothels.

"But Philemon speaks on this subject as follows:

"'But you did well for every man, O Solon;
For they do say you were the first to see
The justice of a public-spirited measure,
The saviour of the State—(and it is fit
For me to utter this avowal, Solon);—
You, seeing that the State was full of men,
Young, and possess'd of all the natural appetites,
And wandering in their lusts where they'd no business,
Bought women, and in certain spots did place them,
Common to be, and ready for all comers.
They naked stand; look at them well, my youth—
Do not deceive yourself; aren't you well off?
You're ready, so are they; the door is open—
The price an obol; enter straight—there is
No nonsense here, no cheat or trickery;
But do just what you like, and how you like.
You're off; wish her good-bye; she's no more claim on you.'"

The Greek *dikterion* or house of prostitution was under State regulation, and was restricted to location in certain portions of the city. The *dikteriades* were excluded from the upper portions of the city, and were placed under other specified restrictions. A distinctive form of dress was required, and prostitutes were forbidden to take part in religious services. The laws, however, were not effectually enforced, though they increased in rigor after the Persian wars. The police were given supervision of the *dikteriades,* who were liable to prosecution for various offences—ruining youths, and committing sacrilege or treason.

The *hetæræ,* who were prostitutes rather than concubines, were very superior women—the most gifted members of their class known to history. Their influence and power were such as to place them above the law, and in the test case of Phyrne, the stern attitude of the Areopagus broke down. In later years anyone was privileged to operate a *dikterion* upon payment of a stated tax.

Rome.—Prostitution is in evidence at the very threshold of Roman history and grows in importance and influence during succeeding years.[2] Within the times covered by existing records, however, religious prostitution does not seem to have existed, though immorality of various sorts had thrived. The early Etruscans had a good start in this direction as may be judged by their paintings, and by various written documents.[2] These people had indiscriminate intercourse between the men and women, the latter not considering it disgraceful to appear half-naked in various public exercises. The young men were positively enjoined to engage in intercourse and to have their bodies polished and free from hair. Roman morals were strict with the women and lax with the men; a double standard was thus established. Cato[3] said "If you should have detected your wife in adultery, you might kill her without trial with impunity, but if you were to commit adultery, she would not dare to lay a finger upon you, nor is it lawful she should."

The prime idea of the Roman was pride in his city, to that end he conceived it his duty to be a good father and to bring forth healthy children. He therefore set high store by the virtue of his wife and regarded her as set apart for the end of procreating Roman citizens. For excessive or libidinous desires he felt free to turn elsewhere, and for this reason prostitution was always looked upon with public toleration. In the earlier years of the city, however, the lives of the men as warriors and husbandmen kept them rugged, but as they became more prosperous and came more and more into contact with foreigners,

they began to adopt more public vices. Prostitution then flourished.

Houses of prostitution were known as *lupanaria* and *fornices*. The derivations of the two terms not exactly certain. According to Rosenbaum[4] the usual derivation of the word *lupanar* is from the proper name *Lupa*, the wife of Faustulus.[2] Lactantius says that because of the easy rate at which her person was held at the disposal of all, she was known among the shepherds as *lupa*, a she-wolf, whence *lupanar* is named.

The word *fornix* probably comes from the word meaning "archway." According to Isidore[5] a *fornicatrix* is one whose person is public and common. These women used to lie under archways, and such places are called *fornices*, whence also *fornicariæ*, or whores. Under many houses and walls in Rome were arches whose tops were only a few feet above the level of the street, and these places, dark and deserted, became the resorts of the lower grade of prostitutes.[6] The name of the arches thus gave designation to the act performed in them and we have derived in this manner our word fornication. There is one other possibility suggested by Rosenbaum, that the brothels took their name from their being located in the neighborhood of the town-wall and its arches. Evidence to this effect might be assumed from the fact that many prostitutes were designated as *summænianæ*, or women of the *summænium*, the district under the walls.[7]

In any event, through usage, the *fornix* soon came to have approximately the same significance as the word *lupanar*.

From the earliest days of the Republic, prostitutes were required to register at the office of the ædile, where they received licenses upon payment of a tax. They were kept under strict control, were required to wear a distinctive dress, and to dye their hair or wear yellow wigs, but the most severe feature of the system was that women once registered could never be erased.

Rise of Christianity.—The rise of Christianity as Ellis[8] has pointed out, produced less change of policy than might have been anticipated. "The Christian rulers had to deal as best they might with a very mixed, turbulent, and semi-pagan world. The leading fathers of the church were inclined to tolerate prostitution for the avoidance of greater evils, and Christian emperors, like their pagan predecessors, were willing to derive a tax from prostitution. The right of prostitution to exist was, however, no longer so unquestionably recognized as in pagan days, and from time to time some vigorous ruler sought to suppress prostitution by severe enactments. The younger Theodosius and Valentinian definitely ordained that there should be no more brothels and that anyone giving shelter to a prostitute should be punished. Justinian confirmed that measure and ordered that all panders were to be exiled on pain of death. These enactments were quite vain." But the greatest change introduced by Christianity was the adoption of a more charitable attitude toward the prostitutes themselves.

In France, the most persistent campaign against prostitution was inaugurated by Louis IX, who, in the year 1254, decreed that prostitutes should be driven out of the country, and deprived of their money and goods, even to their mantles and gowns. In 1256 this decree was repeated, and in 1269, before starting for the Crusades, he ordered all places of prostitution to be destroyed. The repetition of such decrees indicates their ineffectiveness. Louis was even unable to suppress prostitution in his own camp in the East. But the legislation was repeated by many subsequent French rulers—and always with the same results.

Middle Ages.—During the Middle Ages the modern theory of regulation first came into force. In London Borough, near London Bridge, was a row of *Bordells* or *stews* which were first licensed by the Bishop of Winchester and subsequently sanctioned by Parliament. The regulations enacted in the year 1161 were protective rather than repressive. In 1383 the bordells were operated under the auspices of the Lord Mayor of London, who leased them out. They were closed in 1506, but soon opened again and operated until 1546, when they were abolished by Henry VIII. The first known regulations directed against the spread of venereal diseases appeared in 1161, when women suffering from "the perilous infirmity of burning" were forbidden the practice of their calling, and in 1430 an ordinance was passed prohibiting the admission to houses of prostitution of men afflicted with an "*infirmitas nefanda.*"

In France a similar state of affairs existed and prostitution was both protected and regulated. Prostitutes were distinguished by a badge, were forbidden to wear fine clothing or jewels, and were excluded from certain parts of the city. Brothels publicly operated were established at Toulouse, Avignon, and Montpellier. In the former city the profits were shared by the city and the university; at the two latter the business was a municipal monopoly, farmed out to individuals.

In Germany the *Frauenhäuser* existed in many places, notably at Hamburg and Ulm. Admission to these houses was forbidden to married men, the clergy, and Jews; and on Sundays and saint's days they were closed. Prostitutes were forbidden to live in respectable quarters of the town or go to the baths with virtuous women. Municipal hospitality to distinguished visitors included the extension of privileges at the *Frauenhäuser*. Sigismund received such satisfactory hospitality in this respect at Bern and at Ulm that he especially complimented his hosts upon this feature of their entertainment.

Modern Period.—At the beginning of the modern period the wide spread of venereal diseases brought about a marked change in the public attitude toward prostitution. Syphilis attracted so much attention at the end of the fifteenth century that it was supposed to have been a new disease introduced from the new world by members of the Columbus party. The Reformation also brought another influence to bear against the wide extension of prostitution. Ulm closed its last *Frauenhäuser* in 1531, Basel in 1534, Nürnberg in 1562. The London bordells were abolished in 1546. Paris prohibited such establishments in 1560. From this time on municipally operated brothels are not encountered. In the seventeenth century there was new enthusiasm for the suppression of prostitution. In 1635 a Paris edict condemned men concerned in the business to life service in the galleys. Women and girls were to be whipped, shaved, and banished for life without formal trial. The English Puritan enactments were equally severe; fornication was punishable by three months' imprisonment. But these strictures had a temporary effect only, and a reaction soon set in.

From this time on the Continental system of reglementation was developed to a high degree. Reglementation has as its objects the toleration of prostitution rather than its authorization by the state, the protection of health through medical inspection, and the preservation of order through police control. In order to attain these ends, prostitutes were registered, usually by a "morals police," and subjected to constant supervision. In many cases they were required to live in certain streets. The medical examination varied in different cities and at different times; and it was usually conducted by physicians regularly attached to the special police force. The system was widespread in Germany and in France, and there was a somewhat similar regulation undertaken in England under the authority of the Contagious Diseases Acts.

This system gained a strong foothold, and the

general practice was well-nigh standard. The first reaction was a moral one, represented by the crusade inaugurated by Josephine Butler in England for the repeal of the Contagious Diseases Acts. The main object of this movement was to abolish any State sanction for vice, either real or apparent, and to prevent the degradation of the women involved by registration as professional prostitutes. One of the strong coordinate arguments advanced was that the vaunted protection to health was not effective and that there was no safety in the regulation system.

This campaign was successful in England and the Contagious Diseases Acts were abolished. They were also later abolished as applying to India. Mrs. Butler then carried her campaign to the Continent, and stimulated the formation of societies in both France and Germany. These latter came to be very active, and have exerted a powerful influence against the system of regulation, which however they have found to be very firmly entrenched. At the present time the regulation system still prevails in France, Germany, Austria, Italy, and Japan.

Japan.—In character, the situation as regards prostitution in Japan is unique. In practically no locality are the two features of segregation and detailed inspection and oversight combined; as there exists no law entirely forbidding an institution which has demonstrated the impossibility of its suppression, there is no opportunity for corruption in its protection. From a business standpoint, the management is carried on in the light of day, and the low and disgusting features engendered by an underground activity are absent.

In Yokohama the conditions are fairly typical. The main street of the *Yoshiwara* is over a mile long. On each side it is lined with houses of prostitution; in front of each is a cage-like show window in which are seated some of the girls. In a great many there is a frame nearby in which are exhibited pictures of the various prostitutes and under each is the fixed price of her fee. It is therefore possible for the prospective patron to know in advance the charge he will incur. The fees are low, being very seldom over ten yen (five dollars) even in the most sumptuous houses, and they are generally much less.

All traces of vice are rigorously excluded from the other parts of the city. Houses of prostitution are practically impossible of existence, nor is there any street solicitation. The social evil does not, therefore, obtrude itself on the people. When any one wishes to avail himself of the facilities of the Yoshiwara, it is necessary for him to make a premeditated trip to a distinct and comparatively remote section of the city.

In *China* conditions are not at all standardized and vary in different localities. One feature is the "flower boats," which are anchored in the rivers. On these are flower-girls and prostitutes who are available to visitors. In the cities the "blue houses," so called from the color of their shades, afford similar accommodation. In several European colonies in China, Shanghai for example, there have been sporadic efforts at regulation and medical inspection.

The Regulation System.—Scientific studies of prostitution regulation have demonstrated its ineffectiveness as a hygienic protection. Examinations such as it is practical to make regularly under police auspices cannot be thorough enough to detect with surety the presence of venereal disease, either gonorrhea or syphilis. Furthermore there is no possible protection against infection by a woman who has herself contracted one of these diseases at a period subsequent to her last examination. In exhaustive studies of the physical condition of prostitutes it has been found that a very large number of them have syphilis in a chronic form which, while not apparent, would make the woman a dangerous focus of infection. The wide prevalence of venereal diseases in the cities where reglementation is most thorough would further discredit the efficacy of the system.

From the point of view of order reglementation has several defects. It cannot include the whole scope of prostitution, because it is generally agreed that the clandestine prostitution is as extensive in European cities as the prostitution under formal control. In the second place, no European country has had the temerity to register minors, and a large proportion of the business is carried on by girls under the legal age. It may be safely asserted that not half of the prostitution business even in a carefully regulated city is thus subject to control.

Reglementation has had active opposition recently in Germany under the leadership of Professor Blaschko, and in France under the direction of Dr. Fiaux.

In the United States the reglementation system never gained an extensive footing. It was tried for a while in St. Louis, and more recently in San Francisco, but was each time displaced through the efforts of the moralists. Up to very recent years, however, every American city had a tolerated district within which houses of prostitution operated practically without hindrance other than the necessity of paying for police protection. During the last five years the American situation has undergone a radical change. Beginning with the investigation of conditions in Chicago by the Vice Commission of that city, similar studies were made in most of the large communities throughout the country, notable in New York, Philadelphia, Boston, Syracuse, and Portland, Oregon. These investigations led to the practical abolition of regularly established houses of prostitution. This does not mean, of course, that prostitution has been abolished, but merely that the open and established evidences of it have been mitigated. The old "parlor house," which was the well-known institution, has practically disappeared, and such prostitutes as remain are now operating on a more individual basis. The "call house," usually located in apartments, has considerable vogue, and individual girls have their clientèle of customers. The main feature of this change is the suppression of prostitution as a public institution. To illustrate this: eight years ago it would have been possible in a metropolitan city for a large party of men to secure immediate accommodation in a known district; today this would be almost impossible.

The campaign against prostitution in America has secured desirable results in the improvement of order and decency through the abolition of the old-style houses. The objects of the movement are stated to be moral and sanitary, but it is unfortunate that up to the present time the possibilities of venereal prophylaxis have been almost entirely neglected, the efforts being almost exclusively moral. Sex education has been advocated, the treatment of venereal diseases after their contraction has been promoted, but purely sanitary measures have been opposed rather than encouraged.

Causation.—There has been much controversy, in both scientific and moral circles, regarding factors in the causation of prostitution. This is so large a question as to defy decision, but some of the features involved may be briefly mentioned.

The most significant fact is one which has been developed in recent studies of prostitutes who have come under the jurisdiction of the law. A considerable percentage of such girls have been found mentally defective, persons unable to take care of themselves under the normal conditions of their environment.

The economic factor is also of moment, though this is probably of secondary rather than of primary import. It is likely that few girls enter upon a life of prostitution because it is absolutely impossible

for them to earn their bare support by other means, but it is very likely that many are influenced toward prostitution as a means of livelihood by reason of the more lucrative earnings which it affords and the consequent enjoyment of good clothes, better food, and some of the luxuries which would be otherwise impossible of attainment. A negative economic influence is the unattractive conditions of employment that are open to the average girl of the working classes to-day.

The same tendencies, be they hereditary, anthropological, or otherwise, which lead men to crime—as has been pointed out by Aschaffenburg—attract women to a life of prostitution. Thus in families of distinct criminal tendencies the women have become prostitutes where the men have become thieves.

Another causative factor must be sought in the sexual constitution of the women themselves. There are many women sexually hyperesthetic, nymphomaniacs in greater or lesser degree, to whom a prostitute's existence offers much of attraction. This question has not yet been competently investigated, but should receive much wider attention. Weininger, in his analysis of feminine sexuality,[9] has pictured a scale of which motherhood is one extreme and prostitution the other, the mother being interested in sexual relations for the children which they produce, the prostitute being interested in sexual relations for passionate reasons only. Between these two extremes, Weininger held that there existed women of all intermediate degrees.

The present social opprobrium which is visited on any slight defection from conventional standards, tends to ostracize girls and women from the precincts of respectable society and doubtless encourages many to enter on prostitution who would not otherwise be so disposed.

The so-called "white slavery," which has received so much popular attention of recent years, has suffered greatly from exaggeration; but that coercion of girls in one form or another exists is not to be doubted. This coercion may be exerted through ignorance of the language on the part of the girl, or through terrorism by pimps or proxenets. These measures of exploitation are real coercive forces, but the rôle played by actual physical abduction is practically negligible.

Prostitution as a Business.—One of the principal objections to prostitution in modern times has been its extensive commercialization. There has existed a highly perfected business organization to exploit its profitable aspect. The facilities have been extended and advertised, demand has been stimulated by every possible artifice, and provision has been made in excess of normal demand. Where the commercial features of prostitution have been seriously restricted the question has decreased greatly in importance.

In this connection mention may be made of the rôle played by alcohol in promoting patronage of prostitution. It has been clearly demonstrated that a large proportion of first-time venereal infections have been accomplished while the subject was under alcoholic influence. It has further been shown that the business of prostitution has suffered a serious setback when the sale of alcohol in regularly constituted houses has been forbidden. The intoxicating liquors have seemed a necessary concomitant to profitable exploitation. This should not be regarded as a feature of overwhelming importance, but as one which is certainly worthy of careful consideration.

The Study of Prostitution.—Prostitution received practically its first scientific consideration with the exhaustive work of Parent-Duchatelet on prostitution in Paris in 1836.[10] There next appeared a scholarly study of prostitution in classic times by Julius Rosenbaum.[5] The same year appeared a continuation of Parent-Duchatelet's work by Béraud in Paris.[11] The first English contribution was by Dr. Michael Ryan, dealing with prostitution in London.[12] The best known piece of early American work was by Dr. William M. Sanger, who wrote a history of prostitution, with an appendix on conditions in New York in 1859.[6] Recent important contributions to the study of prostitution have been published in book form or as periodical articles by Alfred Blaschko, L. Fiaux, Yves Guyot, and Havelock Ellis. A monumental work on the history of prostitution, of which one volume has already appeared, is by Iwan Bloch.[13] This goes into the subject with a minuteness not before attempted. An interesting study of the workings of reglementation on the Continent is contained in a recent report by Abraham Flexner.[14] The most important journal is the *Zeitschrift für Bekämpfung der Geschlechtskrankheiten.*

Douglas C. McMurtrie.

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Protagon.—Protagon is the name applied to a crystalline substance which may be extracted from nervous tissue, and containing nitrogen and phosphorus. Recent investigations have shown that protagon is undoubtedly a mixture of cerebrosides and phosphatides instead of a chemical entity.

F. P. U.

Protamines.—The protamines are very simple proteins which are characterized by their basic properties. They yield comparatively few amino acids upon decomposition and those of basic nature predominate. They are the simplest natural proteins, and are present for the most part in the spermatozoa of fish.

F. P. U.

Proteans.—If certain of the simple proteins are allowed to stand in contact with water, dilute acids or enzymes a change occurs whereby those proteins no longer show their original solubilities. The new substance formed is called a *protean* and it is assumed that the change in solubility is due to a slight hydrolysis of the protein. The new product, or protean, is regarded as a derivative of the native protein and, hence, has been classed with the group of *Derived Proteins.*

F. P. U.

Protease.—A protease is an enzyme capable of digesting or hydrolyzing protein. Pepsin and trypsin may be taken as the best known examples of proteases in the body.

F. P. U.

Protein is an organic compound of complex chemical structure containing carbon, hydrogen, oxygen, nitrogen, and sulphur, and sometimes iron and phos-

phorus. The proteins constitute one of the three great classes of organic food stuffs and their specific function is to supply nitrogen to the body for reconstruction of cellular material. See *Aliment.*

F. P. U.

Proteoses.—Proteoses may be regarded as protein products of profound disintegration of the protein molecule and their formation may be induced by the action upon protein of acids, enzymes, or the processes of putrefaction. Proteoses are also called albumoses, but it seems best to retain the name proteoses as a general term and the name albumoses as a designation for a specific type of proteoses, namely, that formed from albumin. The proteoses are characterized by being soluble in water, diffusible through parchment paper and are not coagulable by heat. They are differentiated from the peptones by being precipitable from solutions saturated with ammonium sulphate. The proteoses, like the peptones, represent a stage in the digestion of protein. There are several types of proteoses—namely, protoproteose heteroproteose, and deuteroproteose. At present the chemistry of the proteoses is in rather a confused state so that any attempt to give a more detailed recital of their peculiarities would be of little value.

It should be mentioned, however, that when injected intravenously into the dog or cat proteoses produce a marked fall in blood pressure, a retardation of blood coagulation and the production of a transient glycosuria—in short, a condition of shock is induced—resembling closely that produced in anaphylaxis.

F. P. Underhill.

Prothrombin.—When blood is shed it is assumed that the corpuscular elements the leucocytes or blood platelets or both, lead to the formation of a substance *prothrombin* which by the action of calcium is transformed into thrombin. Thrombin acts upon fibrinogen of the blood-producing fibrin, hence, the formation of a clot. See *Blood.* F. P. U.

Protista.—A general term which includes all unicellular organisms—Protophyta, single-celled plants, and Protozoa, single-celled animals. Such a classification is often convenient, for the activities of many of these simple plants and animals are similar, and furthermore, there are many unicellular organisms which either have both plant and animal characteristics or have not yet been classified with certainty.

A. S. Pearse.

Protomastigina.—A tribe of flagellates. Food is taken in at some definite point near the base of the flagellum; with one or more simple contractile vacuoles; without color and usually with reserves of fat; holozoic, saprophytic, or parasitic. Genera included are: *Cercomonas, Monas,* and *Bodo.* See *Protozoa.*

A. S. P.

Protomonadina.—An order of flagellates. It is composed of small species which have no rigid pellicle and may perform ameboid movements, have one to three flagella, and often an undulating membrane. This group includes many parasitic protozoans, such as the trypanosomes, cercomonads, etc. See *Protozoa.*

A. S. P.

Prunus Virginiana.—U. S. Wild Cherry. The dried bark of *Prunus virginiana* L. (Fam. *Rosaceæ*), collected in autumn.

The botanical nomenclature of this plant has had a most checkered history. The drug was originally introduced as the product of the species above named. Later it was reported that this name belonged to the "choke-cherry," the bark of which is worthless for medicinal purposes, and the one here discussed was named by Ehrhardt *P. serotina,* under which name it has since been official. Recent discoveries show conclusively that Linnæus actually did give the name *P. virginiana* to the tree which yields our drug, and by this name it must hereafter be known, that of *P. serotina* Ehrhardt being a synonym. Most botanists now believe that the section of Prunus to which this belongs, with flowers in racemes, should be recognized as a separate genus under the name *Padus. P. virginiana,* thus understood, is a large, graceful tree, with spreading, slender branches covered with red or purplish, smooth, shining bark; that of the trunk, however, is dark and exfoliating. Its wood is the valuable cherry, so extensively used for house-finishing and cabinet work. In general aspect it resembles the domestic cherry trees, but is much larger and has a rounder and more spreading top. The flowers are small (less than one centimeter across) and borne in long, slender, rather erect, terminal racemes. Calyx cup-shaped, five-toothed. Corolla, of five reflexed, broadly obovate white petals. Stamens, twenty or so, perigynous. Ovary, simple, one-celled, two-ovuled. Fruit, a round, black, bitterish-sweet drupe, nearly one centimeter in diameter. Stone, one-seeded.

The wild cherry tree grows in nearly all parts of the United States and Canada. In the Middle States, and in some of the Western ones, it is very abundant and large; in the extreme South it is less common, and in New England, although common, it does not attain its maximum size.

Wild cherry has been recognized by each edition of the Pharmacopœia, from the first, in 1820, to the present. Although occasionally employed in Europe, it is essentially a local drug.

The bark should be collected in the autumn, when its hydrocyanic odor and taste are the most perceptible, and that of the root, moreover, is said to be preferable to that of aërial portions; but it is an abundant and cheap drug, largely called for in domestic and other informal medicine, and apparently indiscriminately gathered. Much of it is nearly devoid of its proper odor. The description is as follows: "In curved pieces or irregular fragments, one-twelfth of an inch (two millimeters) or more thick, outer surface greenish brown or yellowish brown, smooth, and somewhat glossy, marked with transverse scars. If collected from old wood and deprived of the corky layer, the outer surface is nut brown and uneven; inner surface somewhat striate or fissured. Upon maceration in water it develops a distinct bitter-almond odor; its taste is astringent, aromatic, and bitter. The bark of the small branches is to be rejected." The spurious bark of the choke-cherry is much thinner and tougher, consisting largely of bast fibers, which are lacking in the genuine.

Wild-cherry bark contains substances analogous to the *emulsin* and *amygdalin* of bitter almonds. Upon being macerated in water and subjected to distillation it yields *hydrocyanic acid* and a *volatile oil* having the properties of that of almonds. It also contains *tannic acid.*

Wild cherry is used as a sedative bitter tonic and a sedative expectorant; the sedative property due to its hydrocyanic acid, the bitter probably to its amygdalin only. It is somewhat astringent.

The above qualities express its entire value as at present understood. As a substitute for quinine it is entirely obsolete. Dose ʒss.–j. (2.0–4.0). The fluid extract (*Extractum Pruni Virginianæ,* strength $\frac{1}{1}$) and the infusion (*Infusum Pruni Virginianæ,* strength $\frac{1}{100}$) are official, and represent it well. The syrup (*Syrupus Pruni Virginianæ,* U. S. P., fifteen per cent.)

is frequently used as a basis for cough mixtures; its taste is rather pleasant.

Allied Plants.—See *Almonds, Bitter and Sweet.*

Allied Drugs.—Cherry-laurel leaves, Peach seeds, and also Almonds and Hydrocyanic acid.

H. H. Rusby.

Prurigo.—Prurigo is a malady *sui generis.* The condition usually appears about the end of the first year, but may appear as late as the thirtieth year. The affection usually starts as a lichen urticatus, the characteristic lesions of prurigo appearing later. There are two forms: prurigo ferox or Hebra's prurigo, and prurigo mitis, but a distinct line cannot be drawn between the two. In prurigo ferox there are repeated eruptions of pale red or skin-colored miliary papules, which itch violently. This eruption is generalized, but it is thickest on the extensor surfaces of the lower extremities. The papules are so small and project so slightly that they often cannot be seen, although they can be felt. Scratching produces excoriated tips, and these become covered with blood crusts. Other lesions appear as the result of scratching, such as excoriations, pustules, crusts, pigmented areas, and a dry, scaly, and thickened skin.

During the first few years wheals are frequently found, but they disappear as the papules increase. A secondary eczema in all forms may also be seen. In nearly all cases there is enlargement of the superficial lymphatic glands, the femoral being most marked. The flexures are usually free from eruption. As a rule, the eruption diminishes upon the advent of summer. This form is incurable, but the patient can be relieved to such an extent as to be free from the eruption at times. In prurigo mitis the papules are fewer and the itching is less; consequently the secondary lesions are much milder. Most of the cases met with in this country are of this type. In some of these cases a perfect cure may be obtained by careful and persistent treatment. When untreated, prurigo has a marked effect on the patient both mentally and physically.

Etiology.—In discussing the causation of this affection we can do no more than mention certain conditions with which it frequently occurs. It is usually found in poorly nourished and scrofulous children. Occasionally there seems to be an hereditary predisposition, several children in one family being affected. It is possible that there is some congenital anatomical malformation of the skin as is seen in ichthyosis.

Pathology.—The affection probably starts as a vasomotor neurosis. Microscopically the papules are composed of a round-cell infiltration, with edema of the papillæ. Swelling of rete cells occurs and later there is a hyperkeratosis

Diagnosis.—The diagnosis is difficult at first, as in the beginning the eruption consists mostly of wheals. The condition is also misleading when large eczematous areas cover the lesions of prurigo. The following points are characteristic, and when they are present the disease cannot be mistaken for any other condition: A constantly recurring eruption of miliary papules, resembling in color the normal skin, appearing in early childhood, and most marked on the extensor surfaces; the enlarged glands; and secondary lesions from scratching.

Treatment.—Very little can be expected from internal medication, unless the patients are scrofulous or poorly nourished; in which case cod-liver oil and general hygienic measures will be beneficial.

Crocker speaks highly of cannabis indica as an effective remedy for controlling the itching, as in pruritus. The dose should be gradually increased to thirty minims of the tincture, well diluted, after each meal. Phenacetin and antipyrin are among the most valuable remedies for the itching. Rest, an even temperature, and alkaline or sulphur baths will make the patient more comfortable. For the local treatment, naphtol, sulphur, and tar are the remedies most likely to relieve the itching and decrease the papular eruption. The usual way of using sulphur is by the application of the official ointment or Wilkinson's ointment. Tar can be used pure or diluted with oil or lanolin. Naphtol should be used as an ointment in the strength of two to five per cent. Whatever local treatment is used, it should be vigorously continued until there are no fresh papules and the skin is smooth and flexible. Occasionally it will be found necessary to use first some bland ointment to cure the secondary eczema which so frequently accompanies this condition.

Howard Morrow.

Pruritus.—Pruritus is an affection of the skin characterized by itching without any external cause. It is an independent disease, and must be distinguished from the symptomatic itching common in such pruritic conditions as eczema, scabies, etc. It is a sensory neurosis due to a functional disorder of the nerves independent of any source of irritation on the skin. The symptoms may be so mild as to produce but temporary discomfort, or so severe as to cause profound misery or even such a degree of nervous depression as may result in insanity. Scratching is the patient's method of relief, and the excoriations produced are often preferable to the itching. Although scratching frequently relieves the itching in a certain place, it usually excites it in other parts. From the scratching we may get excoriations, pustules, wheals, and pigmented areas. A rare result of such chronic scratching is the condition called lichenification, in which the skin is thickened and the natural lines are deepened, leading to the formation of irregularly shiny papules. This condition is usually found in the flexures, and is often mistaken for eczema and lichen planus.

Pruritus is either general or confined to certain areas. The former is frequently spoken of as pruritus universalis, and although the itching is general, it is seldom felt all over at the same moment, and there are frequent remissions from any itching. The most frequent causes of this affection are disorders of the alimentary tract, functional derangement of the liver, cancer of the stomach or liver, uterine disorders, malaria, gout, rheumatism, and Bright's disease. Pruritus is always worse when the sufferer is in bed, and is excited by exercise, forced rest, and sudden changes of temperature.

The itching which accompanies jaundice is not a true pruritus, for it is produced by the mechanical pressure of the biliary coloring matter which is deposited in the skin. Senile pruritus is an accompaniment of senile degeneration of the skin. Although it is general, it is usually most marked on the lower extremities. It is very persistent.

Pruritus hiemalis and pruritus æstivalis are terms given to varieties of generalized pruritus which occur during the cold and hot seasons respectively. Some authors consider these forms distinct affections. Pruritus hiemalis is due to the dryness and brittleness of the epidermis which is caused by the cold of winter. Pruritus æstivalis is occasionally found during the warm weather of summer.

In the *local forms*, although we can have itching in any part of the body, the following varieties are most common: pruritus ani, pruritus vulvæ, pruritus scroti, pruritus palmæ et plantæ. Pruritus ani may be due to fissures, hemorrhoids, ascarides, or pelvic tumors producing local congestion. Pruritus of the vulva may be caused by ovarian or uterine disease, diabetes,

or urethritis. Pruritus of the scrotum is usually associated with eczema. Pruritus of the hands and feet is mostly found in the gouty, and frequently is associated with hyperidrosis.

In the different forms of local pruritus it is occasionally impossible to discover the cause. The prognosis of senile pruritus is unfavorable. In the other forms the pruritus will usually cease if the cause is found and removed.

Diagnosis.—All chronic diseases which are associated with itching, such as prurigo, urticaria, scabies, and the irritation from fleas, bedbugs, and lice must first be excluded. It is often impossible to differentiate chronic urticaria, as these two affections frequently occur under the same etiological conditions. Careful investigation must be made as to the presence of any renal, hepatic, or digestive disorders.

The diagnosis of senile pruritus must be made by exclusion. In cases of persistent itching around the anus and vulva, careful examination may show a definite point from which the patient says the itching starts. The skin at this point may appear to be perfectly normal, but it must be treated before the itching will cease.

Treatment.—A great deal depends upon the cause, and the sooner this is found out the sooner the patient may be put on appropriate treatment. The internal treatment is dietetic as well as medicinal. The food should be easily digestible and all stimulating liquids should be avoided. The bowels must be carefully regulated. Calomel followed by saline aperients is often necessary at the start. From now on, the internal treatment must be in accordance with the general principles of medicine, and the condition of each internal organ should be investigated. Of the various internal remedies which are used as nerve sedatives, cannabis indica is the best. Ten to twenty minims of the tincture should be given, well diluted, after each meal. Carbolic acid, gr. ij. in each pill, one after each meal, is recommended by Brocq. Antipyrin acts well at times.

External treatment is necessary even if it is not curative, because it enables the patient to abstain from scratching, and this temporarily relieves the irritated nerves. In the meantime other remedies can be directed to the origin of the trouble.

For general pruritus lotions are preferable to ointments. One of the best is composed of liquor carbonis detergens, ʒiij.; liquor plumbi subacetatis, ʒiv.; glycerin, ʒiv.; distilled water, q.s. ad ʒviij. Another is carbolic acid, two per cent., in camphor water. Bichloride of mercury, gr. ij. to an ounce of fifty-per-cent. alcohol, is a good odorless lotion. A mixture of aromatic spirit of ammonia and water, equal parts, is frequently used.

Five or six ounces of bicarbonate of sodium to an ordinary bathtubful of hot water may be used with advantage. Bran baths are soothing. They should be made by adding from four to six pounds of bran to a tubful of water. After a bath the surface should not be rubbed dry, but should be patted gently with a soft cloth and dusted with some soothing powder. Cases of general pruritus which resist the usual treatment may sometimes be given immediate relief by serum and by autoserum therapy.

For pruritus hiemalis alkaline baths and emollient preparations have proved most serviceable. A two-per-cent. solution of salicylic acid in almond oil is an excellent remedy. Similar applications are indicated in senile pruritus.

For local pruritus, dozens of remedies have been recommended, but until the cause is ascertained most of them will give but temporary results. If the patient can locate a definite point from which the itching starts, the destruction of this point by the actual cautery gives immediate relief. Simpler methods, as a matter of course, should be used at first.

For pruritus ani, mercurial applications give the most satisfaction; such are: ammoniated mercury, gr. xx., in zinc ointment, ʒi.; calomel, ʒi., in lard, ʒi. These two are frequently combined. Hot compresses are very agreeable. Carbolic acid in two-per-cent. solution can be used in a compress or in an ointment. Painting the effected area with a four-per-cent. solution of nitrate of silver is frequently of value. A suppository of extract of belladonna, gr. ss. at bedtime, often gives relief; morphine may be added to this. Cocaine, gr. ss. in a suppository, gives temporary relief. On the surface cocaine is frequently used in a boric-acid ointment, or in combination with menthol, two per cent. of each. Camphor-chloral is commonly used. Hydrocyanic acid, naphtol, and ichthyol are useful at times. Marvelous results are frequently seen in chronic cases of pruritus ani after radiotherapy, given in repeated small doses, or after a massive dose. High-frequency electricity occasionally acts satisfactorily.

For pruritus vulvæ, hot compresses of a saturated solution of boric acid sometimes give relief. Tincture of benzoin painted on the parts daily with a camel's hair brush is also an excellent remedy. Electrotherapy as mentioned under pruritus ani should be used if simpler methods fail. Howard Morrow.

Prussak, Alexander.—Born in 1839 in Russia. He studied medicine in St. Petersburg and then for two years devoted himself to special otological work in Germany and elsewhere. Upon his return to Russia he accepted the Chair of Otology in the St. Petersburg Medico-Chirurgical Academy, the first chair of this branch of medicine established in that city. In 1863 he gave up teaching altogether, and confined his work to the practice of his specialty. He died in St. Petersburg on Jan. 20, 1897.

Prussak's name is sure to find a permanent place in the history of medicine through the fact of his having discovered and described a recess in the mucous membrane on the tympanic side of the drum membrane, between the membrana flaccida and the neck of the malleus—"Prussak's pouch." A. H. B.

Psammoma.—A term rather loosely applied to tumors containing sand-like concretions. *Acervuloma* is often used as a synonym. Such tumors form no distinct neoplasm-entity, for similar calcareous concretions occur in a great variety of neoplasms (endothelioma, perithelioma, sarcoma, fibroma, carcinoma). The term is most commonly applied, however, to sand-tumors of the meninges that show the histologic structure of endothelioma (perithelioma). These arise from the endothelial covering of the outer and inner meninges, particularly from the arachnoid, or from the endothelium or perithelium of the blood-vessels and lymphatics of the meninges. It is rarely possible to determine their origin. They constitute a class of tumors ranging from characteristic endothelioma or perithelioma forms to alveolar round-cell or spindle-cell sarcomas. The typical *endothelioma psammosum* consists of cords and masses of cells, often resembling epithelial cells, with hyperchromatic, pycnotic nuclei, often showing mitotic and amitotic figures. The cell cords follow the vessels and connective-tissue trabeculæ; the cells are frequently arranged in concentric laminated masses (resembling the cholesteatoma) that show a striking tendency to hyaline change followed by calcification. As a result of these changes concentrically laminated or radially striated spherical or mulberry-like concretions are found imbedded in the meshes of the connective-tissue stroma. Deposits of lime-salts also occur in the stroma and in the

blood-vessels following a connective-tissue hyaline change. Spicules, needles, and calcareous trabeculæ are formed in the stroma, while the calcified blood-vessels appear as calcareous clubs, knobs, or cylinders. The calcification may be so extensive that the tumor seems to consist of nothing but calcareous concretions imbedded in a network of connective tissue. Cholesterin crystals are frequently present. The great majority of these psammoendotheliomas are small and clinically unimportant, but some of them reach the size of a hen's egg or apple, and may give rise to serious pressure symptoms or may erode the skull. They are occasionally multiple, and may be bilateral in the choroid plexus. When situated at the base of the skull they may destroy the hypophysis and cause pituitary dystrophy. They are of slow growth and do not set up metastases. Psammoendotheliomas of the spinal meninges give rise to more serious symptoms than tumors of the same size situated in the cerebral meninges.

If the term psammoma is to be used at all it should be restricted in its application to the psammoendothelioma; but it is best to drop it altogether. Neoplasms should be designated according to their cell type and not by secondary changes occurring in them. Should calcareous concretions be found in neoplasms in any such degree as to warrant especial attention, the prefix *psammo-* or the adjective *psammosum* or *psammomatosum* should be used to designate this feature, as for example: psammofibroma, psammomyxoma, sarcoma psammosum, psammoglioma, psammocarcinoma or carcinoma psammosum, cystadenoma psammosum, cystocarcinoma psammosum. *Psammofibroma* and *psammomyxoma* are small, insignificant neoplasms found in the basal dura. *Psammogliomas* occur in the brain substance. *Psammocarcinomas* occur rather infrequently in the mamma, intestines, ovary, uterus, prostate, and antrum. Secondary carcinoma of the omentum often contains psammoma-like concretions. The lime-salts are deposited in masses of dead carcinoma cells. A psammocarcinoma may be formed anywhere in the body as the result of such secondary degenerative changes in its cell nests. The occurrence usually indicates a relatively slow rate of growth. ALDRED SCOTT WARTHIN.

Pseudoleukemia (Hodgkin's Disease).*—INTRODUCTION.—In 1832 Hodgkin[1] called attention to a disease characterized by progressive enlargement of the superficial lymph nodes associated, in many instances, with splenomegaly. Numbers of different lesions have since been included under the title of "Hodgkin's disease," among them, leukemia and pseudoleukemia, lymph-node tuberculosis and syphilis, and lymphosarcoma. In fact, it is probable that only two of the seven cases described by Hodgkin were examples of the affection to which Wilks,[2] in 1856, gave the name of his distinguished predecessor and by which designation the condition has since been known.

The first step in the elucidation of a problem which is still beset by difficulties was accomplished by Virchow, when he established the independence of lymphatic leukemia. Shortly thereafter an advance was made by Cohnheim, who, under the title of pseudoleukemia, described a disease which presents the anatomical characteristics of lymphatic leukemia without changes in the blood. Other lesions were eliminated until, in late years, Hodgkin's disease appears to have been universally accepted as an entity marked by histological changes which resemble those of the infective granulomata. These changes were described by Sternberg,[3] and his observations have been confirmed in various quarters. Although Sternberg advanced the view that the histological alterations in Hodgkin's disease are invariably tuberculous, he has since modified this opinion to include only certain numbers of cases. Although the changes in question indicate that the lesion is a granuloma, numerous attempts to demonstrate its tuberculous nature have yielded debatable results. Such efforts have included the administration of tuberculin to living subjects, the inoculation into rabbits, guinea-pigs, and monkeys of freshly emulsified tissues, and the staining of affected nodes for tubercle bacilli.

At the present time efforts are being made[5] to implicate a diphtheroid bacillus as the causative factor in Hodgkin's disease. It is claimed that the inoculation of monkeys with this bacillus is followed by changes in the lymph nodes which are comparable to those of Hodgkin's disease in the human being. However this may be, diphtheroid bacilli are notoriously ubiquitous, and have been detected in such remotely removed conditions as acute lymphatic leukemia, leprosy, beriberi, and paresis, and in apparently normal tissues. In this connection it is to be recalled that Frankel and Much[6] have described a non-acid fast, Gram-positive, granular bacillus in the tissues in Hodgkin's disease, maintaining that it is a variety of tubercle bacillus. While their results have not been adequately confirmed, it appears significant that tubercle bacilli, when grown over long periods, may assume certain of the characteristics of diphtheroid bacilli.

The weight of opinion seems to be that Hodgkin's disease is inflammatory in nature and of infective origin. In certain circumstances, however, the lesion does not confine itself to the lymphatic apparatus proper, but gives rise to secondary nodules in various places. Consequently the suspicion has long been entertained that the secondary nodules are of the nature of metastases and that the disease, if not neoplasmic at the outset, is capable of malignant transformation. Against the view[7] that the disease is primarily a new growth, it is urged that the origin of secondary nodules is to be explained on the ground that the causative agent, which invariably demands lymphoid tissue as a prerequisite to development, is satisfied by the minute lymphomata which are of wide distribution in the viscera and mucous and serous membranes. On the other hand, the occurrence of secondary nodules in Hodgkin's disease is comparable to the deposits that occur in similar situations in certain of the infective granulomata, notably tuberculosis and syphilis. At the same time evidence is not lacking to show that, in certain conditions, Hodgkin's disease is susceptible of malignant transformation, the new tissue undergoing morphological changes in the direction of increased cellularity and assuming the ability to infiltrate and metastasize.

INCIDENCE.—Hodgkin's disease most frequently is encountered between the ages of ten and thirty-five years. It occasionally occurs before the completion of the first decade and after the end of the fourth. It is commonest in the male. Of over 500 cases collated by Gowers, Fischer, Kurt Ziegler, and Longcope,[8] seventy-one per cent. occurred in males.

Although Hodgkin's granuloma appears to exist in remotely separated localities, negroes are noticeably immune. This fact, considered in connection with the susceptibility of the negro to tuberculosis, is not in keeping with the suspected relationship between Hodgkin's disease and the tubercle bacillus. Thus in Baltimore, where the negro population is excessive, Reed[9] encountered in the colored race but one case of Hodgkin's disease out of eight. In New York City, where somewhat comparable racial values obtain, I have seen but one case of Hodgkin's disease in the negro in the course of a fairly extended experience.

* When arranging the subjects for the present edition the editor, in his desire to avoid eponymic terms so far as possible, selected this title for what is known as Hodgkin's disease. Although the author, in common with most clinicians of the present day, does not regard the terms as synonymous, he has consented to the use of this title since it is too late to place it under the preferred designation.

Pathological Anatomy.—The most striking feature in the pathology of Hodgkin's disease consists in enlargement of the lymph nodes. This enlargement may be limited to one or more groups of nodes or it may be universal. The hyperplastic nodes, although varying in size, are usually discrete and movable or, if bound together by connective tissue, are readily segregated by manipulation. Ulceration rarely occurs and there are no attachments to the skin or deeper structures except such as may easily be liberated. The nodes vary in consistence according to the degree of cellularity, while their shape, which oftenest is oval or round, may be altered by the effects of pressure, reciprocal or otherwise. Each node is surrounded by a connective tissue capsule, and the cut surface is smooth, faintly yellowish, or cream colored, with occasional opaque areas corresponding to necroses. In the firmer nodes pearly or yellowish streaks occur and represent connective tissue trabeculæ, while in others the surface is finely granular, due to cicatricial bands surrounding elevated islands of cellular tissue.

Histology.—From a histological standpoint, Hodgkin's disease is conceived in hyperplasia of lymphoid cells, and the granulomatous changes are sequential. Thus in the very small nodes lying at the periphery, microscopic examination shows widespread hyperplasia of the lymphoid cells, both in the cords and germinal follicles, and there is moderate proliferation of the endothelium of the sinuses. As the lesion progresses the reticulum begins to share in the proliferative process and the architecture of the node is eventually altered beyond recognition. The lymphoid cells are relatively diminished in number and are either focally or diffusely distributed, the germinal centers decrease in number and finally disappear, and the node becomes permeated by a network of connective tissue, in the meshes of which are variable numbers of lymphoid and plasma cells, eosinophiles, desquamated endothelial elements, and mononuclear or multinuclear giant cells—a histological composite unknown in any other condition. Later in the disease the stroma increases at the expense of the cellular constituents and finally the node is almost completely converted into fibrous tissue. Thus, in two instances which came under my observation at the New York Hospital, sclerosis and hyaline transformation had so obscured the cellular characteristics that the nature of the disease was established only with difficulty.

Spleen.—Next to the alterations in the lymph nodes the spleen presents the most important and interesting changes. The organ is usually enlarged, although seldom to a great extent. The capsule is thickened, the consistence is increased, and, on section, the cut surface presents a grayish-red appearance and the Malpighian follicles are easily visible. In certain cases grayish or pearly nodules may be seen scattered through the substance of the organ.

Cases have been observed in which the splenic involvement overshadowed that of the lymph nodes. In fact, Wade[10] and myself[11] have each described an instance of advanced splenomegaly in which the histological changes were undoubtedly those of Hodgkin's disease, but in neither instance was lymph-node involvement demonstrable. In both cases autopsy was denied. While evidence of the occurrence of a primary splenic variety of Hodgkin's disease is presumptive, it must be admitted that the existence of such a lesion has not been satisfactorily established.

Finally, granulomatous foci presenting essentially the same histology as that encountered in the primary growth, may be found in practically every organ in the body. They seem to arise in preëxisting lymphomatous collections and have been detected in the bone marrow, liver, kidney, thyroid, serous membranes, prostate, adrenals, lungs, periosteum, tonsils, and elsewhere.

Symptoms.—In the majority of instances Hodgkin's disease first manifests itself in the form of enlargement of the superficial lymph nodes, especially those of the neck. Of 164 cases collated by Gowers and Longcope[12] 93 occurred in the cervical nodes (56.6 per cent.). In the remaining cases the axillary, inguinal, bronchial, mediastinal and retroperitoneal nodes were affected in much the same order. Recently an instance of primary Hodgkin's granuloma of the gastrointestinal lymphoid tissues has been recorded.

The enlarged nodes are painless and usually discrete and movable beneath the skin as well as against one another and the deeper structures. Ulceration does not occur except, perhaps, as an accidental circumstance. The consistence of the nodes is determined by the degree of connective-tissue proliferation and by such secondary changes as necrosis and hemorrhage.

As the disease advances symptoms referable to pressure present themselves. They differ, of course, with the location of the enlarged nodes. In cervical Hodgkin's disease with secondary invasion of the thorax, compression of the larynx, trachea, bronchi, and lungs eventuates in the indescribable horrors of death by strangulation. Pressure effects may likewise be manifested by exophthalmus, various sensory disorders, paralysis of the recurrent laryngeal nerves, edema of the glottis, thrombosis of veins, dysphagia, and the like. In the abdomen pressure is revealed by ascites, jaundice, edema of the lower extremities, venous varicosities, digestive disturbances, and pain of variable location and character.

Fever occurs more or less constantly, but varies in type. In the great group of chronic cases it is mild in degree and the temperature seldom exceeds 102° F. In a second group of cases, fever is marked by elevation of temperature to 103° or 104° F., is intermittent, and not infrequently is accompanied by chilly sensations or by actual chills and sweats. In a third and rarer type of case, the fever is relapsing, pyrexial periods of days or weeks alternating with apyrexial intervals. The syndrome, which may pursue a prolonged course, was described by the celebrated English clinician, Murchison,[13] but was later studied independently by both Pel[14] and Ebstein[15] and most commonly is known by their name. The lymph-node involvement is usually extensive and is accompanied by marked enlargement of the spleen, in which, as well as in the nodes, necroses are numerous. While the pyrexial manifestations are oftenest referred to secondary infection, there are those who believe that absorption of the products of necrosis is not an altogether negligible factor.

There are no constant changes in the blood in Hodgkin's disease, although Pinkus[16] has insisted upon the importance of an increase in the number of small mononuclear elements. Bunting [17] has pointed out certain variations in the differential leucocyte count and believes that the changes are of diagnostic significance. There is, in addition, an anemia of the secondary type.

Course.—In the greater number of cases Hodgkin's granuloma pursues a chronic course and tends to remain localized, but gradually spreads from one group of nodes to an anatomically related group or even to remote parts. Instances are not unknown, however, in which the disease terminated fatally within a few weeks or months, disseminating through the lymphoid system and viscera. In other circumstances, especially when the disease commences in the peribronchial or mediastinal lymph nodes or, possibly, from remnants of the thymus gland, malignant transformation may occur. Cases of this description have been described by Yamasaki,[18] O. M. Chiari,[19] Weber and Ledingham,[20] and myself.[21] In Weber and Ledingham's case the patient presented the classical signs of pulmonary osteoarthropathy. In one of my cases there was an enormous tumor in the anterior medias-

tinum corresponding to the position of the thymus gland. The lower half of the right lobe of the thyroid gland was invaded by new growth, the trachea was infiltrated, and there was a nodule in the capsule of the right lobe of the liver. The histological picture was that of an exceedingly cellular variety of Hodgkin's granuloma, attended by excessive eosinophilia and relatively small numbers of giant cells. In another case studied by Welch and myself,[22] microscopic examination by several pathologists of sections prepared from a large, right-sided cervical growth revealed the changes characteristic of Hodgkin's granuloma. Two months later the patient died, and autopsy showed enormous increase in the size of the original mass, together with secondary nodules in the meninges of the brain and lower dorsal cord, in the lung and liver and in the lymph nodes at the brim of the pelvis. The histology of the tissue removed post mortem proved to be that of a richly cellular round and myeloid cell sarcoma. Finally, there are instances[23] in which the endothelium of the sinuses in the lymph nodes proliferates to such an extent as to warrant the diagnosis of endothelioma arising on the basis of a lesion that is primarily granulomatous. Such growths are not infrequently attended by metastasis.

There are still other cases of Hodgkin's disease in which the nodes become so thoroughly permeated by connective tissue that the conclusion is inevitable that, in instances isolated both as to locality and extent, healing is possible. (Symmers.)

Diagnosis.—The clinical diagnosis of Hodgkin's disease should always be approached with reservation in view of the fact that there are so many other conditions which are attended by similar signs and symptoms, among them, various types of lymph node tuberculosis, leukemia, pseudoleukemia, and lymph node sarcomata and endotheliomata. Leukemia may be eliminated by examination of the blood, while a positive tuberculin reaction may assist in the exclusion of tuberculosis. In this connection, however, it is to be remembered that Hodgkin's disease and tuberculosis may exist in the same lymph node, and, moreover, that a large percentage of individuals have tuberculous foci, which, although apparently obsolete and latent, are sufficiently active to cause a reaction to tuberculin. However, to outline any scheme by means of which the several lesions in question may be differentiated clinically from Hodgkin's disease is, in my opinion, largely a waste of time. In fact, there is but one method by which Hodgkin's disease may be diagnosed with certainty, and that is by excision and microscopic examination of a diseased node. The operation is attended by little risk, pain, or inconvenience, and yields results of definite value in both prognosis and treatment. There is one precaution worthy of note, and that is to remove an enlarged node rather than one of the smaller nodes found at the periphery, since the change in the latter may not have progressed beyond the stage of simple lymphoid and endothelial cell hyperplasia, in which circumstances the histological diagnosis of Hodgkin's disease cannot be made with precision.

Treatment.—Treatment avails but little, and cure is apparently beyond question. Arsenic has been extensively employed and diminution in the size of the glands has been claimed for its use. Here, however, I suspect that often the wish is father to the thought, and that changes in size should be ascribed rather to evanescent anatomical conditions such as edema, hemorrhage and necrosis than to the mysterious alterative properties of arsenic.

Operative treatment is often resorted to, but is without promise of permanent results, and recurrence is inevitable. It may, however, delay the fatal issue by removing a form of potential danger. On the other hand, operation may be followed by widespread dissemination—an unfortunate circumstance which is to be expected, occasionally, from mechanical interference with any disease attended by the cellular depravity exemplified by Hodgkin's granuloma.

Finally, the *x*-ray has been used, and the results seem to justify the procedure. In certain quarters the combination of *x*-ray treatment and the use of a vaccine prepared from a diphtheroid bacillus isolated from affected lymph nodes in Hodgkin's disease has yielded results for which promise is claimed. While there seems to be no objection to the method, it is difficult at present to fix the responsibility for any improvement that may occur, since the *x*-ray is known to yield results when used alone, and the causatic relationship of a diphtheroid bacillus to Hodgkin's disease has not been definitely determined.

DOUGLAS SYMMERS.

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Pseudophyllidea.—Bothriocephaloidea. An order of tapeworms. Scolex armed or unarmed, with two slightly developed groove-like suckers; with three genital orifices; vitellaria situated laterally; eggs with or without a lid. Genera included are: *Dibothriocephalus*, *Diplogonoporus*, *Sparganum*, and *Braumia*. See *Cestoda*. A. S. P.

Pseudotuberculosis.—See *under Lungs*.

Pseudo-tumor.—The term *pseudo-tumor* is applied to certain enlargements or swellings of non-neoplastic character which clinically present features by which they may be mistaken for true neoplasms. In the majority of cases such false tumors are found in the abdominal region. They may be produced by a great variety of causes. When the swelling cannot be constantly felt, but comes and goes, it may be designated as a *phantom tumor*. Such enlargements have no organic pathological foundation, and are dependent upon temporary conditions. On the other hand, enlargements or swellings of the abdominal organs due to organic disease may also simulate neoplasms; these conditions should be included under the designation of *pseudo-tumor* or *apparent tumor* proper. When caused by inflammatory masses of granulation tissue which later contract and disappear, the condition may be spoken of as *vanishing* or *disappearing* tumor.

Phantom tumors may be caused by a contraction of the abdominal muscles or by meteorism. Those

caused by muscle contractions are found usually in the upper part of the abdomen. The right rectus near its costal margin is most frequently the part contracted, but the contraction may affect any segment or portion of the abdominal muscles. The contractions are often spasmodic. The entire rectus may be rigid. Usually, however, but a single segment is affected, the contraction being almost always unilateral. The patients are usually hysterical females who present marked stigmata of hysteria; there are usually coexisting constipation and enteroptosis. The contraction may sometimes be made to disappear in a hot bath; but in cases of marked hysteria anesthesia or hypnotic suggestion may be necessary for the differential diagnosis. The superficial character of the tumor, its flat, horizontal shape, slightly rounded and indistinct edges, etc., in connection with the stigmata of hysteria, make the diagnosis easy.

Phantom tumors, due to meteorism or localized distention of the intestines with gas, are of frequent occurrence in the same class of patients as described above, and are often found in connection with the muscle contraction. The character of the swelling, the percussion signs, etc., make the diagnosis easy. The swellings occur usually in the lower portion of the abdomen, particularly in the appendix region, and above the pubis. They are found frequently in women who either pretend or believe that they are pregnant (pseudocyesis). The associated stigmata of hysteria, and the characteristic physical signs render the diagnosis of slight difficulty.

Apparent tumors of the epigastrium are, according to Einhorn, of infrequent occurrence. He reports forty-two cases, eight occurring in men and thirty-four in women. The tumors presented in the epigastrium or in the left or right hypochondrium, and formed in the majority of cases smooth masses of the size of a hen's egg or a man's fist. They were frequently pulsating, could not always be distinctly felt, and on light percussion yielded a dull sound. They ran a long course, and there was usually a history of a long-continued malnutrition. The tumors remained unchanged or diminished in size. They were caused by prolapse of the left lobe of the liver, exposure and thickening of the abdominal aorta, hypertrophic conditions of the muscles of the abdominal walls, and probably adhesions around the lesser curvature of the stomach. If the tumor is caused by the prolapse of the left lobe of the liver, it is found usually in the median line below the ensiform; it is of large size and gives a dull tone on percussion. Between the dulness of the tumor and the ensiform there may be an area of tympanitic tone. If the tumor is the aorta, it is deep, usually about two inches long, and one to two thumbs in breadth, and pulsates. Hypertrophic conditions of the abdominal muscles are superficial, usually horizontal, and not globular, and are located at one side of the median line.

In very thin individuals the head of the pancreas may be felt and mistaken for a tumor. Likewise floating kidney, liver or spleen, rolled-up omentum, excessively fat mesentery, fecal impaction, distended urinary or gall-bladder, tuberculous thickenings of omentum or mesentery, hydro- or pyosalpinx, cystic dilatation of the appendix, etc., may sometimes be regarded as presenting the clinical appearances of malignant tumors of these regions.

Inflammatory thickenings, tuberculous and syphilitic nodules, encapsulated hematomata, encysted parasites, infective granulomata of unknown origin, localized hypertrophy of muscle, local edema, etc., are also often mistaken clinically for malignant tumors.

The term pseudo-tumor is also applied to the nodules of a chronic inflammatory nature caused by the experimental injection of blastomycetes and other fungi. Similar nodules may be produced by the introduction of foreign bodies or the injection of certain chemical substances into the tissues.

Disappearing tumors of the abdomen are usually the result of acute inflammatory tumors of the omentum, following appendicitis or salpingitis. The absorption of exudates and the contraction of the granulation tissue lead to the diminution in size or total disappearance of the tumor. Similar disappearing tumors occur in the skin, subcutaneous tissues, periosteum, and intermuscular connective tissue as the result of the formation of granulation tissue following trauma or hemorrhagic extravasation. These may sometimes be mistaken for sarcomata, both clinically and microscopically. The presence of numerous plasma cells, the character of the blood-vessels, and the general appearance of the granulation tissue are points upon which the differential diagnosis should be based. ALDRED SCOTT WARTHIN.

Psittacosis.—An infectious disease occurring in birds, particularly in parrots, and transmissible to man. The disease in parrots is of the nature of a chronic enteritis, characterized by diarrhea, wasting, loss of appetite, and falling of feathers. In man the symptoms are those of a grave typhoid, with diarrhea and a malignant atypical pneumonia. The disease may be transmitted directly from parrots to man or through intermediate objects, and, according to some observers, from man to man. The period of incubation is from seven to twenty-five days: the symptoms begin either suddenly with a chill, or gradually with headache, photophobia, malaise, epistaxis, and digestive disturbances, followed by bronchitis and pneumonia. The urine contains a small amount of albumin. There is high fever lasting for from three to four days, and falling by crisis. These symptoms then recur in this order several times, defervescence finally taking place by lysis. During the attack the spleen is enlarged. Sometimes there may be seen a roseolar or petechial eruption. Cough, with mucopurulent or bloody sputum, increased respiration and fine moist rales throughout both lungs characterize the affection from the outset. The patient shows a typhoidal state, with more or less marked delirium. The disease lasts about thirty days. The mortality is about thirty-seven per cent., being highest in old people and much less in children. The prognosis is good if complications do not occur. In the majority of fatal cases, death is due to pneumonia which may be lobular or lobar.

Eberth in 1880, and Wolff in 1883, observed the occurrence of a fatal mycosis in parrots which had been imported in great number from the west coast of Africa during 1880. Transmission to man was not observed. In 1879 Ritter saw a house epidemic of severe pneumonia which he thought was referable to a contagion from parrots, or rather from the cages in which the birds had been transported. The clinical and anatomical picture of the disease was that of an atypical pneumonia. Similar cases were observed in 1882 by Ost, and by Wagner in 1882 and 1886. The disease was introduced into Paris in 1891 by some parrots from South America. In 1892 there was an epidemic of the disease in this city, in which fifty persons were affected. Cases of the disease were also observed in Paris during the next four years, and advantage was taken of the opportunity to study the disease closely. The relation of the disease in man to the affection of the parrot was clearly proved. Cases have been observed also in Italy and Germany.

The bacteriological findings are very unsatisfactory and contradictory. According to Nocard, the cause of the disease is a specific bacillus resembling that of typhoid fever. The organism is short, rather thick, with rounded poles, is motile, and is a facultative aërobe. It does not stain with Gram's method, does

not ferment sugar, does not coagulate milk, and does not form indol. The bacillus is very virulent; subcutaneous injections in rabbits, mice, and pigeons kill within from fourteen to forty-eight hours. In the Paris epidemic this bacillus was not found in the human body; but, three years later, Gilbert and Fournier found it in one case, in the heart blood of a woman dying from the disease. Palamidessi observed an infectious disease transmitted from parrots which he regarded as resembling chicken cholera. The organism obtained by him was regarded as identical with that observed by Nocard. Other observers have failed to find the Nocard bacillus; and Leichtenstern and others believe that the disease of the parrots known as psittacosis may be caused by various bacteria (staphylococcus, streptococcus, pneumococcus, colon bacillus, and proteus), and that house epidemics of atypical pneumonia in man may occur without such diseases of the parrot playing any etiological rôle therein. These writers, however, admit the probability of such a relation in certain cases, as in the Paris epidemic of 1892. French observers generally hold that the bacillus of psittacosis prepares the way for secondary pneumococcus infection.

On the other hand, Nicolle reports an epidemic attacking eight persons (four dying), in which the Nocard bacillus could not be found; but the serum from these cases produced a typical agglutination of a culture of the bacillus furnished by Nocard, in dilutions of 1 to 50 and 1 to 60. The blood of one of the cases also agglutinated typhoid bacilli, although the patient had never had the disease.

Widal and Sicard claim that typhoid and psittacosis can be differentiated by the Widal reaction. In dilutions of 1 to 10 the reaction occurs with both; but the masses of psittacosis bacilli are smaller and more crowded. In dilutions of 1 to 40 there arrives a moment when the bacilli of psittacosis no longer react.

The bacteriology of psittacosis and the true relations of the parrot disease to the atypical pneumonia in man remain yet to be determined definitely. Further, it should be observed that in the popular mind psittacosis is sometimes regarded as a form of avian tuberculosis, and that cases have been reported of a supposed transmission of tuberculosis from the parrot to man, whence the origin of the error.

Treatment.—Preventive measures include care in handling sick parrots, with proper disinfection of cages. Patients with the disease should be isolated. In general the treatment is that used in typhoid fever and pneumonia.

ALDRED SCOTT WARTHIN.

Psoriasis.—Psoriasis is a disease of the skin which possesses three characteristics that should render its diagnosis easy. These are: 1. The formation of dry, papery, thin, silvery-gray scales, mica-like in their arrangement, and as a rule easily detached, is a constant phenomenon. 2. Dryness is an absolute characteristic of the disease at all stages and in every situation. There is never, in a pure type of the affection, the slightest moisture, greasiness, or tendency to ulceration. 3. The development of points or discs of a color varying from pale red to a red of a brighter hue, and showing a certain degree of inflammatory thickening—sometimes quite marked, but usually only moderate or slight—is another characteristic of the disease. These lesions are always well defined at their borders and tend to enlarge peripherally, sometimes with evidence of greater activity at the border than in the center. Contiguous lesions often meet, forming irregular, map-like figures, the points of confluence becoming like the center of the original patch or disc.

At the onset of the disease there is noticed, commonly at some part of the surface of the body where the skin is thicker than elsewhere, a well-defined spot or patch of a pale red color (but of a somewhat brighter red in an acute outbreak of the disease) and of variable size (from the head of a pin to a half-dime silver piece). At the affected spot the skin is a little thickened, and its surface consists of one or two layers of thin, dry, easily removable scales which are quite small in proportion to the size of the lesion. This lesion gradually enlarges—as a rule, symmetrically—and in the part newly involved the characteristic slight thickening of the skin and the formation of loosely attached scales may be observed. When the loose scales are removed it will be seen that the natural lines of the skin, which under normal conditions are quite faint, are now accentuated by the upraising of the intermediate areas through the products of inflammation. When the lesion attains the full limit of its growth, it may be as large as a silver dollar, of about the same thickness—or, in the case of few lesions, it may become a larger

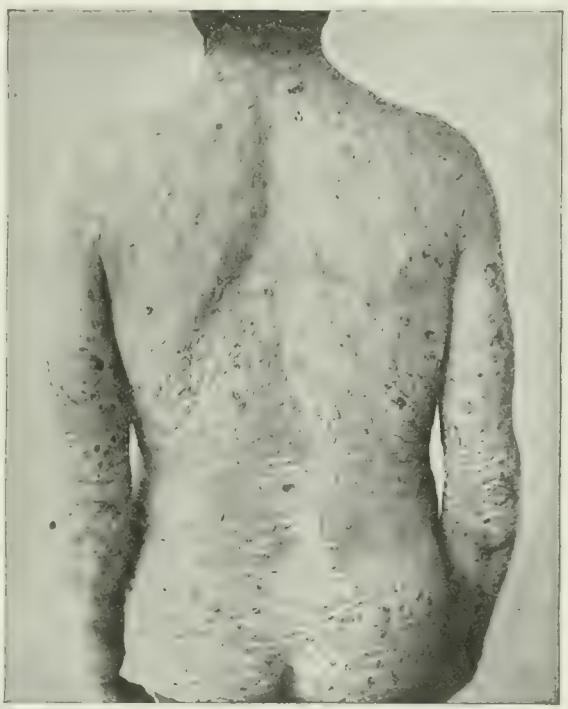

FIG. 4344.—Psoriasis. (From the collection of photographs of skin diseases belonging to Dr. John A. Fordyce, of New York.)

patch—more oval in outline. Through coalescence two or three adjacent lesions may also form quite a large area of irregular shape. I have known an apparently single lesion, on the extensor surface of the forearm, to attain an area of about four by six inches. At no time in the course of its development did this patch fail to show the pathological alterations which are so characteristic of the affection and which have already been enumerated.

If the scales are allowed to accumulate they form dry, mortar-like masses. In some cases the central parts of the large lesions will remain relatively quiescent for a considerable period of time; the thickening process and the formation of scales being confined to a narrow border (from one-twelfth to one-fourth of an inch wide).

"Punctate hemorrhage" constitutes another and thoroughly characteristic distinguishing feature of the disease. If, in the younger or thinner lesions, the scales are removed down to and including the basal

layer, bleeding will take place from a number of isolated spots, not larger than the point of a pin and corresponding to inflamed papillæ, the blood-vessels of which have been torn.

Upon the scalp, when covered with the natural growth of hair, the disease presents an appearance somewhat different from that which it generally does on other parts of the body. There is less infiltration, as a rule, although quite characteristic discs and patches, like those observed on other parts of the body, may occur. The scaling is often excessive, forming piled-up masses of the dry, silvery, papery, and quite easily removable scales. Along the margin of the hairy region, especially on the forehead, there often appears a gyrate band of the disease, one-half of it being located on the hairy surface and the other half on the natural skin surface. Then again, in other cases, the disease develops in the skin of the forehead and extends to a greater or less extent upon the hairy surface of the scalp. In this extended area of the disease the affected skin is red and slightly thickened, and upon it are seated the irrepressible dry, gray scales. Some cases are complicated with a dry or an oily suborrhea—each condition seeming, however, to follow an independent course. Psoriasis being an inflammatory condition not particularly involving the hair follicles and presumably of non-microorganic origin, has no tendency to cause loss of hair, while the many organisms in seborrhea and the direct action of the disease on the follicles in the latter condition causes more or less defluvium.

Wherever the disease assumes a somewhat acute character there we may be sure of finding more redness and a more rapid formation of scales of varying size, but always of marked thinness.

Although itching is not a characteristic symptom of psoriasis, my records show that it was present in some degree in nearly all my cases. In some of these cases the symptom appeared in connection with an acute outbreak of the disease—either simultaneously with or just preceding the outbreak—but in others it appeared to be due simply to the accumulation of scales.

While it is generally held that the disease shows a predilection for the regions of the knees and elbows, my own experience does not give any very strong support to this belief. It certainly has a preference for the scalp and for the extensor or thick-skin surfaces, but in a general outbreak the disease respects no limits. In one case, for example, its manifestations were to be seen on practically every part of the surface of the body save the scrotum and feet.

Exfoliative dermatitis may occur as the result of an acute outbreak of psoriasis, the entire skin being involved in the attack. Such an attack is characterized by general redness of the skin (although there may be free or partially free areas) and by the rapid and constant formation and throwing off of paper-like, thin, dry scales; often surprising quantities being exfoliated in a day. The skin is not much thickened, the color varies from a bright red to a red of a dull luster, and the inflammatory action is of moderate degree. Itching in some measure and burning sensations may be present. These extensive outbreaks usually subside, thus differing from pityriasis rubra, which ends only with loss of hair and nails, wasting away, involvement of vital organs, and, finally, death.

Psoriasis has been called a disease of the healthy. While this is to some extent true, my observation leads me to amend this statement by saying that the people who have it are in as good average health as their less afflicted fellows, while some of them even deserve the appellation of robust.

I have been unable to trace this disease to heredity, and have seen but slight evidence in favor of the belief that it affects the members of certain families. It develops, according to my experience, in the more vigorous years of life—that is, from infancy to middle age; my cases being mostly adults and under the middle decennium of life. The duration of the disease in these cases has varied from a short time to a period of a few years. Furthermore, males have preponderated over females in the proportion of two to one. On the other hand, it must be remembered that psoriasis is quite a rare disease in this latitude, and that there have been too few cases to justify us in formulating any statistics. Prosperity and poverty, sobriety and intemperance, cleanliness and filth, seem to exert no appreciable influence in warding off the disease or in favoring its development. These influences, however, when once the disease has become established, may turn its further course toward the better or toward the worse.

The disease does not appear to have any depressing influence upon the general health. Often it constitutes simply a bodily discomfort, with perhaps, in addition, a certain amount of mental worry consequent upon its presence.

Etiology.—As to the cause of psoriasis, we know nothing positively. There are many theories. In some respects the disease behaves as if it were due to germ influence, the manifestations resembling somewhat those of an exaggerated action of the ringworm fungi—as, for example, the peripheral extension, the frequent clearing up at the center, and the persistent activity at the border. Psoriasis presents a further resemblance to a parasitic disease in the character of its relapses; it being an easy matter to ascribe them to reinfection from small uncured points, such as can always be found on some part of the body. In spite of this statement, experiments have shown that some of these patients seem suffering from nitrogen retention following the too free intake of protein. Pathogenic organisms have not been found.

Course of the Disease.—Recurrences are the rule; often the central parts of the pale patches left after the subsidence of an outbreak are the sites of a new eruption. These relapses often occur immediately or very soon after the subsidence of an acute outbreak. It is probable that a person affected with psoriasis is never absolutely free from the disease after the first onset. I have been able to follow one such case for a period of over ten years—that is, from the time when the patient was only three and a half years of age to that when he was fourteen years old. It is interesting to note that this patient has always been strong and robust and that he has been in no way retarded in his development.

Diagnosis.—The diagnosis of psoriasis should offer little difficulty, if the features already described are kept in mind. In the following paragraphs I will mention briefly the characteristics which should enable the physician to distinguish it from the various affections with which it is most likely to be confounded.

Dry seborrhea of the scalp shows little if any inflammation or thickening. The scales in this affection are smaller than those observed in psoriasis, and if they are present in a mass the latter is usually more friable; often, too, these scales form sheaths around the hairs at their insertion in the follicles. Removal of the masses of scales may show a reddening beneath and a slight moisture. Oily or waxy seborrheal conditions simply have the added features of greasiness and dirtiness, removing them still further from confusion with psoriasis.

Seborrheic eczema of the scalp usually shows fewer scales; if there are patches they are thinner and slightly moist, and the scales are greasy. When the disease extends from the scalp upon the forehead it may resemble psoriasis, but there is little infiltration, the scales are not dry and papery, and the inflamed surface presents a somewhat more moist appearance.

Syphilis of the scalp may show the so-called corona or frontal extension. The color is, however, of a deeper shade, the infiltration more marked, and the scales are smaller, more adherent, less papery looking, and less abundant. Syphilitic patches on the scalp lack the features which have already been described as characteristic of psoriasis.

Ringworm of the scalp is dry, scaly, not infiltrated in any marked degree, has fewer, finer scales, and shows a well-marked, not greatly elevated border which bears evidence of slight exudation. The hairs in the patch are broken or lusterless from the growth of the microorganism.

Eczema of the scalp does not occur in the form of sharply limited patches; then, besides, there is a peculiar stiffening and thickening of the parts affected, and there is either a frank, sticky exudation upon the surface or there are points and lines of broken epidermis where the exudation is just beginning to break forth. Upon drying, the exudation assumes the form of gummy, brownish, or yellowish crusts. The exudation may be entirely within the tissues of the skin, giving it the firmly swollen or thickened appearance.

Seborrheic eczema on the body shows scarcely any infiltration, the scales are few and often greasy, and the affected surface has not the absolute dryness of psoriasis.

Syphilitic patches of the dryest form, when located elsewhere than on the scalp, often show a tint of lividity, and they have a less regular shape than the patches of psoriasis; the scales also are smaller and less plentiful, and they are formed at a less rapid rate than in the latter disease.

In none of the diseases enumerated above can the punctate hemorrhage be produced.

When compared with psoriasis even the dryest eczema of the body shows less symmetry of lesions, more thickening, a less well-defined border, fewer scales, and these not like the scales of psoriasis. Furthermore, the patches have a stiffer look and feel, and itching is more marked.

Ringworm of the body shows fewer scales, and less, if any, thickening of the part affected. On the other hand, the lesion has a sharply defined border, which appears to be the seat of an exudative inflammation. At the center of the lesion the skin is generally found to be nearly free from inflammatory action.

When psoriasis is associated with other morbid conditions of the skin the physician will have to base his diagnosis upon the presence of certain features which are characteristic of this disease, as an isolated lesion if such be present.

Prognosis.—The prognosis of psoriasis is unfavorable as regards a cure, and doubtful as regards the removal of the eruption. In all my experience I have seen but one case of psoriasis—at least so diagnosed—in which recovery was perfect; but even in this case it is not clear that an error in diagnosis may not have been made, for upon reading my notes of the case again at the present time I find that it may possibly have been one of a slightly atypical seborrheic eczema. Recovery followed the use of treatment administered on the supposition that the case was one of psoriasis. This patient was a woman in good circumstances who died of alcoholism.

It is best to promise a patient with psoriasis nothing more than a certain amount of relief.

Treatment.—The treatment of psoriasis is both external and internal, the former being the more efficacious of the two. Arsenic has been for years the chief reliance in the internal treatment of the disease, it being often pushed to large dosage and continued for long periods of time. Its effects show such a mixture of good and evil that I seriously question whether the benefits of the remedy are not more than offset by its disadvantages. Some people reach the limit of tolerance (conjunctival irritation, puffiness of lids, gastric irritation) very early. If they escape these, they may, under a long-continued use of the drug, acquire other dermatoses scarcely preferable to psoriasis. These may go to the formation of hyperkeratoses some of which tend to become malignant. However, it is well to give arsenic a trial, but only in cases in which there is but a small degree of cutaneous irritation. It is usually employed in the form of Fowler's solution (liquor potassii arsenitis); the dose being, for an adult, five drops after each meal. This dose should be gradually increased (an additional drop at the end of every twenty-four hours) until the limit of tolerance is reached.

Another arsenical preparation is what is called "Asiatic pills," the formula for which is as follows: ℞ Acid. arsenos., gr. i.; piper. nigris, gr. xx.; pil. mas. q.s. M. ft. pill. xx. Sig.: Begin with one after each meal; increase by one every day. As a result of taking these pills, some patients have complained of stomachic irritation which they, quite reasonably, attributed to the black pepper, this irritation preventing in itself the object sought—viz., to obviate irritation by the arsenic. Later experience has justified less confidence in arsenic, and placing Asiatic pills in the discard. The newer arsenical preparations, from cacodylate of soda to salvarsan and neosalvarsan, have proven ineffective.

Iodide of potassium administered in large doses has acquired considerable renown as a means of relief for psoriasis, but my experience with this drug has been of such a discouraging character that I have given it up in the treatment of this disease.

Thyroid extract, in the form of tablets (gr. ij.–x., t. i. d.), has seemed, by actual comparison with other remedies, to be decidedly beneficial. This opinion is at variance with that of excellent authorities, but is partially sustained by my observation. All depends upon obtaining the pure, and therefore not inert, substance. As thyroid extract is capable of inducing depression of the heart's action, and possibly dizziness, the dose must be small at first, the effect watched, and it may even be necessary to attempt to neutralize these effects by the administration of strychnine.

As is self-evident, the patient's general condition must be kept at its best by such internal treatment as the symptoms may require, just as if there were no psoriasis. Reduction of nitrogen intake has seemed to render local applications (as chrysarobin), and in decreased strength, more efficacious. Autoserotherapy has received some favorable and other unfavorable reports. The withdrawal of the patient's blood, separation and reinjection of the serum in quantities up to 20 c.c. seems purely empiric, yet there possibly is some change *ad interim* in the "antibody" content.

Pus foci, streptococci mostly, the present fad in medicine; teeth, tonsils, appendices, joints for example, have been said to be present in some cases. Recent reports of "vaccine" treatment (autogenous) have shown favorable effects upon a coexistent psoriasis.

Faithful following of directions as to external treatment, while onerous, must be required. The first requisite is the removal of scales to permit the action of remedies. Naturally, the treatment generally outlined below is to be much modified if the skin is found to be abnormally irritable.

Hot baths at night, in combination with the liberal use of soap, greatly assist in removing the scales. Sapo viridis may be used in full strength for removing scales, or an alcoholic solution (sap. vir., ℥ij.; alcohol, ℥i.) may be employed; but any strong soap will do quite as well. As alkalies exert a special effect upon epidermic scales, it is easy to understand the beneficial action of soaps in removing them in psoriasis. Hot

tar baths or tar well rubbed into the patches before an ordinary hot bath is taken will often be found helpful.

To aid in the removal of accumulated scales from the scalp, it is advisable to apply freely a mixture containing salicylic acid and olive oil in the proportion of one part of the former to eight of the latter. After the mixture has been well rubbed in, it should be allowed to soak into the parts for some time before it is finally washed away. The addition of formalin to this mixture (two and a half minims to each ounce) seems to heighten its beneficial effect. If a milder application is desired, the addition of twenty grains of salicylic acid to one ounce of simple ointment will be found to answer satisfactorily.

In my own experience with the treatment of psoriasis of the scalp, the ammoniate of mercury, preferably in salve form, has proven the most useful remedy. The following are some of the formulæ used: (1) ℞ Hg. ammoniat., ʒss.–i.; Ung. simp. (seu. Ung. aq. ros.), ʒi. M. Rub well in at night. (2) ℞ Ung. hg. ammon., ol. oliv., āā ʒss. M. Sig.: Use at night. If there is not much irritation, Ung. hg. ammon. (U. S. P.) may also be used.

These mercurial preparations can be employed only on a limited portion of the general cutaneous surface, as there is always some risk of inducing salivation if the drug is too extensively applied.

I have used the following, but it produced slight ptyalism: ℞ Hg. ammon., gr. xl.; acid. salicyl., ʒi.; Ung. zinci ox., ʒi. M. Sig.: Apply well morning and night. This ointment may be considered perfectly safe if it is applied over a limited area.

When there is a more general involvement of the skin, chrysarobin in salve form is the best local remedy. Chrysophanic acid is much weaker in its action, and I have abandoned its use. Chrysarobin usually exerts its best action when its characteristic dermatitis is produced. Under its action the skin becomes deep red, almost lilac in color, hot, and itches. The subsiding, clearing patches stand out as gray-white and uninflamed upon this reddened surface. The proneness of chrysarobin to cause irritation precludes its use on the scalp or face, for fear that this irritation may involve the eyes.

The most useful salve is the following: ℞ Chrysarobin, ʒss.–ij.; Ung. zinci ox., ʒi. M. Sig.: Rub well in patches freed of scales at night—leave some on. To this may be added acid. salicylic., ʒss.–i., which often increases its effect.

The varnishes so frequently employed in affections of the skin seem to interfere with the action of the drugs contained, but occasionally a varnish containing chrysophanic acid has proved somewhat beneficial in the treatment of psoriasis.

The following formulæ have been found useful: (1) ℞ Chrysarobin., gr. xv.–ʒi.; liq. gutt. perchæ, ʒi. M. Sig.: Shake. Paint on patches freed of scales. (2) ℞ Acid. chrysophanic., ʒi.; collodii flex., ʒi. M. Sig.: Paint on. (3) ℞ Chrysarobin., ʒi.; collodii, ʒi. M.

Lanolin, when used as the base, makes a more adhesive ointment, but the zinc oxide salve seems to prevent severe irritation. It is customary to suspend the chrysarobin treatment upon the appearance of marked dermatitis, but if this is not severe the use of the drug may be continued. To relieve this dermatitis, one of the following preparations may be employed after suspending the chrysarobin: (1) ℞ Zn. ox. pulv., ʒiv.; phenol. (ninety-five per cent.), ʒi.; amyli pulv., ʒij.; aq., ʒiv. M. Sig.: Shake; apply often. (2) ℞ Zn. ox. pulv., ʒij.; amyli pulv., ʒi.; ol. oliv., ʒij. M. Sig.: Shake; apply. Suspension of the use of chrysarobin and applications of olive oil often suffice to relieve the dermatitis.

Pyrogallic acid at one time was considered a good second to chrysarobin as regards its efficacy in the treatment of psoriasis; and it may still be found an efficient remedy. The following is a suitable form in which it may be employed: ℞ Acid. pyrogallic., ʒss.–ij.; Ung. zinci ox., ʒi. M. Sig.: Use in the same manner as the chrysarobin ointment, and in those cases in which the chrysarobin ointment proves too irritating.

The tar preparations have proven useful in some cases, especially where the skin will not bear stronger treatment. The following are convenient formulæ: (1) ℞ Ol. cadenii, ʒij.; acid. pyrogallic., ʒi.; ether. sulphuric., alcohol, āā ʒi. M. Sig.: Apply night and morning. (2) ℞ Picis liq., ʒi.–ij.; Ung. zinci ox., Ung. diachyli., āā ʒss. (or omit the diachylon). M. Sig.: Rub well in once or twice a day. Leave on. (3) ℞ Picis liquid., ʒiij.–iv.; acid. salicyl., ʒi.; Ung. zinci ox., ʒiv. M. Sig.: Apply in the usual manner.

In the employment of these different remedial procedures it is well to remember that a lotion must be reapplied so often that the parts will be kept constantly covered with the fluid; that a varnish must be reapplied as soon as it peels off; that a salve must be well rubbed in, and a sufficient quantity must always be left on to keep the drugs in continuous action upon the skin; and, finally, that soap and baths and other scale-removing measures must be employed often enough for the attainment of the object desired. Then, when all this has been done, the patient will probably still have some psoriasis, or a new attack will supersede the old one, and it is a wise physician who early fortifies himself against blame by a correct diagnosis and an unfavorable prognosis.

M. B. Hutchins.

Psychasthenia.—The process of sifting out and sorting over the numerous psychical syndromes, which present themselves among people in kaleidoscopic variation may be compared to the mental activities of a group of individuals going through a forest. The lumberman casts his eye about and makes a rough estimate of the hard timber and the soft timber that is standing. The artist views the various lights and shades, the browns and greens and blues, and the character of the lines and masses. To the botanist the arrangement is still different. He sorts maples, hemlocks, poplars, and birches; he is taken up with the family relationships that exist, and has no particular attitude toward the group qualities of interest to his companions. Each in his turn views the myriad characteristics from the standpoint of some use that is to be made of the material. In some such similar way the psychiatrist views the mental variations which exist in his forest. His purpose is to modify them if they are great and inconvenient enough to constitute what he terms a disease. His objective viewpoint is to aid social stability by properly selected treatment. Hence his groupings must have behind them, if they are to be of value, the attitude that demands their amelioration. It is from this point of view that all classifications are best considered since medicine has for its aim the knowledge of disease for the purpose of its prevention, eradication, or amelioration. Hence groupings come and go. They are useful for a time until better ones are found. They should be made, and then unmade so soon as they commence to impede progress.

Psychasthenia is such a grouping which was first advocated by Pierre Janet of Paris in 1903, and documented by two large volumes, entitled: Les Obessions et la Psychasthenie. These volumes described some 325 cases which were subjected to a painstaking analysis by Janet. Within this grouping Janet sought to codify a large mass of material chiefly made up of individuals showing what he termed, obsessing ideas, impulsive acts, mental manias, folie de doute, tics, anxieties, phobias, fear of con-

tamination, sensations of incompleteness and unreality and similar conditions. Janet's generalization sought some common ground of understanding of these cases, which before his time and that of Freud's were more or less classed under a variety of terms. They were all loosely thrown together into a large vat and called "neurasthenia." Out of this diagnostic monstrosity, perfectly valid in Beard's day, Janet brought his group out and sought recognition and handling under this new apellation. Janet based this entire concept upon a psychological generalization to which he gave the term "a disturbance of the function of reality." All these patients lacked the sense of reality in some degree or other, and the symptoms are developed by Janet as indications of this altered sense of reality, which psychologically speaking, he says, plays so important a rôle, in giving a sense of security to the individual.

In Janet's study are collected 230 women and ninety-five men, thus indicating the comparative frequency of the sexes. Most of them were individuals between twenty and forty, and these patients were more often to be found in private life than in the hospitals, which he states was related to a comparatively high grade of intellectual capacity. Janet observed and treated many of these patients from five to ten years and more, from which it may be seen that for him, at least, they were extremely chronic or that the delay in therapeutic results may have been due to his as yet undeveloped technique, as well as faulty mode of grouping.

Janet said that psychasthenia was essentially a chronic disorder, nearly always of long duration. They usually show initially more or less marked neurasthenic signs, excessive fatigue, sense of fulness of the limbs, peculiar sensations in the head, such as sounds, vertigo, fear of fainting, crackling, being caught in a vise, etc. Physically the patient complains of being feeble. They tremble, have digestive disturbances, often lose weight. He arranged this series of cases as follows:

1. Psychophysiological insufficiencies.	a. With predominance of organic troubles. *Neurasthenic states.*		
	b. With predominance of psychological troubles, and above all of the sense of incompleteness. *Psychasthenic states.*		
2. Psycholeptic crises with derivative phenomena.	a. Muscular	1. Diffuse forms. *Motor agitation.*	
		2. Systematized forms. *Tics.*	
	b. Visceral	1. Diffuse forms. *Anxiety States.*	
		2. Systematized. *Psychic-pains. Phobias.*	
	c. Mental	1. Diffuse forms. *Scruples.*	
		2. Systematized forms. *Mental manias.*	
3. Obsessions	Of sacrilege.		
	Of crime.		
	Of shame.		
	Of being ill.		

This table presents the general scheme of the various subdivisions or stages through which the various patients may go, or of the various elements of a mosaic, which individual patients vary.

Janet distinguishes acute, chronic, intermittent, remittent, and continuous forms.

Acute accidents may supervene such as fecal impaction and in about thirty of the cases cited a definite outright psychosis developed. The history of these psychoses cannot be entered into here, but they show in the main that these so-called psychasthenics were really developing stages of the psychoses, and hence they invalidated the group psychasthenia.

Janet's treatment was by simplification of the life of the individual, by suggestion (whatever that means is not apparent), by moral and emotional reëducation.

Janet's psychasthenia has practically ceased to be a useful generalization. Certain of the cases to-day would be best treated as endocrinopathies, particularly dysthyroid states, others are manic depressive cases in the strict Kraepelian sense, still others latent and mild dementia precox cases, following Bleuler, while a certain proportion are best handled under the concept of Freud, as anxiety hysterias and as compulsion neuroses. These latter still make up a very motley group which the psychoanalytic mode of approach will undoubtedly arrange to better advantage. The general dynamic concepts of the psychoanalytic school now termed conversion, substitution, and projection is rearranging this entire group and offering therapeutic possibilities for the severe cases heretofore considered hopeless. SMITH ELY JELLIFFE.

Psychoanalysis.—Psychoanalysis is a method of mental analysis. In medical therapeutics psychoanalysis constitutes a method of treatment by which the human mind is dissected, as it were, in order to discover the hidden motives of conduct which are the cause of the symptomatic manifestations from which the patient is suffering.

The actual existence of a direct and explicable cause for every mental symptom, every mental manifestation, was first recognized by psychoanalysis. Formerly some general cause of fright, early bad impression, or the like was assigned to various "nervous" symptoms, but there was no attempt to subject these to detailed analysis. Thus only indefinite means of cure were prescribed, which could never reach and remove the source of the disturbance.

The methods of psychoanalysis are based upon a very definite concept of mind. This regards the mind as something other than a mere collection of ideas without arrangement or sequence. Rather, ideas are grouped about central experiences, constellations these groupings may be called. They form harmonious, coherent structures of increasing complexity. The process may be compared to the putting together of elementary building materials to form the building, the buildings in turn constituting the larger groups, which finally form the city. Feeling is the cement which holds together the ideas, the material of the constellation.

These constellations represent the mechanisms by which each individual endeavors continually to find the most suitable adjustment to his surroundings. A certain amount of the feeling belonging to the constellations finds adequate discharge in the shifting character of these groupings and their adaptive reaction to the external world. The constellation, then, assumes its proper and not too important place in the life history of the individual.

And so in this orderly arrangement the character traits, the individuality and personality are formed. There is found in every one a slight disproportion of feeling tone, resulting in a relatively inconsiderable deviation from a perfectly adjusted arrangement. This is accountable for personal peculiarities, unexplained forgettings, mistakes, moods and the like.

There are certain individuals, however, who are incapable of healthy adequate reaction to the situations which arise. This is due to a constitutional disposition, which tends to fixation upon some infantile point of development and conditions an infantile reaction toward all situations. These individuals are not only incapable of reacting normally to ordinary events but are further incapacitated for the special demand which some extraordinary situation may make upon their psychical equipment.

The infantile desire, or mode of adjustment, which arises to meet the demand, however, is incompatible with ethical and social demands, and must therefore be repressed. There may be actual experience, which carries with it reproach, or phantasy activity along forbidden paths, instead of the healthful adult re-

actionary discharge. In either case the memory, and the constellation built up with it, becomes a painful one and so must be pushed out of consciousness, become repressed. This constellation, crowded out of clear consciousness, leads a relatively separate existence. It may now be distinguished as a "complex." Its accompanying feeling, or affect, naturally excessive, is not normally discharged, remains undiminished in intensity, and because the individual is no longer able to recognize the repressed complex, normal channels of discharge are no longer open to it. The separate and, as it were, denied existence which the complex must live hereafter conditions the fact that it can be so clearly traced out and recovered in later psychoanalytic treatment, for it has not lost its identity through association nor its definite outlines in the ordinary mental activities to which the constellations are normally subjected.

The unrecognized and separated complex strives no less for activity, but because of its painful affect or feeling tone, consciousness will not admit it. Thus the conflict arises. The complex with its intensity of affect struggles for recognition, the censor denies it. The individual is aware only of a severe but undefined struggle. It becomes unbearable and a compromise is reached, by which the conflict may come to clear consciousness but only in the form of a complete disguise.

There are lesser conflicts in every life, which thus unconsciously determine the slight deviations already mentioned, slips of the tongue, forgettings and the like. The more seriously determined conflicts, however, are solved by more thoroughly effective mechanisms of the unconscious. These are very logical. They express themselves through symbolism, through displacement, that is the transfer of the emotion from the painful event to a less painful or indifferent one, or through conversion, the changing of the conflict into a physical symptom.

Through conversion arises the protean symptomatology of what is termed hysteria. The foundation of the complicated phenomena of the defense mechanisms of obsessions, compulsions, substitutions lies in displacement. The symbol as an energy transformer accompanies all these manifestations, but serves most distinctively in dream formation.

Psychoanalysis involves, then, first of all a full understanding of this concept of the mind, which recognizes the existence and important activity of the unconscious, where these complexes strive for functional activity and expression. It demands further a knowledge of the defense mechanisms by which they succeed in coming to expression and thereby produce the "symptoms." This extends itself to a knowledge of the vast symbolism at the disposal of the unconscious, which admits of great variety of choice and requires a variety of interpretation. The knowledge of symbolism must be acquired by a careful study of this means of expression as it has been employed throughout the developmental history of the race, in the formation of myths, legends, poetry, art, language, in fact in all departments of life, as long as it has been necessary that the direct and crude expression of desire and impulse should be refined and disguised to meet the finer requirements of advancing civilization. Continued experience with the neurotic productiveness of the unconscious brings an increasing knowledge of symbolism and facility in its interpretation.

The definite method of procedure in psychoanalytic treatment is as follows: The patient calls upon the physician and at first is given an opportunity to tell his story, while the physician listens without interruption, unless perhaps to keep the patient to the point if he brings in too many secondary details. This recital may occupy one or two visits perhaps. The patient will thereby describe in his own way the things from which he is suffering. This gives, of course, only the conscious picture of the disturbance, but it is on this level that treatment must begin. Careful attention will discover many hints as to the further pursuance of the inquiry. The physician can also thus determine whether the patient's illness is one suitable for psychoanalytic treatment. If it is such, definite arrangements will be made for regular consultations, preferably not fewer than three a week, of an hour each. Matters of fee, etc., will also be attended to at the outset.

If there is evidence of physical illness, the patient should be sent to a competent physician for physical treatment of the existing ailment, preferably before psychoanalysis is undertaken. The analyst should never undertake the treatment of the physical condition. The reason for these stipulations will be obvious after a consideration of the transference phenomenon. The transference cannot operate favorably to the success of the analysis if it is divided between the analyst and another physician who is carrying on treatment at the same time, nor can the purely mental relations, which should exist in the transference toward the analyst, be disturbed by physical treatment on his part.

When the preliminaries have all been attended to, the work of the analysis is taken up. The discovery of the patient's conscious memories is a comparatively easy task, but this is soon performed. The foreconscious, too, is readily penetrated. It is then that serious work begins. It may seem at once that further progress is impossible. The free association method may then be used as a means of gaining entrance into the unconscious. The patient is asked to make the present situation a starting-point, a situation which apparently has no explanation, and in which conversation seems to have been brought to a standstill. He is passively to observe the thoughts that flow through his mind and recount them as fast as they come. This is really to give himself up to phantasy formation, that is to the free play of the ideas that arise unselected from his buried, unconscious complexes.

This is not so easy a procedure as it would seem. For it happens very soon that the patient falls into silence, nothing seems to come to his mind. In reality the repressed complexes are interfering with expression. It is the resistance against coming to consciousness which seems to block all thought. The analyst has then to begin a detailed explanation with the patient of the whole unconscious procedure, and the significance of this apparent vacancy of the mind. He has to instruct the patient in the reality of the unconscious mental content, the real importance of the apparent absurdities, trivialities and above all of those things which appear as too disagreeable and unpleasant, or actually too painful, to recall and relate. For these all, particularly the unpleasant or painful, are capable in the course of the analysis, of connection with the cause of the illness, which can manifest itself only under these disguises. Though the patient cannot understand these things at once, he is encouraged to impart the thoughts as they come, in order that the physician may recognize them and use them as guiding paths into the actual, fundamental situation.

It must not be presumed that the knowledge of the unconscious and the importance of these things is easily or quickly learned by the patient. The very resistance to the conscious recognition of the complexes prevents this. When he really has mastered this understanding and can follow the associations to their sources, he is then approaching the end of the treatment.

It develops, therefore, upon the physician to be ever on the alert, for every little indication which comes under observation, a slip of the tongue, hesitation, stammering, mistakes, sudden laughter or other emotional sign, each has its significance, the

more profound the more involuntarily they appear, for then they arise more exclusively from the unconscious source. The tracing of one such trivial manifestation, inexplicable and meaningless at first to the patient, may lead directly into the heart of the conflict. An illustration may serve to drive home the significance of this emphasis of the trivial. A young man, telling about his previous illness, said that the physician had prescribed four quarter-grain tablets of "quinine" for him. He had no sooner mentioned the drug than he corrected himself and said "calomel." The analyst at once took up the slip, inquired into its associations and thereby brought out a most important event in the patient's life of significance in his neurosis. The repressed complex, struggling as always for expression, seized upon the similarity in sound of the two words to substitute for the intended name the one related to the repressed occurrence.

The most important therapeutic means for psychoanalysis is to be found in the dream. The split-off complexes, so strongly repressed by the waking consciousness, are able to come to expression during sleep. The vigilance of the censor is relaxed to the extent that repressed and unlawful wishes may escape to the activity denied them in real life. Enough vigilance is still maintained, however, especially in the state preceding waking when we begin to be conscious of our dreams, to prevent their appearance in undisguised form. Hence the varied symbolism that hides the real nature of the dream. The patient willingly enough relates these picturesque dreams in all their detail, bringing thus those actual wish-impulses and the conflicts they create, which it would be impossible for him to recognize in himself or to impart directly to the physician. A moral delinquency, or more frequently an intolerable, unethical wish-phantasy, comes thus to the surface and is voluntarily communicated by the patient. The physician, accustomed to the interpretation of the symbolic language and forms of the dream, obtains a quick insight into the unconscious desires and impulses, the hidden side of the patient, and finds here the broadest avenues opened into the unconscious complexes, which have given rise to the neurotic symptoms.

It is not only the unconscious content that the dream serves to disclose. The mechanisms of the dream throw light upon the symptom formation, for both are the same mechanisms the unconscious uses to effect the compromise between the repressed complexes and the censor of consciousness.

Dream analysis demands a separate treatment, because of its complexity and because of twofold importance of the dream. It serves as the most illuminating guide to the repressed material, it has also a distinct value to the physician as an indication of the patient's progress under treatment. It offers, moreover, to the patient at first a means of discharge of the disturbing impulses, later a stairway, as it were, upon which he climbs slowly upward to satisfactory sublimated levels of outlet. He learns to register his own progress in the dream. This can only be hinted at here.

The main features in a dream analysis, must, however, be briefly outlined. A very superficial penetration into a related dream discovers a rough fabric of meaning. The dream will appear to be constructed in fragmentary fashion of the events and interests of the past twenty-four hours. Associations with matters of importance will be easily pointed out. But this is only the manifest content of the dream. Behind this lies the deeper, more profound, more important meaning or series of meanings. These superficial experiences serve really as the cloak of disguise to hide the latent content, the portion of the dream of real significance.

The general function of the dream is to conserve sleep. Therefore it may not permit the unguarded wish phantasies to appear in recognizable form, which would bring disturbance. Hence the absurdities and apparent nonsense of the dream picture, which lead the dreamer to drop it from his attention and soon to forget it.

The mechanisms which have so distorted the dream are the same, we have said, that were used in the creation of the neurotic symptoms. They are first those of displacement, which transfers the principal emotion or "affect" from its proper situation to some other one. This serves the purpose, just as in symptom formation, of concealing from the patient the real object of his anxiety, fear or disgust, originating from his earlier intense desire, and placing the feeling upon some relatively indifferent object, sparing him thus the unbearable relation. Overdetermination is anothor mechanism, which produces in the dream the appearance of one particular figure, who condenses in himself, in a composite picture, the likenesses of many people related to the various experiences of the patient's life. Symbolism is a mechanism of distortion which utilizes a wide variety of forms to hide the true meaning of the dream from the dreamer and to tax the ingenuity and wide experience of the analyst in its interpretation.

Day-dreams, or conscious phantasy formations demand the same interpretation and are of equal importance with dreams of the night, as guides into the unconscious wishes and conflicts arising out of them. They too utilize the mechanisms at work in the dreams of the night, but in proportion as they do not slip from the control of the conscious, are not so phantastic in their distortions and disguises.

The events disclosed by these various means, free association, dream and phantasy interpretation, all must be considered as fact. It is of but slight concern whether they are actual happenings or existent only in the mental life. They are nevertheless psychological facts of actual reality to the patient, significant in his mental life.

The question of transference to the physician is of the utmost importance. It is the indispensable agent by which alone the patient can be reached, through which alone it is possible for him to put himself and his experiences, with his hidden phantasies, into the hands of the physician. Neurotics and psychoneurotics, the vast majority of persons requiring psychoanalytic treatment, are turned in upon themselves. They are too self-absorbed to meet reality efficiently and fill their place in the outside world. Their sympathies may be easily aroused, enthusiasm in this or that quickly created, but this is merely because their ego is insatiable in its demands. They are ready to espouse any cause, throw themselves violently into friendship or love, only in order to draw some new object into their own circle of interest, absorb or "introject" that, too, into themselves. This insatiable desire is but a part of the unsatisfied infantile affect, the libido separated from its original source, which is submerged among the repressed complexes. The physician comes, therefore, to represent one in a long series of persons upon whom this libido has sought to satisfy itself.

The true analyst recognizes this at once. He accepts the situation as one of vast importance to the patient. For the analyst becomes then a temporary bridge for the carrying of the emotion or affect, until the patient can gradually be led to the recognition of the infantile source of his unsatisfied libido, and guided into a conduction of it into useful adult channels of satisfaction in the real world.

The transference must be carefully watched by the physician. It indicates the attitude of the patient throughout the treatment in regard to his progress. An excessive regard may be unconsciously utilized to detract the patient's attention from his real problem, conceal the material which the analysis should be disclosing. Thus it represents a true resistance.

Or to serve the same unconscious purpose, the regard may turn to hatred, a negative transference, which offers more conscious resistance. The transfer dreams are the best mirror of the patient's attitude toward the analyst, as toward the treatment in general. They will be frequent and will perhaps occur at the very outset of the treatment, where they are of especial value. These dreams will disclose frankly the patient's respect or regard, or its opposite if that arises, any criticism of the physician or his method that may lurk even unconsciously in the patient's mind. This indicates that a certain situation has not been adequately dealt with, some idea expressed by the physician seems ridiculous and silly, or others are beyond the grasp of the patient showing that the physician has gone too fast. All of these things the physician must fully understand in order that he may guide the patient to an appreciation of these various situations and help him utilize them for the furtherance rather than the hindrance of the analysis.

Through these transfer dreams, moreover, the physician is enabled to keep himself under criticism. They mirror his part in the treatment as well as the attitude of the patient, and therefore assist him in discovering the resistances which may arise unconsciously on his side.

The transference might seem to create a dangerous situation, since it really means the transfer of the patient's affection to the analyst. This need not, however, be a source of danger nor an objection to this method of treatment. As a matter of fact the phenomenon of transference is of prime importance in all forms of psychotherapy, but it is only psychoanalysis that has clearly recognized its nature and value and made logical and systematic use of it as a therapeutic measure. If it becomes so intense as to interfere with the progress of the treatment, it must become the subject of careful analysis with the patient, so that he understands its real meaning and the resistances it has raised are removed. It must always be kept before the patient that it is a means to an end, the beginning of the flowing out of the patient's interest away from himself to the outer world. When this is accomplished and the treatment is ended, the physician withdraws, for the patient is able, with a newly acquired independence, to meet the actual world alone.

One persistent difficulty which the physician has to encounter is the innate desire in a patient not to get well. He wants relief from the suffering his neurosis entails, but would retain the symptoms so elaborately constructed as a defense, which permit a certain disguised enjoyment of the original wish impulse, even while denying its claim. This innate desire leads to an avoidance on the part of the patient of an honest discussion and facing of present problems, the following of false association trails, the disguising of the real issue under a variety of symbols and symptoms, which the physician must be able to penetrate and interpret.

Psychoanalysis is thus unavoidably a lengthy, painstaking process. It begins by an examination of the mind on the surface but may reach to any depth. There may be an apparent cure after very superficial treatment. Such is effected also by other therapies, and seems sometimes to take place almost miraculously. A patient may be superficially rehabilitated back to that particular point in his life where the neurosis broke through and be able successfully to make adjustment. This is not, however, a permanent cure. The analyst must perseveringly penetrate to ever deeper levels until he has reached the actual stronghold of the neurosis.

In this lies the answer to the question which puzzles so many inquirers, as to how an analysis, the unraveling of symptoms, can effect a cure. The illness is the result of a conflict but the real source of the conflict is unknown to the patient. He is fighting in the dark an unknown enemy. Psychoanalysis little by little examines and removes the symptomatic disguises, which have concealed but not solved the conflict, until finally the full light of understanding reveals the ultimate source of the entire failure of adaptation and resulting struggle. The patient recognizes the original difficulty face to face, sees it as its true value and thus sets it in its proper place, while he is now free to direct his energy into channels of serviceableness and real satisfaction. It may be that certain neurotic habits, either physical or psychical, have become inveterate, and cannot be completely removed, some reactions persisted in for years of illness cannot be completely changed. The cure may not therefore be absolute. The patient has, however, been brought to a point where this is immaterial. He has received from the physician, during the course of the treatment, a healthful re-education, a broad and helpful philosophy of life, which have lifted him out of his earlier infantile attitude and made him willing to advance to a higher level of adjustment. This means at the same time renunciation of the early sources of satisfaction and fulfilment of his true position in life.

It is plain from these considerations that psychoanalysis is not to be conceived as a simple and easy method of treatment. Nor must it be undertaken without distinct qualifications. It requires a great deal of time and unfailing interest on the part of the physician. He must be willing to give himself in an extraordinary manner. As it demands of the patient a profound probing into the depths of his personality and a gradual effort to reach out to the highest, so the physician himself must be prepared to have himself completely at the disposal of the patient. A previous psychoanalysis of his own mental life will prepare him for the self-criticism always necessary as well as help him to understand his patients. Then he must be a man of wide knowledge, not only in the technical sphere, which must embrace a broad knowledge of mental and nervous phenomena with their close interrelation with somatic conditions, but also in the meaning and importance of symbols and all the mechanisms that manifest themselves in the psychic life. More than this, he must have a broad and true outlook upon life as well as a wide range of cultural interests, for he has to meet such a range of possibilities in his patients and be able to guide them individually into those pathways which will prove of particular value in their new adjustment to life. At the same time it is he who must first infuse into them such a desire for the new and broader life. Psychoanalysis demands much, but it gives large returns in the effectiveness with which it enables the analyst to meet the extensive and profound needs of a very large class of sufferers, for whom there seems to be no other really effectual help. More than this, it brings into its service that boundless range of interest, which reaches to any height and any depth in the study of individual need, and in the interpretation of this in terms of racial history with its world-wide and age-long experience.

SMITH ELY JELLIFFE.

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Psychodidæ.—The moth-flies. This family includes very small nematocerous Diptera, which have the body densely covered with hair giving them a moth-like appearance. *Phlebotomus papatasii* transmits the "three-day fever." Another species is believed to be the carrier of verruga.

A. S. P.

Psychoneuroses.—Just when the term psychoneuroses originated is comparatively unimportant. Although it is recent, the ideas which lie behind it are of the greatest antiquity. It would be of little moment to trace these as excellent historical chapters can be found throughout medical literature, but it becomes of importance, if possible, to present the general problem in the light of its development:

The concept of disease has suffered much moulding. So far back as the light of historical research can take us one can see in primitive animistic thoughts the battle with the unknown forces which brought pain and death. How these were conceived of as "Shades of one's ancestors" as devils, as force coming from the great unknown, the students of animism have well sketched.

From these early times the struggle with the forces which tend to disintegrate the human body became more and more productive of calculable certainty and the science of medicine arose.

Those things which in the beginning were most readily comprehended naturally were of a physical nature: Blows, wounds, cuts, results of falls, etc. The direct relation between cause and effect were not difficult to be established even in the most primitive of minds. In the study of these primitive mechanical factors the science of surgery had its cradling.

It would be natural at first by reason of this insight that the physical forces would be considered envisaged as products of disease; but it took many centuries before physical force, coming through the chemical molecule, became recognized as disease factors. For many hundreds of years chemical factors, therefore, have been studied with increasing definiteness, and most of the problems of internal medicine have been solved in terms of perverted chemistry.

The whole science of bacteriology and parasitology was a contribution made through the introduction of outside physical but unseen forces.

Side by side with the gradually increasing definiteness of these factors there has always been a lingering notion in the minds of the public, as well as in its supposed leaders, the medical men, that thoughts, whatever they may be, have had something to do with disease. Human desires have seemed as operative as physical force, and the thwarting of human desire has been known to produce illness as definite as that received from the wounds of an enemy's javelin. Indeed the literature of medicine of the ancients is filled with illustrations of this kind, chief of which the factors of love, fear, hate and malice stand out. Indeed if one read history aright it was to Thales of Milesia 500 B.C., one of the greatest of the philosophers of the Greek period who stated that hate and malice and envy were responsible for most of the ills the world knows.

Thus there has grown up gradually a field of knowledge showing that physical, chemical and psychical forces can produce disturbances in the orderly working of the human body, which when they become great or inconvenient are called disease.

Diagnosis is solely a practical instrument, and classifications of diseases have value only in so far as they enable one to handle the disease process better, that is, produce cures. Hence with increased knowledge classifications modify. Each classification is nothing more or less than the crystallization of knowledge at a certain stage in its progress. If it tends to linger too long in the old settings it retards progress; while without it frequently our concepts are too nebulous to have any practical application. Any classification, therefore, is nothing more or less than an index of the state of evolution of a concept, which defines in the broadest of terms, not a thing, but a way of grouping things. From this point of view, then, the psychoneuroses is a term not of a thing but of a group of disorders, which are recognized to be due to psychic events, and which for purely practical purposes may be separated from other groups of disorders, also of purely psychical origin, and which vary from them in matters of degree, and which are more particularly spoken of as neuroses or as psychoses.

In other words, for practical purposes one may speak of them as benign psychoses, by which the term psychoses is meant to include a large group of mental disturbances, many of which are thought to be purely psychogenic in origin; but some of which have a definite somatic causation.

The point to be emphasized here is the term used in the classification itself, not meaning a thing but as a purely pragmatic concept of use in handling things.

From one attitude of mind, however, the psychoneuroses may be considered en bloc. There is little need of differentiating the kaleidoscopic modifications which are present in the group; there is no practical advantage to be obtained by giving differential terms to them says one who holds to this point of view. Whereas this attitude of mind can be readily comprehended, applied too laxly, it would mean that classifications are of no value under any circumstances; whereas too rigidly applied it leads to such a formalism that it defeats its purpose.

One is wisest when tracing the evolution of the concepts which lead up to classifications to attempt to present the present day modes or attitudes of looking at the problem with as clear an etiological basis behind them as possible. For after all disease will only be understood, and therefore capable of being treated, in the light of its origin.

The psychoneuroses have been usually divided more or less arbitrarily into four or five broad subgroups, although there is a tendency on the part of some lazy students to lump them all under the broad general terms of nervousness, neurasthenia, phobias, functional neuroses, obsessions, fixed ideas, hysteria, etc., etc. In recent years, the most signal advance in the analysis of the group of phenomena has been made by Freud, who at one stroke, as it were, divided the group into psychoneuroses and actual neuroses, in the former of which are placed hysteria and compulsion neurosis, and in the latter anxiety neurosis and neurasthenia. The etiological causations which lie behind these are discussed in their respective chapters: Thus in the psychoneurosis hysteria, the symbol, which is the carrier of the energy, is converted into a physical process—a so-called hysterical conversion, which may be hysterical blindness, deafness, paralysis, skin disease, disturbance of the bladder, of the heart, of the blood-vessels, of the veins, of the skin, of the bones, etc., etc., in which sense one speaks of hysteria as the mimic of all somatic diseases.

In compulsion neurosis the symbol, which is the carrier of the energy, is no longer the converted physical product, but is a purely *substitute* product. The symptom has no necessary relationship whatever to the underlying cause, so that in this group, which is largely made up of fears, obsessions, tics, etc., such as the fear of being in the theater, fear of crossing an open space, of being in a dark room, of hearing certain words, etc., etc. (see *Phobias*). There is no physical conversion but the pathological affect is attached to an apparently meaningless situation. These two groups are set off from the actual neuroses by Freud under the head of the psychoneuroses. When it comes to the actual neuroses, consisting of anxiety neurosis and neurasthenia, there are definite somatic etiological factors, whereas in the psychoneuroses the etiological factors are more mental, hence psychogenic. In anxiety neurosis the chief etiological factor is usually connected with injury to the sexual life of the individual, and appear chiefly as virginal fear, the fear of the newly married, the fear from diminished potency, from interrupted coitus, in intentional sex abstainers, in the menopause, in frustrated sexual excitement, and in senility. Whereas

in neurasthenia some definite toxic, infectious, or fatigue factors can be found on proper investigation.

It is preëminently useful in therapeutics to distinguish these four groups, although it can be readily comprehended from the discussion that has already taken place that they are a medley, in which now one now another factor is prominent, and in which no absolutely sharp lines of demarcation can be drawn. In diagnosis the most important factors to eliminate are those of somatic origin. Thus if on first studying a so-called neurotic patient a positive Wassermann is obtained it can be said that the patient is suffering from syphilis, in which fatigue or neurasthenia is a beginning sign. Neurasthenia is also a legitimate diagnosis following influenza, but the diagnosis is unwarranted in lead poisoning, diabetes, nephritis, beginning carcinoma, etc., etc., simply because the patient complains of fatigue. The neurasthenic or fatigue factors appear in the foreground, whereas the etiological factors are hidden. To make a diagnosis of neurasthenia here is folly. The hazy and more or less nebulous autointoxication hypothesis should be avoided, because a careful study of the so-called neurasthenic phenomena very frequently will tend to show that the fatigue is combined with other symptoms, which will indicate that the psyche is more involved than the soma. It is largely for this reason that so practical a clinician as Dejerine prefers to take the whole group and treat it from a disturbed emotional side. "Straighten out the emotional life," he says, "and the patients will get well." This, however, while true is only a crude approximation, and although it is effective for a great many does not get sufficiently near to scientific explanation as one would wish, especially in the comprehension of the dynamics of the psychoneurotic group, *i.e.* hysteria and compulsion neurosis. (See *Phobias.*)

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Psychoses, Infection-exhaustion.—*Synonyms:* Confusional Insanity, Amentia, Acute or Grave Delirium, Typhomania, Delirium of Collapse, Febrile Psychosis.

This psychosis is characterized by disturbances of perception (hallucinations or illusions of the special senses) disorientation of time and place, and insomnia. In addition many patients have fleeting delusions, usually of a painful sort, and increased motor activity. A few cases, however, will remain in a stuporous condition. The psychosis may precede, accompany or as is commonly the case, follow attacks of the various infectious diseases, as influenza, typhoid fever, erysipelas, rheumatic fever, pneumonia, malaria, etc. It may follow the puerperal state or surgical operations. It also is seen after alcoholic excess or in those addicted to morphine or other drugs.

ETIOLOGY.—In this type of insanity, as in other acute forms, we may expect to find a dual causation, such as a toxalbumen in the blood acting upon a predisposed, unstable, nervous system. The writer believes that this twofold etiology is all but universal in mental diseases. Medical practitioners see an endless variety of idiosyncrasies or susceptibilities among their patients to drugs or common articles of food.

It is not unreasonable to expect that there is an equally variable susceptibility to the various chemical substances which may be found in the blood, whether normal products of metabolism or the toxalbumins resulting from infectious diseases. The well-recognized fact that in the majority of insane there is a history of neurotic taint in others of the family strongly supports this view. Given then an unstable nervous system in a neurotic individual or a degenerate and let him meet with any of the many accidents which may tend to lower his vitality or be attacked with an infectious disease, we have a right to expect profound nervous disturbance. If the dose of the poison be unusually large, either from a sudden absorption by the circulation or from defective elimination, we may expect serious mental symptoms. On the other hand, the more unstable the nervous system, or the more susceptible, the more quickly may we expect such symptoms from a relatively small quantity of the excitant poison. As this factor is incapable of measurement and is always uncertain it interferes with the making of a definite prognosis. Experience shows that the history of numerous cases of mental or nervous disease in the family does not warrant a bad prognosis in a case of this psychosis. Such a family history may indicate merely an unusual instability or susceptibility to a trivial exciting cause and recovery may be rapid and complete.

CLINICAL HISTORY.—The onset of symptoms is usually rapid. They may occur with startling abruptness. The prodromal symptoms are restlessness, insomnia, or sleep broken by disturbing dreams, irritability, headache, and some mental confusion. In women we often see some hysterical symptoms. This evidence of a loss of self-control must not be slightingly considered, as it may be the forerunner of serious mental disturbance. One of the first symptoms to be noticed is hallucinations of one or more of the senses, usually of more than one. Hallucinations of hearing and sight are especially common. Consequent upon the hallucinations are delusions. The patient hears voices in the room or the wall, or overhead, or the next room, which tell of distressing things about to happen—that the patient is to be burned or killed, or that his soul is lost, or his children are to be tortured, or his loved ones ruined; that his friends are to prove false, he is to be financially ruined, etc., etc., or he hears pistol shots or the noise of fire engines. Hallucinations of sight of the same nature add to his distress. Strange forms—robbers, monsters, officers of the law, forms of the departed, the figure of God, the Virgin, or the dead—appear before him. A rapid shifting of these hallucinations gives rise to various delusions and sudden acts of violence and attempts to escape on the part of the patient. Suicidal and homicidal attempts are not uncommon during this delirious condition. Friends and members of the family are not recognized; the physician is taken for an enemy or the Evil One. The hallucinations and delusions are not always persecutory, although more commonly so. They may be of a hypochondriacal nature. The patient may believe he has no stomach or he is dead.

Or the hallucinations may be of a religious or erotic character. A woman believes she has been assaulted and outraged, or she has seen the Saviour and He is to make her His bride. Hallucinations of all the senses may be looked for, and we frequently find the patients complaining that poison or filth has been put in their food or foul gases are injected in their room.

The delusions of these cases are as a rule transient and change with the hallucinations. They are not fixed as in the cases of primary delusional insanity (paranoia). The delusions are more freely talked of soon after the onset of the disease and gradually fade, while in primary delusional insanity there is an evolution of the primary or chief delusion, and it is talked about more and more as the disease progresses.

Some patients, however, will not express their delusions. We can observe merely a suspicious attitude and we can only infer the presence of hallucinations and delusions from the patient's behavior, which

expresses fear, terror, a capriciousness or change in conduct toward those about them. Such a case may first attract attention by jumping from a window, and it is not always possible to decide at once whether this was an attempt at suicide or a frantic effort to escape from some imagined harm.

There is almost always seen some confusion of mind. There is incoherence of ideas, a failure to recognize friends or surroundings (disoriented). Mistakes of identity are very common. This essential symptom may be of all degrees from a simple haziness of comprehension, a misunderstanding resulting from the hallucinations, to complete delirium with no memory of the illness remaining upon recovery. There is, as a rule, a partial memory of the events of the illness upon recovery. Patients often remember their coming to a hospital and say that for some weeks it was a blank, or there may be almost a complete memory of the events connected with the period of alienation. Occasionally the delusions may persist after the hallucinations have disappeared and the patients have in other respects recovered. Such cases often are very troublesome, as they repeat stories of abuse during their illness after they have apparently recovered, and even after they are able to return to their homes they blame their friends or physicians for an improper commitment. They retain a vivid recollection of the necessary restraint exercised by nurses or friends and persistently refuse to see that such methods were needful or humane. As a rule, however, the delusions fade with returning health, and a reasonable attitude is taken.

The progress toward recovery in curable cases is not always uniform. There may be several relapses to the confused state during convalescence; the saner periods ("lucid intervals") may be short, or the periods of confusion, usually two or three, may be separated by longer intervals of comparative sanity. Occasionally, there may be a daily alternation of sane and insane periods extending over a period of weeks. This is sometimes so marked as to suggest malarial infection.

The course of this disease in recoverable cases varies from a few weeks to a year. It is seldom less than two months and is often more than six. While the majority of patients recover, in the more severe cases death ensues from exhaustion. In the class of cases described as *acute delirium* death is almost certain. In other cases a chronic insanity follows—it may be a chronic deluded condition resembling paranoia or there may be a tendency to dementia.

This disease is chiefly one of middle life, occurring between the ages of twenty-five and fifty. But no fixed age limit can be set as it is evident that the conditions of an unstable nervous system and the introduction of noxious substances into the circulation may occur at any age. This condition may be seen during old age, though it is not common. It is noticeable that while children are especially subject to infectious diseases, the occurrence of this type of insanity in children is very rare. Yet children are especially liable to a brief febrile delirium in the course of infectious diseases.

While I have attempted to give a brief and general description of this malady, it must be borne in mind that individual cases show a great variety of symptoms or a predominance of one group over others, and it is perhaps true that no two cases present exactly the same clinical picture.

In some of the younger cases, occurring soon after puberty, we are apt to find a stuporous condition, which, for a time, may be so prominent as to mask or suppress the essential hallucinations or delusions. This class of cases (*acute primary dementia, curable*) exhibits a profound stupor or passivity. There is marked cerebral anemia, and evidence of a sluggish circulation. The patient lacks the initiative and will make no effort to eat until food is placed in his mouth, and he may even not swallow then. He neglects the calls of nature and will lie passively all day long. The cataleptic condition may ensue. There are dilatation of the pupils, diminished reflexes, and cold surface.

There is no resistance as is seen in melancholia. This condition may result from a mental shock or from any physical cause producing exhaustion or anemia, such as parturition or febrile disturbance or trauma.

The stuporous condition disappears and more active symptoms supervene and we see for a time the hallucinations, delusions, and excitement as already described. We may see one or more relapses into the stuporous condition before recovery takes place.

Acute or *grave delirium* or *typhomania* is, fortunately, a rare condition and may fairly be considered to be an extreme type of this affection. There is always an elevation of temperature which may be due to the infection of pneumonia, tuberculosis, measles, etc. It is the most severe form of maniacal delirium seen. It may come on very suddenly, so that if the patient be seized while among strangers it may never be possible to identify him. Death is the rule after a brief and severe illness, averaging about ten days, the delirium becoming muttering and later giving place to coma.

Insanity is a frequent complication of the infectious diseases both during and after the febrile movement. It is seen in variola, typhoid fever, scarlet fever, measles, pneumonia, cholera, erysipelas, rheumatic fever, influenza, diphtheria, multiple neuritis, phthisis, or any of the inflammatory processes.

The delirium may precede the rise of temperature (*initial delirium*), but more commonly occurs during the height of the febrile disturbance. Such a delirium may occur in those who possess a normal brain stability. In such cases there is a serious poisoning from the toxalbumens and an impoverishment of the brain cells from the circulatory and nutritive disturbance. But in those possessing marked nervous instability delirium may accompany a low temperature. Febrile deliria, though characterized by the hallucinations, delusion, and great confusion seen in infective psychosis are by common consent not deemed a true insanity although psychologically and clinically they may not be distinguished from it.

But if with the subsidence of the febrile movements the delirium persists, or if the mental disturbance appears for the first time after the temperature becomes normal, the mental symptoms are not so evidently the result of the febrile condition. While it is true that the toxins are still a factor, the exhaustion of the brain cells is also a potent one. Under these conditions one may see a short delirium with great excitement and extravagant or distressing delusions where the patient takes no notice of surroundings, and, if the exhaustion is not fatal, recovery taking place within a few weeks (*collapse delirium*). Or there may be a less active mental disturbance running the slower course as described.

The complication of the puerperal condition with any form of mental disease, whether manic depressive insanity, hebephrenia, paranoia, or exhaustive psychosis, is loosely spoken of as puerperal insanity. The last mentioned is the form of insanity described in the books as the type of puerperal insanity, or mania, and is more precisely described as *postpartum insanity*.

Much has been written upon this distressing condition and its occurrence is very alarming and naturally causes the greatest anxiety for the family as well as for the patient. Many of these cases are simply an infectious insanity and run a short course. Since the general use of antiseptics in midwifery this trouble is undoubtedly less frequent. This complication is undeniably seen when the parturition has been free from a considerable rise of temperature. It is highly probable that the exciting poison is distinct from that

which supposedly causes a rise of temperature, and this acting upon a brain impoverished by a diminished blood supply or impaired by months of worry and anxiety (arising from poverty or illegitimacy of the child, *e.g.*), with insomnia, produces mental alienation. The course of the disease is similar to that described, and all the varieties occur.

It is imperative that the child be taken from the mother at the earliest intimation of trouble, both for the child's safety and to relieve the mother from any annoyance. Where there is active delirium and a possibly brief course of trouble, home treatment may be tried, but only with sufficient assistance from nurses to allow constant attention upon the patient. Such care is, as a rule, impossible for financial reasons, or, in densely populated districts, the annoyance to the neighbors is too great to be endured, and one is driven to resort to unduly radical measures to keep the patient quiet.

Delirium tremens is so generally considered to be a disease entity that its consideration will be found elsewhere. It is clinically to be regarded as a special variety of this psychosis with a well-known exciting cause and especially characterized by hallucinations of sight and delusions of a distressing character.

Differential Diagnosis.—While the term mania, as often used, includes those cases here described, it is more accurately used to define a condition of exhilaration or good feeling, with great motor activity and restlessness with an increased flow of ideas, in which hallucinations and delusions may be present, but delirium and confusion are not marked. Mania comes on slowly and begins before the age of thirty years, is apt to recur and is a comparatively rare disease. There is in mania an hereditary predisposition. Melancholia, which is closely allied to mania, begins slowly often after an attack of neurasthenia, is characterized by a primary depression of spirits; the depression is not secondary to distressing delusions, and there are self-depreciatory delusions; orientation is good. It does not tend to follow febrile delirium. As in mania there is a tendency to recur.

In paranoia there are fixed delusions without confusion. Paranoiacs, however, are subject to exacerbations of excitement, which may for a time be mistaken for attacks of infectious psychosis. A close study of the case will soon remove all doubt.

There is frequently some difficulty in differentiating the short excitement and semi-delirious conditions seen in cases of general paresis or other organic brain disease. Observation and careful study of these cases will soon reveal evidence of gross brain disease, and the diagnosis may then be established. When the onset of general paresis is sudden and follows a febrile disturbance, as it does not infrequently, a positive diagnosis is impossible at the outset.

Prognosis.—The prognosis is, as a rule, favorable except in the severe cases of the most acute form of delirium in which the exhaustion is so profound as to cause death or in which it may be affected by the complication of a physical trouble.

If there is a fair stability of the nervous system, recovery from the mental symptoms, with the exceptions mentioned, may be looked for. The best index to recovery is an increase in bodily weight, and it is important to keep a weekly weight chart for consultation. The increase in weight is often very rapid, sometimes five pounds a week for several weeks. In women a return of the catamenial flow is an index of restoration of the physical health, and if the mental condition does not improve simultaneously or very soon after the physical improvement, there is reason to fear a terminal dementia or chronic insanity.

Recovery should take place within a year or so, at most, from the appearance of mental symptoms. If there is no decided improvement within fifteen months, the case may be said to have become chronic. The hallucinations with confusion may continue and *chronic insanity* results, which like other acute vesaniæ tends toward a decline of the mental powers with a terminal dementia which is of various degrees.

In a certain proportion of cases the confusion disappears, but the delusions, which are more or less fixed, may persist and we have a chronic delusional insanity with a less rapidly ensuing dementia.

Or the stuporous condition may recur or persist and lead to a chronic dementia. It is assumed that the inherent strength of the neurones is weaker in these cases and they are incapable of restoration.

Treatment.—The place for treatment must be early considered in every instance. If the case is very acute and there is reason to expect a short illness, home treatment, if practical, should be advised. It must be admitted that the fact of commitment to a hospital for the insane does affect the business and social status unfavorably, although this prejudice is often very unjust and unreasonable. Home treatment should not be attempted without the assurance of abundant and competent nursing aid, which is necessarily expensive. In the majority of cases, however, it will be found necessary to resort to treatment in a hospital especially equipped for the care of the insane.

The exhaustion calls for prompt and assiduous measures. Frequent and regular feeding is all-important. It may be that artificial feeding by means of a nasal tube will be required, but it should not be resorted to until all attempts to persuade the patient to take food naturally have failed.

The food should be simple and reenforced with stimulants, especially alcohol. The continuous bath is the most efficient sedative known. The patient carefully watched is kept many consecutive hours in a tepid bath at an even temperature. If feeding and bathing do not induce sleep, hypnotics may have to be used, but their use is to be deprecated unless absolutely necessary. Bromides, veronal, or trional should be tried first. Rarely in an acute delirium a few doses of morphine with atropine subcutaneously, may be necessary to induce a brief rest. This should not be used repeatedly, but be followed by the hypnotics. Frequent feeding with liquid food, with small amounts of chopped meats and repeated small doses of alcohol will often induce a natural sleep, especially if supplemented by warm baths and sponging. Attention should be paid to the rapid elimination of poisonous products by aiding the bowels, kidneys, and skin to throw off their excretions.

At first rest in bed is essential. To accomplish this forced detention in bed sometimes becomes necessary. This may be done by the nurses holding the patient, but preferably by mechanical restraint, as a sheet, or more rarely by some bed harness. These measures are used much less than formerly. They are very liable to abuse. They are, however, necessary in surgical cases or where exhaustion is extreme. The use of this measure calls for the best judgment of the experienced physician.

If the patient must be held for any considerable time by others, there is a liability to increased exertion and resentment on the part of the patient, who is more apt to yield to the inevitable of mechanical restraint. The excitement and fear are increased when the patient is held in the grasp of others.

After the stage of exhaustion is past and food is taken well, tonics, as iron, strychnine, and phosphates, are called for. Bodily weight should be watched as it is the best indication of improvement. A quiet environment away from the presence of overzealous and well-meaning friends does much to promote recovery. Strangers can usually do better for a patient who is not in an unconscious state than can members of the family. Edward B. Lane.

Psychoses, Involutional.—Certain epochs in human life—puberty, adolescence, the climacteric, senescence, and senility, for example—are in many cases accompanied by mental disturbances which, superficially, are distinctive of the given epoch.

The tendency among modern writers on disorders of the mind is to classify those which accompany the last three epochs as the *involutional psychoses*—largely a term of convenience and one which does not in the least connote a uniform etiology, pathology, or symptomatology.

The frequent incidence of an involutional psychosis in women at the time of the grand climacteric, has led certain observers to ascribe to this natural phenomenon an etiologic significance entirely unwarranted by the facts. The climacteric is, in reality, never more than the proximate cause of the mental disease in question. The problem of causation, in its entirety, is a most complex and subtle one. In many cases the fact of the existence of insanity in the patient's forbears is intentionally concealed from the physician by the immediate relatives of the afflicted person; and in many others no reliable data are obtainable on this point, even where no attempt is made by those concerned to obscure the truth. If the whole truth were known, it would certainly appear that practically every victim of an involutional psychosis is the possessor of the insane diathesis. And even as matters now stand, history after history of such cases discloses the present or past existence of marked eccentricity or actual insanity, not only in the patient's forbears—either immediate or remote—but in brothers, sisters, uncles, aunts and also in their offspring.

Factors other than heredity are doubtless active in causation. Among these the grand climacteric in women has already been mentioned. Further physical causes are exhausting illness, particularly of the infectious order, and severe surgical diseases. Causes of a moral and emotional order likewise play a causative rôle, notably remorse, worry—both domestic and financial—anxiety, and grief. But after all, heredity is paramount.

The first severe attack may not make its appearance until the middle period of life, but in a large number of cases there is a history of preludes in the form of transitory depressed states, with or without excitement, which often date back to the second decade. The onset of a typical case is rare after the age of sixty-five. The incidence of the disease among women is greater than among men, but this preponderance in the former is not particularly striking. The development may extend over weeks, months, or even years.

The one phenomenon which gives the involutional psychoses whatever clinical distinctiveness they possess is *melancholia*. The outward expression of this phenomenon is comprised in three distinct groups of symptoms: (1) the emotional; (2) the mental; (3) the physical. And from the beginning to the end of these disorders the morbid emotional tone of the patient dominates the picture.

In the simplest cases there is a conscious loss of the sense of well-being, of the joy of living, without acute mental pain. The intellectual processes are coherent, but the sufferer finds concentration difficult and ultimately loses the mental aggressiveness upon which the successful prosecution of his affairs depends. He is no longer able to approach people and win their confidence because his self-confidence has vanished. He becomes sensitive and suspicious to the point of being deluded. Ideas of reference take form in his mind. He becomes convinced that people are taking advantage of him, are endeavoring to oust him from positions of honor and trust, because they are aware that he is losing his grip. He is certain from the looks and demeanor of his associates that they know he has ruined himself by sexual or other excesses.

The accompanying physical signs are equally characteristic. The ordinary facial expression is one of settled gloom, although the ability to smile on occasion is still retained. The sense of bodily fatigue is marked and persistent, and the organic activities are at a low ebb, particularly in the morning after a night of broken sleep and restlessness. The appetite is capricious; digestion labored; peristaltic action sluggish; the beat of the heart enfeebled, and its rhythm disturbed. There is marked hypotension in the palpable arteries, and vasomotor disturbances of various kinds are manifest. Often there is a very appreciable loss of body weight.

Throughout the attack, the victim of the above-described disorder reacts to his emotional depression and to his disordered bodily sensations in a manner that is distinctive. His insight may be impaired, but is never actually lost. Consequently he is able to conceal his symptoms from those to whom he does not wish them known, and endeavors to hide the gloom of his countenance in a self-imposed isolation, more or less complete, where he fosters the delusion that he has made an utter failure of his career, that he has criminally neglected and brought ruin upon his family or other dependents—in a word, that his situation is practically hopeless; nevertheless, if suicidal ideas or impulses arise, he rarely gives way to them in a fashion to excite alarm.

In very many cases, unfortunately, the conditions are much more serious. In certain ones the emotional activities of the patient are dominated by the feeling of his absolutely limitless sinfulness. This feeling is doubtless brought about by the conviction, which is practically universal in the human breast, that punishment inevitably follows upon crime. Its possessor is satisfied that the unspeakable burden of emotional, mental, and physical misery under which he labors is God-sent and punitive; and indulges in an examination of conscience that is incredibly meticulous, in the effort to discover the reason for the divine wrath that has descended upon him with such inexorable fury. With paralyzed inhibitory power, sadly warped judgment, and annihilated sense of proportion, he recalls the thoughts and deeds of his life and encounters in every nook and corner of his conscience a hideous specter of guilt.

The list of sins of omission and commission that such a patient may fasten upon himself is extraordinary in length and diversity, and those for which he takes chiefest blame are usually so heinous that, in his sane state, their mere contemplation would cause him unspeakable horror. It would be futile to attempt to reproduce the entire list. Let it suffice to say that sins of a sexual order, ranging from masturbation to bestiality, generally dominate the delusional content, although the "unpardonable" variety, which the patient can never clearly define, finds a prominent place.

Reaction to this type of delusion is very marked. The patient's countenance, gestures, and acts faithfully reflect the mental and emotional torture he experiences. Haunting terror, anxiety, and other forms of mental pain throw into action the mimetic muscles in kaleidoscopic succession. At times the patient moves restlessly about, wringing his hands, groaning explosively, and peering anxiously out of the window; at others he lies huddled upon couch or bed, plucking at his hair, or pulling at his flesh until he brings blood. He is not disoriented, and thought processes are not retarded, although the language employed is more or less stereotyped and expressive of the delusional content—the patient is to be incarcerated for the remainder of his days, or even for eternity, in a black dungeon; he is to be killed by some diabolically ingenious method, or tortured everlastingly with like fiendishness.

Such a patient makes a great show of resistance when attendants or others attempt to feed, dress or undress him, or to get him into his tub. He strikes,

pushes, and pinches those about him at such times, and gives explosive utterance to foul and obscene words. If he is got to bed fairly early, he will toss restlessly about, indulge aloud his delusions and self-recriminations for hours at a time, and finally sink into a more or less disturbed sleep, from which he awakes a few hours later as deluded and garrulous as ever.

If active hallucinatory phenomena are present, the suicidal impulse may be very strong; indeed, it may be strong in any case. False hearing is generally more common than false sight, but all the special senses are at times involved. The patient imagines he hears voices which threaten and accuse him, call him vile names, or command him to kill himself. He sees grotesque faces at the window, which leer, grimace, or mock at him. To him his food appears to be covered with poison, vermin, excrement, or even semen. Flesh meat tastes to him like human flesh; all his food stinks; the house is full of horrible odors; poisonous gases come through the radiators—and so on through a long list of false sense perceptions.

Even in cases where the situation is as serious as just described, the actual attempts at suicide are seldom genuinely alarming. Certain patients mournfully complain that suicide would not solve the problem for them—they are certain that their punishment is to continue in the life to come. Others beg to be killed, or allowed to throw themselves under a railroad train; and if the opportunity presents itself, do essay to hang, drown, or poison themselves, but the attempt is, for the most part, suspiciously half-hearted.

Throughout the entire course of this type of case, the bodily accompaniments of the mental disorder are striking. There is often a notable aging, as evidenced by a discharge of the color of the hair, and by increase in the prominence and tortuosity of the temporal arteries. The tongue is invariably coated, even though the bowels, which tend to obstipation, are kept freely open. All the organic functions may be impaired, and a very marked loss of body weight may occur.

Intense motor excitement may exist from the beginning, or it may develop at any time during the course of an attack of involutional melancholia. This phase of the disease is most commonly observed in women, but is also seen in men whose motor responses to emotional stimuli are excessive, even under normal conditions.

At the height of the excitement patients rush about the room, pace incessantly up and down like caged wild animals, or roll on the floor, giving vent continually to moans, shouts and lamentations. The pupils are widely dilated, and the facial expression indicates the most intense mental pain. Such patients pluck out their hair, pick holes in their skin, masturbate openly and shamelessly, compress their throats with their hands, and beat their heads against floor or wall. The sense of physical pain seems to be markedly blunted, or entirely annihilated. These same patients are frequently blasphemous and obscene beyond words, destructive of clothing and furniture, utterly indifferent to their personal appearance, and, withal, savagely homicidal.

If the excitement is at all prolonged, the naturally consequent sleeplessness, refusal of food, excessive output of muscular energy, and masturbation, bring about a deplorable state of affairs on the physical side. Emaciation becomes extreme, and the skin exhibits all sorts of trophic disturbances—notably boils. Ultimately there is marked exhaustion with febrile movement.

In a certain group of cases a peculiar delusional expansiveness without marked reactionary motor manifestations is a prominent clinical feature. The ideational content bears the stamp of the ultragrotesque. Certain male patients either attribute to themselves the powers and achievements of the Creator, or believe themselves royal personages; while among females the idea that they are the Virgin Mary, pregnant with the infant Jesus, or otherwise worthy of adoration, is not uncommon. Hallucinatory phenomena of a varied order are also a marked clinical feature of this group, and loss of insight, disorientation and other signs of actual mental enfeeblement are seldom lacking.

In still another group delusions of a somatic order predominate. Patients in this group are wont to exhibit graver errors of judgment and less inhibition over morbid speech and conduct than those encountered in certain other groups. There are practically no limits to the hypochondriacal melancholic's fancies: He is completely out of sorts, can't get any air into his lungs, his stomach and liver never work, his intestines are hopelessly impermeable, his kidneys have ceased to act, his heart is going to stop beating, he is paralyzed, his brain is made of lead, he is made of glass and will break if roughly handled—and so on through an almost interminable list of organic disasters.

In many of these cases, as will readily be appreciated, there is some basis in fact for the multitudinous complaints. Nevertheless the hyperbole employed by the patient in the description of his feeling of physical ill-being and the utter impossibility of convincing him of the absolute erroneousness of the interpretation he puts upon the nature and cause of this sense of ill-being quickly betray the quality of the underlying mental disorder.

In a final group may be placed the victims of certain feelings which mark the utmost in desolation of human emotion—those of transformation or dissolution of self and, as a consequence, the entire world. The march of events clinically is from negativism to nihilism. And it is easy to understand this phenomenon if we take into consideration two facts: (1) that the personality or ego represents the sum total of all the bodily feelings, and (2) that a normal conception of the world about us is the result of a perfect harmony between inner and outer relations. It naturally follows, then, that with a profound disturbance in or entire dissolution of the inner relations which subtend personality, the harmony between the inner and the outer relations is seriously disturbed, if not entirely annihilated, and the individual's conceptual faculties—so far as the world about him is concerned—are grotesquely distorted or reduced to the vanishing point:

"This is not my hand—this is a *dead* hand," is a common contention of patients in this group; and subjectively disordered sensation frequently leads to similar negations with regard to the normal existence of other parts of the body. The same patients also contend that the faces of those about them are not real, but masks, that the sun and moon are not natural objects but artificial—electric lights, etc.; and this mania of disavowal may be limitless.

The nihilistic tendency is even more striking. Here the patient often whiningly complains that although he can't remain where he is, he nevertheless has no place to go: "There isn't any place, there isn't anything anymore. What am I going to do? What am I going to say? Won't you tell me? Won't you tell me?" And he may go on in this strain for days at a time. Often he will vary the theme by declaring that there is no food and no money in the world, no water in the ocean, no living beings anywhere—in a word, that everything in the universe, down to the very last atom, has vanished.

Course and Duration.—As previously stated, the initial phase of the disorder in question—covering usually a period of several months—is apt to be the stormiest. During this time both the homicidal and the suicidal impulses are strongest, the sleep most disturbed, and the loss of body weight most profound. After this the patient generally settles down to a

condition of greater tractability and goes along for many months without, on the whole, showing any notable change. During this time the disease is marked by peculiarities that are more or less distinctive—for example, a night of five or six hours' sleep is apt to be followed by a day of unusual restlessness and agitation, whereas a night of only two or three hours' sleep is often followed by a day of comparative calm. The appetite and digestion are not infrequently good; nevertheless the gain in body weight is seldom noteworthy. The patient's habit of dress betrays the various manias which torment his mind. He will not tie his shoe strings or his cravat because, in his mind, such acts have a significance sinister to his welfare, and he will not voluntarily go out of doors because he fears everybody and everything. As a rule, his day is spent pacing up and down his room moaning, lamenting, wringing his hands, picking at his skin or hair and interrogating those about him as to the meaning of it all. In spite of his constant restlessness and lamentation he may at times take up a paper and read, write a brief note, or work over a picture puzzle. For the most part his gait is slow and shuffling, his speech characterized by endless repetition of words or syllables. He gives the impression of a general retardation, but the latter is more often apparent than real. If an interesting conversation is going on about him, he at once becomes alert and in many ways betrays his interest in and understanding of what is said.

Toward the end of the attack, in favorable cases, the appetite increases, the body weight goes up sensibly and the sleep improves. This physical betterment is always the forerunner of mental improvement, but may exist for a discouragingly long time before the mental improvement makes its appearance.

In the great majority of cases recovery from the individual attack is complete in about a year, but many cases run along for from two to five years before the mental balance is restored. Hence, mere duration of symptoms is a most unsafe guide in determining the prognosis.

Prognosis.—One of the most difficult things in mental medicine is to forecast with precision the ultimate outcome of a case of involutional melancholia. Many cases which, at the outset, seem most favorable turn out badly, while many others, after exhibiting for years marked delusional states, insomnia, and suicidal tendencies, recover and resume their ordinary vocations. The time of life in the determination of prognosis, is by no means paramount, since numerous recoveries are recorded in cases ranging in age from forty-five to three-score and ten; nevertheless, youth is one of the factors that make for a favorable outcome. Others are sudden onset; determinable and removable causes; absence of hallucinations of sight, hearing and smell; retention of affect; absence of strongly impulsive and epileptiform tendencies; no persistent loss of body weight; absence of visceral delusions; no picking at the skin or plucking out of the hair; no long-continued neglect of the calls of Nature, and no filthy habits.

The bad signs, on the other hand, are slow onset; fixed delusions—particularly those of a visceral nature; gradual failure of bodily vigor; persistent loss of nutritive energy and body weight; persistent hallucinations of sight, hearing and smell, picking of the skin or hair; persistent refusal of food; an inalterable fixity of emotional depression of face, or persistence of muscular expressions of mental pain (wringing hands, groaning, etc.); persistent suicidal tendency of much intensity; arterial degeneration; no natural fatigue following protracted motor efforts, such as walking, standing, etc.; mental enfeeblement.

Cases which, from the early months of the disease, persistently present a preponderance of the above-mentioned unfavorable symptoms are very apt to terminate in one of four ways: (1) in a state very much akin to that observed in dementia precox; (2) in senescent deterioration; (3) in actual senile dementia; (4) in death from exhaustion or intercurrent disease, notably tuberculosis.

Relapse in recovered cases is not so infrequent. The causes are generally similar to those which brought about the first attack, but a close study of the family history in such cases commonly reveals an unusually bad hereditary taint.

Treatment.—Very little advance has been made in this direction in the last quarter of a century. All authorities are agreed that, except in the very mildest cases, where homicidal tendencies are entirely absent and those of a suicidal order are absolutely rudimentary, hospital care is imperative; at least until convalescence is thoroughly well established.

During the early months of the disease recourse to tube-feeding is, in many cases, absolutely indispensable. Without its aid death from inanition in such cases, would unquestionably supervene. And anyone with even meager experience knows that this form of feeding is an expedient that is seldom practicable in the home, through lack of the necessary force of skilled assistants. The successful protection of the family from the patient's homicidal tendencies and the safeguarding of his own person in the presence of strong suicidal impulses are equally impracticable in the home for the same reason.

With the sequestration of the suicidal patient the danger of self-destruction is not completely eliminated unless every possible thing which might be used for the self-infliction of wounds has been removed from his quarters. Even with the last-named rendered suicide-proof, so to speak, eternal vigilance should be the watchword.

Actual bodily restraint, except in the most violent cases, is to be avoided since experience teaches that the patient loses less nervous vitality when allowed to indulge his motor impulses in the way of walking, etc.

The most important factor in treatment is feeding, and it is absolutely imperative that those in charge of the patient should have a thorough knowledge of dietetics, and at command a commisariat which affords the most ample opportunity for putting this perfect knowledge of dietetics to practical use. Every ounce of fresh air gained is an important help toward recovery, and when the patient begins to take on weight at the rate of three or four pounds a week, recovery is practically assured. It should always be remembered that many patients who refuse food when it is served at the regular meal times will, if the same food be left in a given place, eat it surreptitiously and apparently enjoy it. The practical lesson this teaches is that tempting articles of food should always be left about in places other than those in which meals are usually served. If the appetite is poor one of the simple bitters such as calumba or gentian, or a sound beer or ale, will prove of service.

Another desideratum is fresh air and sunshine. Not infrequently the thing that the general run of patients most fear to do is to go out of doors. Efforts on the part of attendants to overcome this reluctance may bring about a leakage of nervous energy on the part of the patient sufficiently great to nullify the good effect of the excursion. Hence, great tact is necessary to effect successful trips in the open; and oftentimes a ride in an automobile will prove of greater benefit than a walk, since an immense amount of fresh air may thus be secured in a short time without physical effort. Frequently the patient, after an hour's ride in a motor, will quiet down markedly and even doze for an hour or more as he sits in his chair. When convalescence is well established golf and tennis help materially to get the patient out of doors, but neither of these games nor any others are of any service before that time.

The exhibition of drugs finds very little place in modern treatment. If a general tonic is indicated a combination of iron and quinine in the form of a citrate is probably most generally useful, but care should be taken that the iron is not pushed to the point of producing headache and other unpleasant cephalic sensations. Sedatives and hypnotics are of very doubtful value. Opium, bromides, and cannabis indica still have, however, warm advocates. If any of these is given, its effect should be closely watched and its use discontinued directly untoward symptoms of even the slightest degree are observed.

The question of the value to the patient of visits from relatives and friends is more or less a moot one. In the writer's opinion such visits should be made only during the convalescent period. In the earlier stages of the disease they serve mainly to create in the mind of the patient discontent and dissatisfaction with his surroundings. Travel is a valuable agent in promoting a cure, but it should never by any possibility be recommended before the last stage of convalescence is reached. Even then long journeys by rail are to be avoided and the patient should in every way be spared the bustle and excitement attendant upon sojourns in large hotels. A quiet watering place or a mountain resort should be selected and the patient got there by easy stages. Furthermore, he should remain there until he is fully capable of resuming his former social and vocational duties.

Prophylaxis.—When the patient is finally discharged he should be cautioned to report to his medical adviser at once should he find the burden of his daily activities growing disproportionately heavy and his body weight decreasing. The medical adviser, if he be wise, should immediately withdraw the patient from his various activities, prescribe a temporary but complete rest and lay down a dietary destined to promote a rapid increase in body weight.

Senescent Deterioration.—In a very small group of mental cases belonging to the involutional period of life, the clinical manifestations are considered by certain observers to be sufficiently distinctive to establish the complex as an entity. The disorder is characterized: (1) by markedly defective power of judgment; (2) by emotional instability and (3) by delusions of such a pronounced persecutory order that Kraepelin has given the name *praesenile Beeinträchtigungswahn* to this psychosis. The present writer prefers the term—senescent deterioration.

The onset is generally insidious. Quite imperceptibly there takes place a change in the patient's habits and conduct. He becomes quieter, distinctly antisocial, discontented, unaccountably mournful, distrustful and irritable. Meantime thought processes and orientation remain intact. Hallucinations gradually make their appearance—at first, vague and transitory; later, more vivid and clearly defined. Hypochondriacal ideas hold a very prominent place in the clinical picture. The patient complains of the most varied disorders which change with kaleidoscopic rapidity. Many of them are of an hysterical order, but the utter senselessness of the others serves to differentiate. Of these latter two of the commonest are: (1) that the spinal marrow has absolutely disappeared and (2) that the brain has completely dried up. Later, delusions of persecution appear in rich variety, ranging from those of poisoning and marital infidelity to mysterious happenings and adventures of a most melodramatic coloring.

The celerity with which delusions appear and disappear is very noteworthy. Equally noteworthy is the ease with which the patient, under suggestion, submerges a given delusion or group of delusions. His inability to focus these delusions upon anybody in particular and his failure to react to them even in slight measure are likewise striking.

In view of the orderly character of this thought processes the patient's utter lack of judgment and insight is astonishing. His memory for remote events is generally unimpaired. On the other hand, however, in his recital of experiences of delusional origin only, fabulation is pronounced and the most glaring memory defects are exhibited.

At the outset an anxiety depression characterizes the patient's emotional tone, and suicidal tendencies of greater or lesser degree are not seldom present. Later this state of affairs is apt to give way to one of irritability and excitability. The patient becomes voluble, exhibits outbursts of fury, is abusive and creates noisy scenes, but, for the most part, is easily quieted. Sudden transitions from causeless laughter to equally causeless tears are common. At times a show of great self-reliance is manifested.

In course of time the delusions become more and more senseless, but retain their old characteristic of changeability. At one moment the patient withdraws absolutely from his circle of friends, goes on a self-imposed hunger strike and exhibits in his delusions a tinge of the mysterious. Then comes a swift transition and he again becomes friendly and gregarious.

In spite of the increasing senselessness of the delusional states and gradual descent to lower and lower levels of mentality, the patient, curiously enough, practically never exhibits any noteworthy confusion, and never sinks to the low level of intellectual degradation observed in the true senile dement.

Senescent deterioration, as elsewhere stated, may represent the terminal stage of involution melancholia, but it may also properly be regarded as a primary disorder whose only discernible cause is heredity.

In the small sum total of cases the preponderance of the female sex is somewhat striking. In this sex the onset is generally in the fifties or the early sixties, while in the male it is somewhere in the fifties.

The question of differentiation in the case of senescent deterioration is, as in that of most mental disorders, a good deal on the academic order. The general vagueness of the delusions of persecution and their lack of fixity, together with the patient's failure to react normally, so to speak, to them appears to distinguish it from paranoia; while the absence of katatonic manifestations does the same service for it with regard to so-called dementia precox. From dementia paralytica it differs by reason of the absence of all the bodily signs common to this last-mentioned disease and the further absence of weakness of thought processes in the presence of severely crippled powers of judgment.

It is almost needless to say that senescent deterioration is incurable. Hence, the only question that arises, so far as treatment is concerned, is with regard to institutional care of those afflicted with this disorder. In certain cases the patient's shifting emotional states with their consequent hunger strikes and other manifestations equally subversive of household peace and comfort, render home treatment impossible, while in others a greater degree of amenability eliminates the necessity of sequestration in an institution and saves the patient and, incidentally, his family from the stigma which attaches to his enforced removal to a hospital for the insane.

Senile Dementia.—See the article on *Psychoses Senile.* J. W. Courtney.

Psychoses, Manic-depressive.—In discussing mania and melancholia, it was stated that probably the majority of authors has come to regard these, not as separate diseases, but as phases of a constitutional affective psychosis which has been denominated manic-depressive insanity. After a long experience with cases in the clinic, Kraepelin, having observed that there were all possible gradations from states of excitement to those of depression and from cases in which there were during life only one or two attacks

of the same phase to those in which there was recurrence at regular periods, while the relation to circular insanity was shown by attacks of mania which were regularly followed by a period of depression from barely noticeable to decisive, or *vice versa*, has come to the conclusion that we have to do here, with a single disease condition of different manifestation in different cases and that by the recognition of this we shall make a great practical gain, particularly in our conception of the difficult mixed conditions. That this view, whether it stands the test of time or not, affords a useful standpoint from which to study these psychoses, and may well be adopted, at any rate until some more satisfying conception is presented, has impressed itself upon many psychiatrists, as shown by its adoption in most of the newer textbooks

Etiology.—Mercier has asserted that insanity is the result of two etiological factors, heredity and stress. In no form of mental disease is the former factor more definite than in manic-depressive insanity. Kraepelin states that he has found an hereditary predisposition in as high as eighty per cent. of his cases. This is particularly apt to be "like heredity" and in some instances cases of manic-depressive insanity have been traced through several generations. That with this hereditary predisposition, conditions of stress frequently coincide is not remarkable, hence the outbreak of the attacks is attributed to the most varied causes, among which mental strain, emotional shocks, and physical illnesses, pregnancy or the puerperal state, menstrual troubles, and injuries to the head may be mentioned; but on the other hand we meet with so many cases in which the outbreak of the disease is not preceded by any of these factors, that we must be inclined to view them as in the main contributing causes only, and must seek the roots of the disease in the hereditary and constitutional make-up of the individual. Upon similar grounds we must look with skepticism upon attempts to make pathological changes in metabolism and alterations of circulation responsible for the occurrence of the attacks, while the more recent endeavors to connect these conditions with disorders of internal secretions have not yet proved successful.

Pathology.—That a disease which is capable of complete recovery, sometimes in a short time, though the tendency to recurrence is great, is not due to any permanent changes in the brain, would seem evident, and in fact, we have been able to connect none with it. That its manifest heredity and often the similarity even in the form of attacks through several generations speak for some defect in the nervous system of the stock and of the individual seems probable; and returning from the period of the extreme domination of an anatomical pathology, which demanded that a change of structure be demonstrated in every case, the tendency of recent years is to pay more attention to the individual in his mental make-up and how he reacts to different situations, and the opinion is gaining ground that, in the functional psychoses at least, we have to do with faulty biological reactions due either to inherent defect in the mental mechanisms or to acquired morbid mental habits, which in their turn may be connected with abnormal somatic conditions, though whether as cause or as effect is not certain. Though our knowledge in this direction is still fragmentary, in no psychosis does the connection between the pathological manifestations and the mental constitution of the individual appear more probable than in manic-depressive insanity. While not clear in every case, the tendency to excessive emotional reaction can be traced in quite a number of the victims of pathological states of excitement or depression, and traces of the manic-depressive constitution can be found in a large number of people who never get outside the bounds of sanity. That further investigations along this line are desirable, and that every physician, but especially the family practitioner, should feel it a duty to study such facts bearing upon this subject as may come to his knowledge and should record the results of his observations, may well be emphasized, since the establishment of the connection suggested and the acquirement of ability to recognize in advance a poor mental constitution or faulty habits of thought, which suggest a threatened mental upset, might well open up to us the prospect of a rational prophylaxis.

Clinical Manifestations.—The manic-depressive psychosis, as already indicated, is made up of the cardinal states of excitement, depression, and stupor in various sequences and combinations. The simpler forms are described under the heads of mania and melancholia and need not be considered here, hence we may proceed at once to the description of the periodic and mixed states.

The characteristic of manic-depressive insanity may be said to be its tendency to recur at irregular or (less frequently) at regular intervals. According to the form which these recurrences take they have been given various names which, however, apart from those of periodic (or recurrent) mania and melancholia, in which attacks respectively of excitement or depression follow one another after lucid intervals of longer or shorter duration, circular insanity, in which cycles of excitement and depression follow one another, and "mixed states," they mainly confuse the subject.

Periodic Attacks.—In the majority of instances the first attack is one of depression and occurs in two-thirds of all cases under the age of twenty-five years. In women the first onset is very frequently about the time of puberty and the recurrent attacks not infrequently show a certain connection with the menstrual periods. The attacks vary greatly in their severity and in some instances are doubtless so slight that medical advice is not sought, though later inquiry will bring out a history of a period during which the patient was "nervous" or suffered from a "nervous breakdown," which upon closer investigation shows that symptoms of exaltation or depression were present, at least in abortive form.

Naturally for a diagnosis of periodicity the case must be followed for some time, for the attacks may be very infrequent; indeed the patient may not live long enough to have a second attack, though a woman who has had an attack of depression in early life is quite apt to have a recurrence at the time of the menopause.

Periodic Mania.—It has been asserted by some authors that the attacks of periodic mania are in general milder than is an attack which occurs only once in life, and that they particularly tend to recur always in exactly the same form. In fact in some cases they are so mild that the public at large cannot be persuaded that the victim is other than ill tempered, lacking in self-control, or criminal in his propensities, and many patients have served several terms in jail for offenses which later are found to have been committed while in the exalted phase of this disease. The French have described some of these cases under the name of "folie raisonnante" from the fact that the patient often is entirely clear and self-possessed and can excuse his derelictions with considerable dialectic skill. Nevertheless they may vary in intensity to the most marked maniacal states with confusion and numierous hallucinations. The confusional element may in fact be sufficiently prominent to justify speaking of periodic confusion.

There are also cases in which delusions are chiefly prominent and occasional cases in which these take on a more or less systematized form have given some justification to the description of a "periodic paranoia.

Periodic Melancholia.—As in periodic mania, in periodic melancholia the attacks are in the main milder than in the cases in which there are but one or

two during a lifetime and they have the same tendency to exact reproduction, the same delusions in particular always recurring.

On the strength of the characters of the recurrent cases, some authors have described mania and melancholia as different diseases from manic-depressive insanity, under which latter term they include only the periodic, circular, and mixed states; but observation by those who handle a large amount of material, of transition forms of all sorts, and of frequencies from one attack in life to many recurrences, seems to justify Kraepelin's view that all are phases of one underlying condition, and this idea has steadily gained ground.

In general it can be said that first attacks of mania or melancholia do not present any characteristics which will permit us to say positively whether or not there will be recurrence. The individual attacks vary in duration from a few weeks to a number of months, though they may last several years and recovery may still occur. The average duration is usually six to eight months. In established cases there is a tendency to a shortening of the lucid intervals and to lengthening of the duration of the attacks, so that finally the patient is never quite clear. In a few cases, the disease begins with a number of short attacks of manic or manic-stuporous character which succeed one another very rapidly and then are followed by a lucid period of several years.

Circular Attacks.—The manic and depressive phases may follow one another with or without interval. According to the French nomenclature (Ballet) the term "circular insanity" is reserved for those cases in which manic and depressive attacks follow one another without interval, while the sequence (for instance)—mania, depression, interval, and repeat, (or *vice versa*), is called "insanity of double form," and that of mania, interval, depression, "alternating insanity."

According to Kraepelin, the first attack is usually one of depression, anxiety, or more or less pronounced stupor. In about half the cases this is followed by a lucid interval, while nearly as frequently an attack of manic exaltation immediately succeeds the depression and passes on to temporary recovery. In a small number of the cases the depression begins anew and is followed by excitement, and so on. When the disease begins with a manic attack, there is usually next a remission, much more rarely depression or stupor. However, several manic or several melancholic attacks may follow each other before an attack of the opposite phase is interposed, so that he lays stress not so much upon the circular character as upon the marked tendency to periodicity, in the manic-depressive psychosis.

In only four to five per cent. of cases is there a regular alternation of phases during the whole of life.

Mixed Forms.—As already indicated, in many cases, especially when one phase is about to change into another, there is a mixture of symptoms of the exalted and of the depressed phase present at one time. For instance, a patient who has shown psychomotor excitement and flight of ideas with exalted mood may, while keeping up his motor activity and constant talking, develop gradually or suddenly a depressed or cross and suspicious mood, and perhaps later may in addition lose his flight of ideas while preserving psychomotor excitement, or the change may occur in reverse order from a melancholia. Kraepelin has recognized eight possible combinations of symptoms which the appended table should make clear.

The changes from the normal of psychomotor manifestations, of ideation, and of the emotional state, form the cardinal symptoms of mania and melancholia. If now acceleration is expressed by + and retardation by −, while exaltation and depression of the emotional state are indicated respectively by these same signs, a glance at the table will show the combinations which have been actually found to occur.

For example, the cardinal symptoms of mania are (1) psychomotor excitement (or acceleration), (2) flight of ideas, (3) emotional exaltation (or excitement); while those of melancholia are (1) psychomotor retardation, (2) difficulty in thinking, (3) emotional depression.

	1	2	3	4	5	6	7	8
	Mania	Melancholia	Manic-stupor.	Agitated depression.	Unproductive mania	Depressive mania.	Depression with flight of ideas.	Akinetic mania.
Psychomotor								
+ = Acceleration	+			+	+	+		
− = Retardation		−	−				−	−
Ideational								
+ = Acceleration	+			+			+	+
− = Retardation		−	−		−	−		
Emotional state								
+ = Exalted	+		+		+			+
− = Depressed		−		−		−	−	

If now in a melancholia the mood changes from depression to exaltation the picture becomes one of manic stupor. The patient manifests no external signs of excitement, speaks little or not at all, but in his expression, perhaps by absurdity in personal adornment and by occasional silly laughter he shows that his mood is one of exaltation. His quiet may, however, be broken by sudden violence, or by a bitter or abusive remark, while sometimes cataleptic conditions are observed. If on the other hand, the exaltation of the manic phase becomes depression, we have the picture of agitated depression. The patient continues to show excitement and flight of ideas, but his mood changes to one of irritability and ill nature, he complains constantly of his surroundings, is suited by nothing, and since he is well oriented, he has a decided tendency to injure or at least to annoy his fellow patients. In unproductive mania the mood is exalted, and there is psychomotor excitement, but the patient has difficulty in understanding, is poorly oriented, and often makes the impression of being demented, which is later shown not to be the case. This is quite a common condition. The patient may be suddenly violent and dangerous and may have periods of great excitement. Though used in English books, the term "depressive mania" does not seem a happy one. Kraepelin uses that of "depressive Erregung," which might perhaps be better translated "depressive excitement."

The patient is constantly on the go, talks a great deal but mainly emits a series of monotonous complaints, hangs about the doctor or the other patients, and expresses ideas of persecution and fear.

In akinetic mania there is psychomotor retardation and the patient may remain quietly in bed while showing flight of ideas and tendency to association by sound, though he is liable to sudden outbursts of violence.

Manic-depressive insanity does not tend in general to dementia, but there are a certain number of cases in which the phenomena of the exalted stage persist in rather mild form for years, so that the term chronic mania has a certain justification. Careful observation, however, will show that the symptoms are exaggerated from time to time with a certain periodicity and this "constitutional mania," as Kraepelin prefers to call it, shades off by degrees into morbid personality. A similar course of events in some patients in the opposite phase justifies the term

"constitutional depression." The very mild periodic attacks have been called "cyclothymia."

Diagnosis.—Since diagnosis in mental diseases is important chiefly for predicting the outcome, the differentiation of the manic-depressive psychosis is intimately bound up with questions as to its nature and relationships to other psychoses. As previously stated, the whole conception is disputed, even the most ardent adherents of Kraepelin having to admit that it offers certain difficulties and that the occurrence of periodic phases of exaltation and depression do not absolutely justify the diagnosis of a non-dementing psychosis.

Especially have the relations of this psychosis with dementia precox been discussed, for in young subjects in particular the diagnosis between these two diseases continually confronts us as important, since the one essentially tends to recover (*i.e.* from the individual attack) while in the other, dementia is to be expected. Dementia precox quite frequently begins with an exalted or with a depressive phase which makes an early diagnosis impossible and it is difficult to set any absolute criterion as to what symptoms justify the assumption of a dementing psychosis.

Urstein from a study of over 1,000 cases has shown that a great number of cases which later showed catatonic dementia had begun with manic-depressive symptoms. He lays stress upon the early presence of stereotypy, negativism, and cataleptic symptoms, but especially upon "intrapsychic ataxia," the splitting of the personality, which led Bleuler to apply the name schizophrenia to dementia precox. On the other hand, even the presence for long periods of the catatonic symptom-complex is not always conclusive of a dementing psychosis as shown by Kirby in a recent study, and it seems possible that manic-depressive insanity and dementia precox may occasionally occur in the same subject. Nevertheless, the development in a doubtful case of stereotypy, negativism, and cataleptoid attitudes, with emotional dulness, not depression, and clear signs of mental deterioration would point decidedly to dementia precox rather than to manic-depressive. There is usually in dementia precox lack of any deep-seated affect and a peculiar childish and silly demeanor. The unrest when present is usually sudden and motiveless, while the peculiar mannerisms of speech and conduct are very suggestive. A history of similar disease in a parent or near relative of the patient would speak rather for the manic-depressive psychosis, since in it the influence of heredity is much greater than in dementia precox—it is put at eighty per cent. and forty-five per cent. respectively.

The recent attempts of Fauser and others to use a digestion and dialyzation test carried out with different organs after the manner of Abderhalden's test for pregnancy (with placental tissue) are said to have shown that in manic-depressive insanity the blood serum contains no ferments capable of digesting brain tissue, sexual glands, or thyroid, while in dementia precox and other presumably organic psychoses it does, but we have not yet sufficiently accurate data to make this test of practical use in diagnosis.

Of interest and importance are the more recent views with regard to the relationship between manic-depressive insanity and paranoia. These have been quite clearly exposed, among others, by Specht, who considering more particularly the querulant variety of paranoia finds the development of the delusional system connected with an early depressed, a later exalted mood, and other features of the manic-depressive psychosis. Again the boundary lines of paranoia are very differently drawn by different authors.

Especially has there been described an "acute paranoia," in most cases of which there is, however, either a certain degree of exaltation with psychomotor activity and flight of ideas, or on the other hand, depression and retardation, or mixed conditions along with the more or less systematized delusions, so that the close relationship to manic-depressive insanity has to be acknowledged. Also there is frequently periodicity. Cases of manic-depressive insanity of more chronic course, with definite and more or less systematized delusions and but little marked affective or psychomotor disturbance, may pass for some time as paranoia, but prolonged observation will generally sooner or later show at least traces of excitement or depression which stamp their connection with the manic-depressive group. True paranoia of the Kraepelin school is a disease of slow and gradual development, the roots of which may be traced back into early life and its steady and little varying course contrasts with the periodicity of the manic-depressive psychosis.

With the psychoneuroses (hysteria, neurasthenia, and hypochondriasis) manic-depressive insanity comes into close contact and the diagnosis of its mildest form, or cyclothymia, from these conditions is by no means easy; in fact a large number of cases of this last undoubtedly go through life under the label of one of these neuroses.

During the periods of exaltation these patients feel themselves well and efficient and indulge often in feverish activities, which, however, are usually shallow and unproductive, while the onset of the depressed stage drives them to a sanatorium or causes them to take up some vaunted system of cure which gains an unmerited reputation by the change to the submaniacal phase occurring while they are under its régime.

Periods of excitement in hysteria may considerably resemble maniacal attacks. They are, however, usually traceable to some definite exciting cause and the exaltation of mood, the flight of ideas, and the great distractibility of mania are wanting. Again, attacks of mania do not suddenly and completely disappear as those of hysterical excitement often do.

To differentiate the depression of the hypochondriac from that of the true melancholic is often a difficult task, for melancholic ideas quite generally have a hypochondriac coloring, and hypochondriasis as a disease *per se* has no longer any standing. The nature of the delusions, whether or not they remain within the bounds of the possible, will usually determine our decision. It is not insane to think that one has a serious disease of the abdominal organs, though it may be incorrect, but the patient who imagines that he has an animal inside of him which is gnawing away his viscera, that his intestines are dried up, or that his heart is turned to stone, can no longer be considered as sane.

The diagnosis of manic-depressive insanity from amentia, epilepsy, general paresis, organic and senile psychoses, is considered under mania and melancholia.

On the whole, time is the factor required for confirming the diagnosis, for periodicity on the one hand and the appearance of dementia on the other are the determining factors for and against manic-depressive insanity.

A first attack is often difficult to estimate, and while in a typical case the diagnosis may be easy, there are a large number of instances in which manic-depressive symptoms blend with those of other psychoses. On the whole, we are still far away from the possibility of a sharp differentiation in every case and the idea that in the non-organic psychoses the difference in symptoms depends more upon the difference in biological reaction in the individual than upon an essentially different causation appears to be gaining ground.

Prognosis.—Manic-depressive insanity is essentially a non-dementing psychosis so that the outlook as to recovery from the individual attack is good,

though the probability of recurrence sooner or later is strong; just when cannot be predicted until the disease has established a definite rhythm.

When the disease begins early without any apparent cause the chances are that the attacks will recur at not widely separated intervals; while when the onset is later and occurs in connection with some deep reaching cause—as for instance the puerperium—a longer period of freedom may be expected. A woman who has had an attack will very likely have another at the time of the menopause, and where there have been periodic recurrences they are apt to become more frequent at that time.

Even when it lasts a long time there is no true dementia and there has been complete restoration to health after a duration of five years and more.

When the subject of manic-depressive attacks reaches middle life, the prognosis is disturbed by the probability of arteriosclerosis to which the manic-depressive patient seems particularly liable and which then may lead to permanent changes in the brain with accompanying mental deterioration. It has been thought that the frequent variations in blood pressure and in the innervation of the vessels which seem to be connected with sudden changes of mood, exert an injurious effect upon the blood-vessels and favor the early development of arteriosclerosis. This view harmonizes well with the results of the recent investigations of Cannon which seem to show that the emotions, particularly those of anxiety and fear, are connected with increase of the adrenal secretion, whose effect in producing high blood pressure is well known. It has long been known that the blood pressure is apt to be raised in melancholia.

Treatment.—The manifestations of manic-depressive insanity are those of mania and melancholia whose treatment is discussed elsewhere.

A word may be added here as to prophylaxis however. Since of all psychoses the manic-depressive is most manifestly transmissible to the descendants, a person who has had an attack should be advised against marrying. This applies also to cases of cyclothymia although it is doubtful if these patients will accept such advice or if the prohibition can be enforced against them, though if it could, the number of manic-depressives would be greatly reduced.

As to personal prophylaxis, the descendants of families in which this psychosis is known to exist should be guarded as far as possible from those stresses of life which have been found by experience to favor an outbreak, and they had best choose quiet callings which do not involve much strain and excitement, avoiding in school years any overstudy. In a married woman who has had one attack in connection with child-bearing, the question as to further pregnancy comes up. Undoubtedly it is safer that she should bear no more children and the prevention of conception by legitimate self-denial cannot be objected to. That she will thereby be assured against further attacks is, however, by no means certain, as the coincidence between parturition and the attack may be accidental only. Granting that she has become pregnant again, is interference justified? Apart from any moral scruples upon the part of the attendant it has been urged that it is not, since the association may be accidental, the production of abortion offers no surety of preventing an attack, and the trauma may even precipitate one. On the whole, the best opinion seems opposed to interference except in a case presenting very urgent symptoms.

As to methods of mental training calculated to correct faulty habits of thought and so act as prophylactic, our knowledge of a connection between such habits and manic-depressive insanity is as yet too indefinite to permit of the evolution of any. Further studies in this field are altogether desirable.

Charles Lewis Allen.

Psychoses, Senile.—Classification.—In this group we shall study:

1. Presenile Psychoses. (*a*) Presenile delusional depression. (*b*) Acute presenile dementia, or Alzheimer's disease.
2. Arteriosclerotic Psychoses.
3. Senile Dementia.

Presenile Delusional Depression.—This is a psychosis of the involution period of life dependent upon beginning degeneration of the nerve elements of the brain. It is characterized by emotional depression, loss of weight, early somatic delusions with anxiety and restlessness, and variable ideas of persecution and of impending misfortune. The course is rather severe and though betterment is frequent in early cases some mental damage and increased instability remain.

Etiology.—Familial predisposition to early or rapid aging of the brain cells seems to determine its frequency and often even the time of onset. This last, however, may be brought on or hastened by overwork and worry, emotional shock or some infection, as la grippe. The age at onset varies quite widely. Occasionally we meet with it in the early forties, especially if there be constitutional vulnerability and an exciting cause; generally, however, it is seen a few years after the climacteric in women, and about the age of fifty-five in men.

Pathology.—Even in cases of apparently mild type, quite widespread destructive changes of the cortical neurones are found at autopsy. The cells least affected show swelling, then slow disintegration of the cell body, followed by similar changes in the nucleus, with loss of staining properties. The glia cells proliferate and are supposed to aid in the elimination of the products of this cell destruction. The lymph spaces and smaller vessels may be crowded by lipoid substances, and certain masses of this homogeneous material are believed to be the basis of the numerous plaques so prominent in these and other senile brains. So general is this destructive parenchymatous change that the relative paucity of these stained nerve cells in comparison with those of a normal section is most strikingly apparent. Indeed, it is remarkable how severe losses in the number of cells the brain cortex may suffer with retention of mental faculties that in life suggested but slight structural change.

Symptomatology.—There is usually a considerable period of vague premonitory symptoms. Imperceptibly a change takes place in the *disposition* and *habits* of the patients. They become more quiet, are unsociable, discontented, uneasy, and restless, sad without cause, irritable, and suspicious; have unreasonable outbursts of anger or tears, are disinclined to exertion. Their *memory* for passing events grows less acute. *Consciousness* is intact, and they are able to *orient* themselves perfectly. The *will* is seemingly unimpaired, but really they are less able to control their emotions and desires than heretofore. *Judgment* early shows considerable damage. They do not yet have hallucinations or delusions, although these are foreshadowed in their unreasonable whims and suspicions. There is usually some disturbance of digestion and general nutrition, and their power of endurance rapidly fails. The patients are really not yet insane, but are showing the first signs of mental incoordination: evidences of physiological involution of the faculties coming on at a prematurely early period, and with perhaps pathological rapidity; indications, in fact, of an essentially pathological process at work. They become extremely selfish and self-centered, introspective, and soon are definitely hypochondriacal. This attitude, with their general suspicions, forms the basis for their first delusions. They appear oversensitive to cold and complain of various disturbing conditions, "fleeting rheumatic pains," cough, hiccough, belchings, disagreeable feelings in the head and back, dizzy spells, distressing dreams,

peculiar sensations in the eyes, and ringing in the ears. Things do not appear the same to them, and they immediately suspect foul play. A forgotten piece of wearing apparel has been stolen. If it is found, they cannot believe it is the right one, but a clever substitute, and still accuse the supposed thief. At other times poison is put in the food, they taste alum on their meat, saltpeter on the toast. They are convinced that some one is planning a deep game against them, and do foolish things to overthrow their schemes. One patient had a large hearth stone removed to uncover the dynamite secreted beneath. They do not usually name their enemies, but seem content with vague suspicions. When they do, however, they generally accuse some near friend or relative of enmity or unfaithfulness. In fact, the idea of conjugal infidelity is rather common with them.

Hallucinations sometimes appear with the delusions, but more often not until later. The patient feels by a peculiar tingling in her hand that her husband has met with an accident, she can feel the corrosive action of supposed poison in the stomach; another patient says that the meat is disgustingly "embalmed," he can taste the chemical preservative; he sees dark phantom shapes at night, sometimes robbers come into the room and reach over the bed, or he sees them downstairs getting away with their plunder; he hears his wife talking with another man in an adjoining bed, overhears plots in the next room, his daughter's screams as she is being carried off.

The early onset of these somatic delusions and ideas of reference seem to be the basis for the changes in the emotional content. Thus some cases are as extremely depressed as typical manic-depressive cases. But whereas, in the latter, the emotional state is primary and continuous, it seems to depend largely in the former upon the delusions dominant at the time. Thus we find greater variation in the presenile cases. Instead of melancholic depression, there may ensue a paranoid type with suspicions. Depressions are seldom associated with confusion or stupor, but their delusional ideas lead to sleeplessness, restless activity, and great anxieties.

These two types, the depressed and the paranoid, offer so many points of clinical difference that some have considered them separately. It is true that the suspicious cases are more apt to have excited spells and to be more talkative and violent, but considering the cause and outcome we have not thought it wisest to subdivide further a group which at best are not apt to run true to type, but to have a variable arrangement of symptoms in their progress to chronic dementia. The type cases are apt to be those that get better and that do not run a long course.

In this early stage outrageous conceptions may seem to call forth no particular demonstration nor incite to vigorous measures to pursue the culprit. This is associated, it may be, with such calm and otherwise reasonable conversation as might lead one to suspect the patients did not believe what they were saying themselves. Often, again, a few soothing words may quiet all their agitation and they will seemingly be convinced that what they said was untrue; but a moment afterward they are relating some similar terrible thing. They have been persuaded to agree with their companion, but are not truly convinced, as they never fully realize the full gravity of their accusations. And this, too, accounts for their showing so little spite in action. It must also be remarked that they do not fasten their spite permanently upon any one person. Their enemies change almost as frequently as the content of their delusions, and the supposed murderer of a man's daughter may enter the room and soon win the confidence and esteem of the old man.

All this is assisted by the very evident impairment in *memory*, especially for the recent past. The details of events long past, even those of childhood, may be ready and accurate, while they may not know what day of the week it is nor whether they have seen you for some days or not. In relating past events they are apt to get side-tracked, to wander off into endless repetitions and add thereto, under the influence of delusions, most improbable and impossible inaccuracies. The *train of thought* is interrupted, but accompanied with such a very remarkable acceptance of the most absurd notions as plainly indicates very serious impairment in *judgment*. The *mood* of these patients is variable.

The depressed cases may refuse food and if not carefully watched and forcibly fed, if necessary, will run down in weight to extreme emaciation and weakness. If this is allowed it greatly exaggerates their excitement and handicaps their chances of improvement.

As the general impairment of the faculties progresses, their delusions become more absurd, their emotional excitement or depression reaches wider limits, their conduct becomes more unbearable, and the necessity for suitable restraint more self-evident in the interest of all parties. The insane jealousy already mentioned reaches extreme bounds. Detectives are hired to watch the suspected parties; incriminating and circumstantial fabrications are told to the police and friends; they hear all manner of incriminating conversations, and see the guilty parties together at night. Their enemies are hounding them, have torn their children to pieces, and are just on the point of attacking themselves. It is a common thing for God to take them into His confidences and warn them of things about to happen; they hear His voice, see Him, feel His presence beside them. At times they may be so absorbed with these hallucinations as to appear indifferent to everything and slightly confused. However, no definite confusional type of the disease is so noticeable as that found in the insanity of the later epoch.

If improvement does not commence within a few months, their delusions gradually grow more unreasonable, and after a year's sickness very few reach any degree of improvement that can be called a recovery, that is, they become so demented as to be unable to leave the hospital. Such cases either progress slowly, as chronic senile dementia, later to be considered, or die within two or three years from exhaustion or from some intercurrent affection. A considerable number, however, perhaps fifty per cent., begin to improve within three to six months of onset and slowly win their way back to clarity of mind, though some false beliefs are apt to stay as dogging suspicions well into convalescence. Their improvement does not usually extend beyond a moderate degree of comfort and ability to live a quiet life at home. Very few get well enough to accept responsibility and undertake normal labor again.

Diagnosis.—The diagnosis can best be made by exclusion. However, given a case in the fifth or sixth decade of life, who has not had a mental upset earlier, with vague premonitory symptoms of impairment of mental energy, memory, and judgment, who suddenly grows deluded about somatic disturbances, with depressions or suspicions, loses weight rapidly, does not sleep much and gets restless and anxious, we may be pretty sure with what we have to deal and will govern our prognosis accordingly.

In manic-depressive cases the onset is apt to be more sudden, the emotional depression is more uniform and colors all the picture, whereas in presenile depression the delusions are the characteristic determinants. In manic-depression stupor or confusion is more frequent, but impairment of judgment less and the memory defect is not nearly so noticeable. Besides, careful inquiry will nearly always bring out a history of some sort of mental obliquity earlier in life, and probably manic-depressive attacks in near relatives.

In the depressed form of paresis, the Argyll-Robertson or contracted pupils, fibrillary tremor of the tongue and lips, and the peculiar speech and handwriting should be distinctive enough to avoid confusion with presenile delusional depression.

Sometimes early cases are mistaken for paranoia, but the changeability of their suspicions, their lack of judgment, impairment of memory and lack of any real attempt to pursue the object of their suspicions, we consider sufficiently distinctive.

Their periods of moodiness, the refusal of food, and sudden violence at times have suggested to some the onset of dementia precox. These acts, however, are purposeful rather than merely impulsive, and are evidences of increased emotionalism rather than of destruction of feelings; and, finally, the subsequent terminal dementia is of a type similar to that of ordinary feeble old age, plus delusions, rather than the blankness of the imbecile.

Treatment.—Bearing in mind the considerable number that may improve in the early months with proper attention, no time should be lost before attempting the most radical measures for recovery. Too often, just these cases are the ones in whom mature age and position makes any recommendation for institution care very unwelcome advice. Yet an early dislocation from their surroundings and friends, and the better control of the details of life afforded by a good sanatorium, or hospital, is sometimes the best that can be done. Good food, moderate exercise, reassuring talks, massage, baths, and every effort to promote increased nutrition and secure adequate rest, without harmful drugging to keep anxious relatives easy, may thereby be the best attained. In no class of mental cases is early, energetic treatment more imperative. As a rule, alas! these cases, from their age and standing in the community, are "tided along" by the family physician, and fussed over by anxious relatives, until they have lost thirty to fifty pounds in weight and are so handicapped by inanition that recovery is much delayed, or permanent impairment assured. After the first months have passed without improvement, and a considerable degree of dementia is evident, they often may be as well cared for at home if the nature of their symptoms allow it. Often, when procrastination has had its way and it becomes impossible to keep them longer out of an institution for the insane, their chances for recovery are very slight and treatment then resolves itself chiefly into how best to preserve their comfort and safety alone. In the anxious states, constant attendance night and day is indicated to guard against attempts at suicide. Refusal of food for two or three meals should be followed by nasal feeding. If properly done, no injury is likely to be caused and but very slight discomfort. At the feeding times laxatives, digestives, etc., thought necessary, should be given after the liquid food. If these patients have been tube fed a long time, which rarely occurs, however, in these cases, care should be taken that the dietary is varied from the usual egg-nog to nutrient broths, juice of cooked vegetables, and other things that can be made into liquid or semi-fluid form. This wards off symptoms of scorbutus and apparently hastens nutritive processes.

The indications for drug therapy are found in the sleeplessness, lack of digestive activity and the obstinate constipation which is usual. Milk infected with the bulgarious bacillus is much lauded by some as a laxative, but repeated trials in these cases have caused us to have little confidence in the claims. Compound licorice powder, occasional calomel tablets and saline laxatives we have found more useful. Many are much aided by laxative enemas. As a general rule, there is not much trouble in overcoming the constipation if enough food is ingested, especially in mixed diet. Their delusions hinder real appetite, but usually digestion is fairly good when they are made to take sufficient.

Alzheimer's Disease.—Since 1906 many observers have reported cases in the presenile period that show a rapid dementia, with pathological lesions similar to those found in advanced senile dementia. These cases have varied in age from thirty to sixty, the majority being under fifty years. While some consider them as atypical cases of senile dementia the course is so much shorter and the mental damage so rapid and extreme, besides showing atypical features in the clinical symptoms that it is generally becoming recognized as a separate clinical group, if not a distinct disease entity. We will not here devote much space to what is, at best, a somewhat rare affection, though the possibility of such a severe disease ought not to be lost sight of in considering the presenile psychoses.

The etiology is obscure. The onset is marked by gradual reduction in memory. Disorientation, apraxia, and transitory aphasic disturbances come on within a few months. Rapid confusion and helplessness ensue; motiveless restlessness, hallucinations of sight and hearing, suspicions, delusions, increasing childish behavior and untidiness follow, and within two or three years result in bedridden helplessness, as is seen in senile cases only in extreme age, and after a long course of perhaps ten years, or more. Besides widespread degeneration of the brain cells there has been described commonly the plentiful formation of plaques or collections of waste materials from degenerated brain elements into groups of homogeneous masses. The cortical cells exhibit often an irregular degeneration which has been termed Alzheimer's neurofibrile degeneration. While these two processes cannot now be considered as occurring only in this disease, as was at first thought, and even though upon pathological findings alone these brains cannot be as yet differentiated from cases of senile dementia, the onset is generally so early in life, and the progressive dementia so rapid and severe, as to attract special consideration to this group, which will likely prove to be essentially a distinct disease. The diagnosis may be impossible at first, though plainly suggestive when the varied symptomatology of senile mental changes are shown in an unusually rapid course in the early presenile period. The prognosis is uniformly bad. Death occurs, usually, from bed sores, pneumonias, or other intercurrent ailment associated with general exhaustion. Treatment is plainly symptomatic, and appropriate care can usually best be given in a suitably furnished hospital or sanatorium.

Arteriosclerotic Psychoses.—It has long been the custom to estimate old age according to the amount of degenerative change noticeable in the arteries. When this was not indicated by the condition in vessels which could be palpated, it was inferred to be present in the cerebral vessels if enfeeblement of mind preceded much crippling of the bodily powers. Accurate observation, however, has repeatedly demonstrated that presenile psychoses, and even senile dementia may be manifest in extreme degree without much evidence of hardening of the arteries, and, conversely, that a considerable degree of general atheroma may be present, even in the cerebral vessels, without noticeable mental change.

Sclerosis, however, is generally irregular in distribution, being much more severe in certain arteries than in others. When it affects the cerebral vessels, to any great extent, some are apt to have their lumina permanently narrowed, with consequent starvation of the brain areas supplied by them. The same process is responsible for miliary aneurysms of these terminal arteries with a similar result upon the nutrition of the surrounding areas. Other arteries become obliterated by the narrowing process, or become plugged by emboli from vessel changes in other parts of the system; this causes brain infarcts and rapid degenerative changes, due to the paucity of collateral circulation in this organ. In still other cases, the sclerotic process is responsible for rupture of a vessel, with consequent hematoma of the brain. The sudden increase of intracranial pressure when this happens, and the shock and dislocation of the brain substance usually causes sudden unconsciousness, and the whole

process is termed apoplexy. Thus, we find that while hardened arteries are not responsible for all the senile cerebral degenerations, there is still a large group with consequent varied mental phenomena that are directly caused and dependent upon the process of arteriosclerosis of the brain. Undoubtedly, in many senile cases arteriosclerotic changes progress along with other cell changes that seem independent, and thus there are mixed forms hard to differentiate. But the primarily arteriosclerotic cases are so numerous and so fairly well defined that it seems best to consider those psychoses dependent upon these changes in a separate group.

Etiology.—As arteriosclerosis is essentially a systemic disease we must ascribe the ultimate causes of these psychoses to the various systemic conditions associated with the atheromatus vessel changes. That a specially vulnerable vascular system may be inherited, or that a constitution of irregular balance in the functioning of certain organs of internal secretion or excretion underlying these vessel changes may be a family characteristic has often been noted. The effect of the toxins of acute infections and the results of chronic absorption of waste products from a disturbed alimentary canal have been ascribed as primary elements. That syphilitic infection is responsible for a definite proportion of these cases has long been acknowledged, while those stages of increasing inefficiency in the action of the kidney in cardiorenal disease may allow poisons to collect which raise the blood pressure and add the exciting cause for rupture to already weakened vessel walls. Much has been written about the detrimental effect of certain sedentary habits of life, and of an excess of proteids in the dietary. Doubtless these may be causative elements in some cases, but their definite influence still is rather a matter of individual opinion. It seems undoubted, however, that the abuse of alcohol may definitely hasten and exaggerate natural tendencies to arteriosclerosis, if not be, primarily, an independent cause.

Symptomatology.—A complete description of the arteriosclerotic psychoses would naturally include the consideration of the mental states associated with apoplexy and cerebral embolism and infarction, and would include those terminal states of dementia due to the extensive organic brain softenings following these lesions. The multiform paralyses and other somatic disturbances in these cases so overshadow the merely mental symptoms that they are best treated in a separate article, and we must content ourselves here, by just noting their relations with the subject in hand. Before definite rupture or infarction takes place various mental phenomena may arise directly dependent upon the crippling of the normal nutritive supply to the brain, by reason of cerebral arteriosclerosis. The distinguishing characteristic of these mental symptoms are their gradual onset, chronic progressive course and tendency to be combined with focal nervous disturbances. The age at onset is usually in the presenile period, between fifty and sixty-five, although alcoholic habits or syphilitic infection may determine a much earlier beginning. The patient gradually finds his mental acuteness impaired, his power of long-continued mental application is weakened, his memory becomes increasingly unreliable, especially for recent happenings, his interest becomes more circumscribed, his judgment weakened, and his confidence in deciding on new things so undermined that the conservativeness of caution often becomes the indecision of the weak-minded. They often rely upon their associates too much, and lay themselves open to business fraud and other undue influence in important personal affairs. These symptoms of progressive mental impairment, common to all senile degenerations, are, in these cases, associated with peculiar functional disturbance of sensory and motor nerves, which are variable but point to focal brain disturbance. The sleep is much disturbed. A few seem to sleep more than usual, especially in the daytime, but generally insomnia is greatly complained of. Especially are they liable to awaken at night, after an early nap, and find themselves unable to get to sleep again throughout the night. Again, they often complain of repeated sudden awakenings with a start of fright, and get to dread sleep on account of these frequent horrible awakenings. They lose weight and strength, become irritable and often suspicious and childishly emotional, laugh or cry easily, and are very distractible.

These changes in character and poise of mind may become very marked, and gradually, on the groundwork of focal nervous sensations, delusions arise which, at first, are transitory but later become more permanent, though their distractibility often leads them from their intentions. Hallucinations of hearing and sight are frequently troublesome in advanced stages, they talk to the objects of their delusions, complain of gastric distress, parasthesias of legs and arms, have attacks of numbness and weakness of one or more limbs and are subject to dizzy spells and sometimes even complete loss of consciousness, with or without convulsions. These epileptoid attacks may grow quite frequent, and in other cases may seldom or very rarely occur. Instead of loss of consciousness, there may be attacks of confusion of ideas, and for days the patient may be disoriented, active, and resistive.

All or any of these symptoms may quickly pass away, leaving only greater enfeeblement of body and mind. The local parasthesia and muscle weakness may be transitory, but often leave some sensory disturbance more constant in the parts most affected, so that it is possible to judge in some cases the progress of the focal lesions by the amount of the peripheral disability.

The course is variable. Sometimes nearly all the symptoms pass away for a time, leaving only general reduction of mental and physical power. Sooner or later similar attacks tend to produce still more crippling, and even though definite apoplexy may not ensue the end result is a dementia with physical stigmata, significant of the increased severity of the brain affection in localized areas. Death is usually the result of exhaustion, apoplexy, or some intercurrent disease, as pneumonia.

Diagnosis.—The diagnosis may be easy where cardiorenal complications and generalized arteriosclerosis accompany the retrograde mental changes. More often the history of the patient may be of more help, perhaps, than the symptoms presenting at any one examination. The gradual loss of memory and power of concentration and understanding, associated with physical signs suggestive of organic brain disease, but changeable in the degree of crippling, the passing pains, numbness, tremors, aphasic symptoms lasting but a few days, and the alcoholic habits perhaps may make decision easy when the actual symptoms presenting are only suggestive of a mild senile dementia. High blood pressure and urine indicating chronic Bright's disease are corroborative evidence.

Prognosis.—A great many of these cases die within three or four years of apoplexy. Others run a long course, with gradually increasing crippling of mental and bodily powers, and may become childish, demented, bedridden and helpless and usually die of some digestive disturbance, or hypostatic pneumonia. In early cases that retire from work and live in ease and comfort the process seems sometimes to be hindered, and in other cases, some claim, is definitely arrested. Such good results would appear to be exceptional, however. Cardiorenal complications generally aggravate the mental symptoms and accelerate the vessel changes.

Treatment.—In early stages of arteriosclerosis, with some symptoms of reduction of mental power, careful regulation of the life of the individual so as to avoid much excitement and mental or physical exertion, overloading of the stomach, especially at night, and

the abuse of alcohol, will sometimes do more to hinder the progress of the affection than definite medication. Potassium iodide has been recommended and praised by some. When a positive Wassermann reaction is demonstrated, salvarsan and the iodides are indicated. Hydrotherapy, carefully and judiciously employed to suit the case, has many advocates, but in spite of the alleged "cures" at the various spas in this country and Europe the improvements seem most temporary, or to mean "feeling better" from the patient's standpoint, rather than much change in the pathological lesions. Electricity may aid in combating the pains and paresthesias. The mental effect of electricity in these cases aids in keeping them under observation and control as much as any essential good it does. Remembering that manifestations of the psychoses are but secondary effects of organic brain disease it may the more readily be accepted that the treatment should primarily be directed to the cause, and not to their effects, if improvement is expected.

Senile Dementia.—Under senile dementia we group all these cases of progressive mental failure in the aged, dependent upon a peculiar parenchymatous degeneration of the neurones of the brain, due to the process of aging. Although sometimes associated with arteriosclerotic processes such degeneration is independent of the arterial changes, though the clinical history may be modified somewhat by the complication. Thus the old-time medical dictum, that "a person is as old as his arteries," cannot now be accepted as carrying the semblance of truth it did when it was thought that arterial degeneration always preceded old age mental changes.

Etiology.—Some have urged that senile degeneration is caused by lack of proper nutrition, due to primary atrophy of the intestines; Metchnikoff and others that early decay is dependent upon absorption of toxins from a deranged intestinal tract, with the overgrowth of certain putrifactive organisms therein. Others have thought that the changes in the ductless glands were responsible for the biochemical poisons that seemed the immediate causative factor. While each of these theories may have a certain plausibility in certain cases, it is but fair to state that up to the present no proven influence has been found to explain why tissues age and cease to function, as is seen in the brain cells of senile dementia.

In some families, through many generations there seems a predilection for the elderly to show signs of mental involution before general weakness of other bodily functions become noticeable. Yet in most old people who escape bodily crippling to extreme age there is a distinct reduction of mental power and acuteness, and a definite degree of limited responsibility. It is only the extreme cases that have to be sent to hospitals. Thus the data, as taken from statistics of asylums, cannot be accepted as at all indicative of the relative prevalence of the disease in the community.

Symptomatology.—For convenience of description of the various symptoms that may accompany the process of senile dementia we group the cases into: (1) senile dementia; (2) senile confusion; (3) senile delirium; (4) senile persecution.

These groups signify clinical types rather than essentially different processes, and it is not unusual for one patient to exhibit a different type at an early stage than later.

Senile dementia is characterized especially by the gradual onset and progress of a general mental deterioration. None of the mental faculties are at first lost; they become blunted, and this accounts for the peculiar coloring of the whole clinical picture.

Perception may be good, but the full comprehension of details is lacking. In this way their realization of time, of place, and of persons may be at fault. They get lost easily, even at home, become lacking in animation and general mental acuteness, appear stupid, sleepy, uninteresting, and uninterested. Besides the clouded *orientation*, the *train of thought* is interrupted. They cannot read with understanding nor follow a discourse; in fact, they lose the thread of ordinary conversation or do not see the point at issue. They lose their power of initiative, their creative faculty fails, they cannot adapt themselves to new surroundings or conditions, nor change their point of view. They think in a regular routine according to their accustomed habits, lose their flexibility of thought and power to change easily at will from one subject to another, do not modify their opinions nor further elaborate previous conceptions. Thus their conversation flows in one tedious round of ever-contracting ideas, which are brought in everywhere without regard to their connection or bearing. The elaboration of ideas and perceptions into new conceptions, the power of analysis and synthesis of thought, the formation of opinions and judgments are hopelessly impaired. This explains their lack of full comprehension of passing events, their proverbial "conservatism," and their inability clearly to see and withstand the delusions which naturally come to them.

Great impairment of memory is apparent, especially for the recent past. Ideas long dormant, however, may be revived, and circumstantial and detailed accounts of happenings long past are often remembered with remarkable clearness, when most important happenings transpiring to themselves or others seem to find no lodgment whatever in their brains. One will remember where he lived as a boy, who were his school-fellows, recount the details of his marriage arrangements, but be absolutely ignorant of where he is or of the fact that he was brought from his home the day before. In fact, he is apt to live wholly in the past and mistakes his companions for his former long-lost associates. Occasionally, when defective remembrance leaves unmistakable gaps in narration, the missing links are filled in with inventions without any realization of their fictitiousness. Thus, in process of time, a well-worn favorite story, by silent elision of the main facts and insertions, may become a totally different and incomprehensible fabrication. As the memory grows weaker, the circle of ideas narrows until the impoverishment of thought and diction is evident in their painfully monotonous remarks.

Delusions are numerous even in the early stages of the disease, but call forth no particular activity until the severe disturbances of the emotional life take place. At first they are wont to imagine that some evil is to befall them, or are constantly worrying about their health. This may be associated with actions and ideas of childish self-importance. A common delusion is that their food does not digest and that nothing passes from the bowels, that their enemies have ruined and killed them or left them for dead. They may even make childish preparations for suicide, and somewhat infrequently may accomplish it. Hallucinations of sight and hearing are sometimes very prominent and fantastic. They see changing colored pictures on their bedroom walls at night, likenesses of dead friends or relatives, landscapes and gardens; they hear angels, recognize their friends' voices, hear threatenings and preparations for their own destruction.

The general trend of the emotional life is toward complete blunting of the sensibilities and desires, the merely animal wants dominating their higher emotions until complete uniformity is reached. This process, however, is often marked with great fluctuations in the tide of the emotions, which, when influenced by their delusions, may cause widespread devastation and distress. The patients grow silent and indifferent, are not influenced so acutely by the pleasures or sorrows of existence, grow self-centered and more jealous of their own bodily wants, reserve their choicest blessings for any Jacob who will satisfy their hunger, bear with the fortitude of indifference even a Job's losses, but are up in arms and rebellious at the least attempt to cut

off their supply of tobacco. Again, the patient's humor changes and there is evident extreme satisfaction, childish joy, and unnatural susceptibility to great fluctuations in humor. One moment he is irritable, dogmatic, and impatient; the next, for the slightest cause, he is in tears and despondency; a moment later, radiant and laughing. During these periods of elation of spirits, the passions, untrammelled by the checks of judgment and reason, are apt to run riot. This is seen in their outbursts of anger with vociferous and unbridled swearing and abuse, and especially in the increase of their sexual impulses. They often contract foolish marriages or content themselves with indecent exposure, masturbation, and obscene talk. At times they even make indecent assaults, especially upon young girls.

Gradually this mood may be more continuous and bring about for a considerable period great changes in conduct and action. Extreme restlessness and irritability are developed, they quarrel constantly with their companions, are ever working or fussing over imaginary work, talk a great deal, threaten, and sometimes become violent. They run about the neighborhood, collect heaps of trash, meet with accidents and mishaps, and are a constant trial to their guardians. At night their greatest restlessness is manifest. They get up and wander about the house, often with serious danger of setting fires, rummage around and tire themselves all out, and may be quiet and sleepy the next day. They grow neglectful of their toilet and even of ordinary cleanliness, and sometimes, if uncared for, become most distressingly filthy.

The physical changes which accompany this mental degeneration indicate a serious decline in the general health. The appetite grows poor, nutrition suffers, the subcutaneous fat disappears, the skin becomes wrinkled and yellow, with pigmented areas and spots of keratosis senilis, which may break down into carcinomatous degeneration. Occasionally there is troublesome itching of the skin—pruritus senilis. The teeth are lost and the alveolar processes of the lower jaw are absorbed, with characteristic change in its shape and consequent falling in of the lips. The muscles atrophy and weaken, the bones become more brittle, the arteries harden and are distinctly visible in their tortuous course up the emaciated limbs. The pulse grows weak and slow and is apt to be irregular. The hair becomes sparse, coarser, and turns gray, with, possibly, the exception of that of the eyebrows. The eyes grow far-sighted, then gradually get dim from clouding of the lens. Arcus senilis is common. The pupils are not infrequently contracted, unequal, and react sluggishly or not at all. The tendon reflexes are generally increased, sometimes decreased, and occasionally absent. The superficial reflexes are wont to be uniformly diminished. The voice changes gradually to a peculiar, weak shrillness or to a husky indistinctness accompanied by other symptoms of aphasia. They become hard of hearing, clumsy, tremulous, and uncertain in their motions. After the onset of mental symptoms the physical signs of age are apt to progress much more rapidly, so that a patient may within a few months look many years older than he really is. Many of these physical peculiarities were strikingly shown in the subjects of the accompanying illustrations.

Senile Confusion.—When the process of mental deterioration above described has advanced toward its final limits, we may have the picture presented of what is usually classed as senile confusion. All idea of time, place, and the recognition of their companions and relatives is lost to these patients, they do not know how old they are nor where they live, how many children they have, nor whether they are married or not. The train of thought is hopelessly disjointed. They do not seem to have any motives for action and the scope of their ideas is increasingly narrowed. Single phrases and sometimes words or syllables are often repeated over and over with senseless monotony and sometimes with a certain rhythmical cadence. There is evident, also, frequent elision of the nouns in speech or writing, and other signs of amnesic or motor aphasia.

Often fantastic delusions of grandeur or of persecution are exhibited. One old patient would stop in his fruitless hunt "for the cows" about the ward, and attempt to harangue with silly pomposity and perfectly meaningless phrases an imaginary audience of grangers. Others are depressed, with hypochondriacal, nihilistic notions—the remnants, perhaps, of a former more active melancholia. Every idea that it is possible for them to conceive is seemingly told and believed in as fact.

Hallucinations of sight are not uncommon, especially at night, and vary according to the mood of the patient. This varies constantly. One moment they are silent, morose, and woe-begone; the next, elated and childishly cheerful; and then again, suddenly, without apparent cause, are sad and lacrymose. At night they show special restlessness. They get out of bed repeatedly, wrap up their bedding and other clothing, and wish to start to walk home. They tear the sheets, smear things, and, if not carefully watched, become disgustingly filthy and destructive. Their appetite wanes and often they refuse food. They may become so weak that they cannot get out of bed for weeks or months, but pass their final days in a state of semi-consciousness or mental twilight without appearance of suffering or desire, the merest wreck of their former physical and mental greatness.

Senile Delirium.—This is really an exhaustion psychosis from a rather sudden senile breaking up, accompanied by active delusions, hallucinations, mental confusion, and generally physical collapse.

As a rule, the symptoms progress rapidly when once developed, although various lighter signs of senile degeneration may have been evident for weeks or months previously. The onset is often determined by some acute sickness, accident, or mental shock. Thus we find it following rather abruptly the partial convalescence from la grippe, summer diarrhea, a fall or blow on the head, apoplectiform seizure, or more rarely from bad news or worriment.

Within a few days or weeks the consciousness of the patients becomes completely clouded. They do not recognize their friends nor realize what is going on about them. There is no continuity of thought, but entire irrelevance and incoherence of speech and action. They may not know whether it is daylight or darkness, whether they are hungry or have just eaten, neglect the calls of nature, may soon pass into great motor restlessness, and rapidly sink into lethal exhaustion.

In their talk they manifest frequent aphasic disturbances—especially the elision and slurring of words, the unintentional gaps in meaning, the naming of objects wrongly even when corrected. Multitudinous delusions are evident, sometimes of a persecutory or sad character, but often of a grand or joyful content. They are poisoned, bewitched, about to be hanged, torn to pieces, castrated, or set up as a target. Their children have been destroyed, there is no hope for mercy, they are eternally lost, are too bad even for Satan's care. They hear loud calls and reproaches, singing, threatenings, hear their scaffold being built, see knives and swords, poison in the food. All these ideas are not told about soberly; they are rather inferred from their disconnected utterances and from their actions in trying to avoid the consequences feared. In fact, their talk may degenerate into mere meaningless sounds and senseless repetitions of the same sounds (echolaly). The mood of the patients is usually depressed and worried, but may become calm and serene or joyously happy. There is almost always great motor restlessness, especially at night, no inclination to go to sleep, but a constant nervous tension and desire to go away, break out of the window,

tear the sheets, scream, bite, and scratch if hindered. Later, they weaken, creep about on the floor, smear themselves in every way, roll about, and object to and oppose everything that is tried to be done for them.

Under this head should be included the "dark-room delirium" so often observed after cataract operations in the aged. Here, however, hallucinations of sight are apt to be uppermost, the talk more sensible and connected, and the motor restlessness not so marked.

The duration of senile delirium may vary considerably, with many repeated remissions and relapses throughout its course. Sometimes these cases may eventually, with careful treatment, make a very good recovery, but as a rule it is at best partial, and finally leads to grave dementia. Those cases that do prove rapidly fatal, and they are not uncommon, show more and more confusion and continuous excitement, their strength fails rapidly, they do not assimilate the food they are forced to ingest. Then there ensue semi-consciousness, picking at the bed clothes, subsultus tendinum, extreme emaciation, weakness, profuse sweatings, deglutition- or ether-pneumonia or some other accident, and death.

Senile Persecution.—This group includes a number of senile cases in which various delusions of persecution are continually uppermost in the downward progress to complete dementia. The onset is gradual, with usually a change of mood and habits. The patients grow quiet, morose, suspicious; seclude themselves, and, finally, become definitely deluded and it may be actively hostile. They think they are robbed, insulted, intentionally and slyly poisoned, that their income has slowly been taken away. They hear threatening voices calling to them. They are charged with electricity, wet with corrosive acids, shot at and perhaps killed many times a day. Sometimes they become markedly elated, deck themselves, and put on airs.

The general conduct of these patients is good, they keep neat, and to a casual observer seem no different from normal old persons. At times, however, under the influence of delusions, they become more irritable and troublesome. The train of thought is not early impaired, nor the recognition of persons, places, time, and the general events of their environment. They often cause much trouble to themselves and others when at large, but under proper guardianship and restraint they usually pass a fairly comfortable and quiet existence to about the normal limit of life. In all their delusions there is a marked and growing childishness and absurdity, their persecutory ideas are ever changing and not much elaborated, they are easily influenced to modify their opinions, and in many ways show that the essential process is the gradually progressive dementia.

Pathology.—Macroscopic examination of the brain shows evident destruction of nervous tissue, with consequent loss both in volume and weight of that organ. The space thus available within the skull is filled up by compensatory thickening of the skull and by collections of serum. The average loss in weight has been estimated as nearly half a pound. The general contour may not be noticeably changed, although such brains are apt to be much softer than normal. Sometimes distinct calcareous or atheromatous patches may be evident in the larger arteries, and less frequently minute capillary hemorrhages and aneurysms or larger areas of softening, especially in the region of the basal ganglia. The pia is white, opaque, and thickened in patches. Infrequently there are adhesions of the dura; sometimes hematomata may be noticeable.

Microscopically there is an evident thinning of the cortex with atrophy and destruction of the parenchymatous elements and subsequent sclerosis and increase in neuroglia cells. Pigmentary degeneration is frequently noticed. The acute changes in the cells incident to sudden failure of nutrition are often also to be seen.

The histological cell changes especially characteristic of senile dementia commence with a swelling of the nerve cell, and the gradual accumulation within the cell body of fine granular material which does not stain normally, and besides these there are often other granules of more or less color, which are the pigmentary changes above referred to. As the disease progresses the non-staining granules resolve themselves into definite collections of lipoid substances, which may be few in the cell or accumulate to such an extent as to completely destroy it, or produce the familiar picture of fatty degenerative cell changes. These fatty products are seen in advanced cases crowding the lymph channels, and often collections of such substance which do not stain well are very numerous, both within the cortex and beneath it, and give a peculiar mottled appearance to the microscopic pictures. These collections of fatty or lipoid substances are known as plaques, and are generally associated with all severe cases of senile degeneration. Similar appearances are found in Alzheimer's Disease, noted above. In senile dementia, also, is occasionally noticed the characteristic Alzheimer neurofibril type of cell degeneration. These cell changes, and consequent absorption, account for the growing paucity in number, which is very striking in comparing senile dementia brains with normal ones. The greatest destruction is noticed in the frontal areas, although the process in general is confined to no special area. Blood-vessel changes are often seen associated with the characteristic nerve cell changes, but that the latter do not result from the arteriosclerotic and other vessel changes is evident when it can be demonstrated that over half of typical senile dementia cases show no such vessel alterations.

Diagnosis.—The boundary lines between slight forms of senile dementia and normal old age are not sharp and well defined, and in certain cases the judgment as to their presence or absence must be purely arbitrary. The grave emotional outbreaks, and more certainly the cropping up of delusions in other cases, may soon make the diagnosis more certain. Much the same hazy boundary lines lie between these cases and those belonging to the involutionary years and presenile periods. In cases of melancholia the onset of senile symptoms is coincident with a growing tendency toward hypochondriacal and nihilistic delusions and an evident increased emotionalism. From general paralysis the diagnosis would seem not difficult, but, as a matter of fact, frequently mistakes are made between these two diseases. The excitement and delusions of grandeur may be quite similar, but the paralytic is more prone to enter cheerfully into minute details and be less impatient and irritable than the case of senile excitement. The accompanying physical signs would also be of eminent value.

The forms of senile persecutory insanity may be mainly distinguished from true paranoia by the general mental weakness, the disinclination to further elaborate their delusions and act accordingly, and, finally, the almost entire lack of true systematized delusionary plots. From the similar cases included under presenile insanity there would seem to be no strict boundaries. In the later cases, however, there appear less marked emotional periods with an increasing general mental failure.

Prognosis.—True senile dementia is never fully recovered from. Under appropriate conditions there may be marked remissions, decrease of emotionalism, and a generally calmer habit of mind sufficient to enable the patient to return home to spend the rest of his days in a quiet, dreamy, second childhood. On the other hand, the onset of confusion may lead to accidents and no end of trouble if the patients are not closely watched and cared for. Abject helpless dementia seems to offer no ray of hope for even temporary clearness—the mental fires have burned out and

nothing remains but the whitened ashes. As before stated, the presenile forms may exhibit almost complete restoration, and may even afterward reengage in many of the activities of life. The great majority, however, of all these patients eventually become more and more markedly weak-minded, until they are carried off by some sudden intercurrent disease.

Treatment.—A. Prophylaxis.—Little stress has been laid upon this aspect of the subject by writers, obviously because, when the signs of dementia first appear, the sclerosis of the arteries and other grave pathological changes have already progressed considerably and certainly cannot be prevented; only occasionally can they be hindered, and still more rarely stopped by means of treatment. There are so many persons, however, in the community with slight nervous symptoms in earlier life sufficient to cause the experienced clinician to suspect their brains as offering a suitable soil for the involution insanities, that a few words in this connection may not seem amiss.

In such cases the regular habits of life, plain nutritious and unstimulating food, exercise, and the avoidance as far as possible of all worriment and severe mental or physical strains considered so important in the care of the really sick, will be found more beneficial in preserving the mental equilibrium than in restoring it when once disturbed. Many times if business men would be satisfied with a competence, and would retire from the wear and tear of exacting work comparatively early in old age, as has been so shrewdly recommended of late by a prince of finance, many would undoubtedly escape the untoward effects of senescence who now yearly hopelessly break down. Particular care to avoid excitement and the adoption of measures likely to hasten convalescence from acute physical disease in the aged will often prevent severe and sudden mental collapse. For similar reasons, operations that are so frequently recommended in old persons "if the heart is all right," should always receive due consideration as to the mental risks which may be incurred.

B. General Treatment.—The first requisite in caring for the aged insane is to secure good, careful, conscientious attendants. For this reason, relatives often make the best nurses, contrary to the usual rule in mental diseases. The whole daily life of the patients has to be mapped out and regulated. While diversion is ofttimes an object, it must be borne in mind that the old are very conservative and enjoy old haunts and familiar habits of life better than constant change of companionship and scenery. It seems sad and incongruous sometimes to find some old home body forced to travel and see new faces and scenes in the hope that her mind may be diverted from the introspective ideas of beginning involution.

On the question of diet we would not be dogmatic. If everything that has been recommended as allowable were to be taken, there would be no restriction; if everything objected to were cut off the list, the patients would undoubtedly starve or die of thirst. It seems absurd to me to withhold such staples as bread, milk, and spring water from these often very delicate toothless old people, because, forsooth, there may be a proportion of lime salts contained in each that is supposed to increase the arterial deposits. Yet such a course has been advocated. The various prepared foods upon the market have proved very efficient in feeble cases. As a general rule, all the food and drink should be served warm or hot. The living rooms of the patients need to be light and well ventilated, and kept warm both day and night. Efficient night attendance, especially with those who are restless or confused, is imperative. Cleanliness must be insisted on. For this reason the rooms are often best rather scantily and plainly furnished, with guards to the windows at night if necessary. Outdoor exercise in moderation quiets excitement and tends to produce more natural sleep, as do also massage and warm baths in certain cases.

C. Special Treatment.—Attempts to modify the degree of dementia by specific medication have uniformly proved unsatisfactory. Usually such remedies as will assist the general attempts to increase the physical nutrition will be found best. Potassium iodide has been lauded by some for its specifically alterative effects in this disease. On the whole I have been disappointed in its use. On the other hand, cod-liver oil in as large doses as the stomach would bear, has proved much more efficient. In emaciated individuals rubbing with quantities of *pure* lard or other animal oil has seemed at times to decrease the dry harshness of the skin and markedly increase general nutrition.

For the noise and restlessness opium should not be used. In fact, it has but little place in the insanities of old age. After extensive use of all the newer sedatives, I believe that dormiol, in appropriate doses, is the most generally serviceable. From two to four drams of the ten-per-cent. solution of this drug in water will usually be found sufficient, although such doses can be safely repeated if necessary. It does not seem to depress the circulation appreciably. Small doses induce a calmer frame of mind during the day, and larger ones will quickly produce dreamless and restful slumber at night. Its effects are transient and it is easily taken, and has no disagreeable effect subjective or objective. Sulphonal and trional are serviceable on occasion, but chloretone has proved disagreeable and is too depressing to the heart to risk in most cases. In patients manifesting extreme weakness or collapse, complete rest in bed and vigorous stimulation with alcohol and nux vomica and warmth are sometimes the only things which will avert a sudden dissolution. I have always been singularly unfortunate in the use of digitalis in these cases and I believe that a special watchfulness is needed with this drug in senile delirium and collapse. For continued refusal of food the use of the stomach tube is invaluable. The patient must not be allowed to starve himself too long before this measure is resorted to. In vigorous individuals it has been my custom to feed after the second day's abstinence, but in debilitated cases we must not wait for so long a time. In feeble cases I have found that the introduction of the nasal tube seemed to cause more discomfort and in many cases to set up more disturbance of the mucous membrane than when the tube was introduced through the mouth. In all such cases very great care is to be taken not to get the least amount of liquid into the trachea, on account of the danger of insufflation pneumonia and a rapidly fatal termination of the case.

The question as to whether a patient would be better off in a hospital or asylum or at home has to be settled according to the character and station in life of the individual case. The milder types can very comfortably be cared for at home. Many of these cases, even, when their circumstances will not allow of constant and intelligent supervision, are undoubtedly better off in a well-managed hospital, while even quite severe cases can avoid the stigma of the asylum if they can command trained attendants or the facilities afforded by the private retreats and sanatoriums so numerous throughout the country.

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Psychoses, Symptomatic.—By symptomatic psychoses one understands those psychoses which instead of forming definite rounded-off entities in themselves, standing in the foreground of the clinical picture, are so to say, side issues, symptoms of other disease conditions, either forming an integral but yet not dominant part thereof, or being found as an occasional, not regular accompaniment of the same. The psychoses classed in this manner are those found

with or as a sequel of: Infectious diseases, cachectic diseases and anemic states, diseases of the heart, uremia, eclampsia, diabetes mellitus, uric acid diathesis, Basedow's disease, tetany, myxedema, gastrointestinal diseases, diseases of the liver, Addison's disease. In this classification given by Bonhoeffer a special grouping can be made of the exhaustion psychoses including the anemic and cachectic states.

It was formerly thought that to definite somatic diseases and to definite pathological deviations of physiological states, such as the puerperium or lactation, definite types of mental disarrangements corresponded, and one spoke of typhoid psychoses or pneumonic psychoses or cardiac, puerperal psychoses, etc. Accumulated observations have shown, however, the lack of specificity of any psychosis connected with or following these somatic diseases or states mentioned.

More and more the conclusion has impressed the observers that the form of psychosis in these cases depended as much on the constitution of the host as on the particular somatic disease which gave immediate rise to it; and one has, therefore, concluded the existence of reaction types of hosts, governing in a large measure the appearance and the form of the psychoses to which external or exogenous causes, so called, give rise.

Any observer of experience will confirm that various constitutions react in various manners to the same noxious agents. Some beings respond to damaging agencies of various kinds with affections of the respiratory or gastrointestinal tract, others to the same agencies as the above with affections of the joints or muscles or both; a third group shows a special vulnerability of the nervous system, which becomes predominantly affected when the host is subject to the same noxious agents which in the first-mentioned group gave rise to symptoms on the part of the respiratory or gastrointestinal tracts or of the joints or muscles respectively; and thus, in a more specialized way one individual presents a manic reaction type, responding with maniacal manifestations to various influences such as emotional agents, menstrual factors, mental strain, and other exhaustive factors, psychic sexual trauma, etc., others with paranoid symptoms to similarly varied influences.

If we adhere to the theory of evolution and the variedness of constitutions in various individuals of the same species which it implies, we need not wonder at this variedness in the response to the same exogenous agents in various individuals and the similarity of response to various factors in the same individual, but rather would expect it. Diving deeper, *i.e.* to more simple relations we find an illustration of this in chemistry. The various chemical elements have their chemical affinities.

Whereas concentrated nitric acid, for instance, has a most powerful chemical action on most elements and chemical compounds, including nickel, copper, and silver, it leaves gold and platinum unaffected.

Taking thus gold as a host we find it immune against nitric acid, whereas its brother or cousin, silver, is totally transformed by the action of that acid into a substance with wholly different physical properties, nitrate of silver.

The more elements enter into a compound and the greater the number of atoms composing its molecule, the greater, of course, are the complications in its chemical affinities toward the substances it may come in contact with and the greater the variety of reactions, according to the nature of such substance. The end result is always a mathematical equation between the chemical and physical forces of the host or defender on one side and the invader on the other.

After this little illustrative digression return to the concrete subject is in order.

The subject is presented by passing in review the physical diseases above listed and discussing what psychoses each of them may give rise to.

Infectious Diseases.—*Typhoid Fever.*—The psychotic disturbances observed with this disease may make their appearance in the beginning as so-called initial deliria, or at the height of the disease, or at the period of defervescence.

The initial deliria occur, according to Aschaffenburg, in two forms, the delirious and the manic. But in the latter form only the flight of ideas, as a part manifestation of the confusion, is manic, the other symptoms having little in common with mania. They have nothing in them characteristic of or specific for typhoid fever, but their occurrence in itself has a prognostic significance in so far as the mortality of typhoid cases with initial deliria is said to be about sixty per cent.

Erysipelas.—As an infectious disease it comes next to typhoid in the frequency of psychotic symptoms accompanying it (seven to eight per cent.). According to Kraepelin, Ruger, and Frenkel it is mainly the head erysipelas that leads to psychotic symptoms, a conclusion somewhat difficult of interpretation in view of the great frequency of the head cases. The fourth day of the disease is the period of predilection for the onset of the psychotic symptoms. The latter are deliria of various type, with nothing characteristic except perhaps the brief course and the rapid convalescence.

Acute Articular Rheumatism.—In the fatally terminating hyperpyretic cases the psychotic symptoms are most apt to be ushered in at the end of the first or beginning of the second week, being mostly in the nature of grave deliria persisting until death. In the particularly frequent cases in which the psychotic manifestations set in in the after-stage the causal connection with the psychoses is often a very loose one.

Scarlet Fever.—Psychic disturbances occur particularly in adults and especially in the stages of defervescence and desquamation, mostly as mixtures of delirious and hallucinosis-like states. A special uremic coloring may be added in the nephritic cases, such cases in conformity with the late appearance of nephritis being observed mostly during reconvalescence. Funkhauser points out inhibition of intellectual development as a particularly frequent sequel.

Measles rarely leads to psychotic disturbances, but sometimes to initial deliria (Kraepelin) and in convalescence to stuporous states.

Variola rather frequently gives rise to initial deliria and sometimes during the suppurative stage to a Wernicke-hallucinosis-like state. Two Korsakoff-like types with neuritic symptoms were observed by Westphal.

Diphtheria rarely presents psychotic disturbances, in contrast with the frequency of nervous (neuritic) sequelæ.

Malaria.—Griesinger's view of the occurrence of intermittent psychic disturbances equivalent to the febrile attacks is denied by Müller who considers them as febrile psychoses characterized by emotional excitement and anxiety. In the stage of malarial cachexia, psychoses of longer duration, with the character partly of amentia, partly of hallucinosis, partly of Korsakoff's syndrome have been observed (Collin and others).

Relapsing Fever.—In all stages of the disease psychic disturbances in the nature of epileptiform excitement may occur (Meschede and Kraepelin).

Cholera, Dysentery, and Acute Gastroenteritis.—The susceptibility of alcoholics to the cholera virus may account for the alcoholic-delirium character of the initial psychic symptoms seen in cholera cases and for the occurrence of amentia-like and Korsakoff-like states in convalescence, the latter seen frequently also as a sequel of gastrointestinal diseases by Moenkemueller.

Pneumonia has a close relationship with delirium tremens, apex pneumonia being more frequently attended by psychotic symptoms than those of the lower lobes.

Influenza.—The frequency of the complication of this disease with psychoses is only a relative one; mostly febrile deliria, rarely asthenic psychoses have been observed (Kirn). The melancholias or other known clinical types following influenza present, according to Kirn, a strong hereditary predisposition.

Tuberculosis.—Leaving aside tuberculous meningitis, psychic disturbances are mostly seen in connection with tuberculosis of the lungs. The peculiar euphoria and optimism of phthisics in the late stage are well known, but many also present great irritability, hypersensitiveness, and emotional weakness in this stage (Bonhoeffer). The actual psychoses are mostly of the amentia type, but hallucinosis-like conditions and simple deliria are also found, although Kraepelin points out the rarity of delirious symptoms in pulmonary phthisis.

Septic Diseases.—Long duration or weakening factors may cause the appearance of mental symptoms with these. Puerperal fever is an especially well-known member of this group. Euphoria with ignorance of the gravity of the situation is often present. Otherwise the septic deliria and psychoses have nothing distinctive from other deliria.

Chorea (Sydenham's).—The near relation of this disease to the infectious diseases, particularly acute articular rheumatism justifies placing it here. The time of predilection for the grave chorea psychoses is the age of puberty and the subsequent years up to about the twenty-fourth year (Kleist). Most frequent are the milder mental disturbances manifested by anomalies of affect and psychic hyperesthesia.

It is the liability of affect that chiefly counts. Tendency to apprehensiveness, outbursts of annoyance and anger, crying spells on the least provocation, sometimes rapid change to a merry, unbridled mood. Often it is evident that we have to deal with an exaggeration of the motor utterance, a hyperkinesis of expression, whereas the general affect is an indifferent one. On the whole the depressive affective manifestations preponderate. A decrease of spontaneousness is observed in many of the milder cases (Kleist). The diminution of initiative and listlessness often make one think of hebephrenia, the differential diagnosis from which may sometimes present difficulties.

Lack of the feeling of being ill, sometimes increasing to euphoria may be found in grave cases (Bonhoeffer). Transitions beyond euphoria to a maniacally elated mood, with flight of ideas, progressing to incoherent confusion, are relatively frequent in the grave cases with fatal termination (Bonhoeffer).

The elements found in the fever-amentia can be found also in the majority of chorea psychoses, even though frequently episodically only, not throughout the whole psychosis. Wollenberg and Kleist point out as a peculiarity of the chorea psychoses the tendency to hypochondriacal intestinal and cutaneous sensations.

The prognosis of the chorea psychoses is on the whole favorable, with quite a number of fatal cases, nevertheless; the choreas of pregnancy are particularly unfavorable in this respect, often taking the course of delirium acutum.

Therapeutically bed rest and if necessary isolation are fundamental factors. Bonhoeffer recommends hyoscine and morphine, pointing out nevertheless the drawbacks of the hyoscine. Warm packs may prove very beneficial.

In the cases of chorea gravidarum artificial induction of labor may have to be considered, but in the majority this does not bring the psychosis or chorea to a standstill.

The *diagnosis* of the infection psychoses may present difficulties. In regard to causal connection between the psychosis and the infectious disease one must not forget that not infrequently the febrile process and especially the defervescence may act as an exciting factor in bringing out the psychosis.

The differential diagnosis will have to consider particularly catatonia, especially in the most acute phase, since grave catatonia cases not infrequently are ushered in with a febrile phase. Grave motor excitation, negativism, grimacing, verbigeration, theatrical mode of speech, and perseveration may initiate a grave catatonic psychosis or a febrile psychosis as well.

A disease picture diagnosed as symptomatic catatonia may develop into a true catatonia in the further course and *vice versa*. There is not a single catatonic symptom that is not found in infectious psychoses. A thorough anamnesis may clinch the point. True delirious symptoms, combined optic-tactile hallucinations or illusions, with disorientation and delirious monologue are rather in favor of symptomatic psychoses.

Excessive grimacing, jaw sparring, lip pursing, chewing, tongue twisting, inarticulate screaming are on the whole more likely to be of a symptomatic character.

Pronounced negativism is by no means pathognomonic of true catatonia but is quite frequent in the infection psychoses. It may occur as a reactive negativism, on approach or with tests at passive mobility, or as a continuous tonic contraction, with the characteristic facies and position of head raised from the bed.

The religiously colored or apprehensive states of excitation may cause difficulty in distinguishing them from progressive catatonic or paranoid states on the one hand, or from epilepsy on the other. Here, too, the anamnesis often has to be resorted to to decide the point, the symptomatology being in no way pathognomonic for the infectious etiology. A latent epileptic predisposition may be brought out by the infectious disease, or again the possibility of certain epilepsies having a toxic (infective) etiology has to be thought of.

Pronounced flight of ideas, distractability and an elated feeling-tone may simulate a picture of confused mania. On the other hand, keeping in mind what was said of manic reaction types, a maniac trend may be made manifest by the infectious disease for the first time.

Sometimes the differential diagnosis from general progressive paresis may present considerable difficulties.

Stuporous cases with focal symptoms, also amentia forms with maniacal traits and fantastic delusions of grandeur are of this order, some of them presenting a characteristic speech disturbance. Also cases with a Korsakoff course and paresis-like speech may arouse the suspicion of general paresis.

Sometimes a prolonged stupor or amnesia may leave as a sequel a euphoria very similar to that of general paresis.

The *prognosis* as to life depends a good deal on the gravity of the infection in each particular disease. The onset of the psychotic symptoms in a very early stage of the disease is in itself of unfavorable prognostic import, such cases being apt to terminate fatally. Otherwise the character of the fundamental disease and the general physical state, at the time when the psychosis sets in, are determining factors, the prognosis being on the whole good in cases of acute infectious diseases of presumably short duration, in strong healthy individuals.

As to the duration of these psychotic symptoms the violent excitements, especially when occurring during the defervescence, wear off in a few days. Stuporous and amentia-like states may take weeks or months to recover from.

The prognosis becomes very unfavorable as to life, when the disease takes on the character of a delirium acutum. In cases with a Korsakoff course much depends on the development of arteriosclerotic and alcoholic manifestations. Where such are altogether absent, the prognosis as to recovery is not bad.

There is not always a parallelism between the severity of the physical breakdown and the slowness of convalescence.

The appearance of catatonic symptoms, if it expresses an increase of the delirious motor unrest manifestated by mimic faciolingual symptoms of irritation has a rather doubtful but not decidedly unfavorable prognostic meaning. Neither is the symptom of carphologia unconditionally fatal.

The clouding of consciousness usually denotes a graver lesion. On the other hand in amentia cases milder clouding forestalls a protracted course.

The presence of the psychosis in itself impairs the prognosis of the underlying disease, because of the difficulties it opposes to the general management and the application of therapeutic measures. Furthermore unintentional self-mutilations and suicidal attempts have to be counted with, such being remarkably frequent in the initial infection psychoses.

The *treatment* of an infection psychosis has to be in the main the treatment of the infectious disease underlying it.

In other respects the principles guiding the treatment of the acute psychoses have to be followed. Maintenance of a proper state of nutrition is essential. Administration of plenty of liquids is particularly important. Tube feeding may have to be resorted to sooner than in the ordinary psychoses, wherever the general loss of strength makes it desirable or imperative. Saline intestinal infusions and warm baths judiciously applied may prove very beneficial.

Exhaustion Psychoses.—This term does not comprise a clinical entity, and in using it one must be aware that we have to do with mental diseases which cannot be separated from the toxic and taxic-infectious ones. The states to be considered here are those occurring after loss of blood, as postpartum hemorrhage, hemoptysis, those attending the cachexias of carcinoma, pernicious anemia and other chronic progressive anemic conditions.

The psychotic states observed by Elsholz in *carcinoma cachexia* showed great correspondence with the types seen in the infectious diseases, with regard to the sudden onset and the partly delirious and epileptiform, partly amentia-like symptom-complexes.

In primary pernicious anemia various types are observed. In one case Bonhoeffer noted a prodromal stage of two weeks' duration, characterized by lessened capacity for work, lassitude, somnolence, and diminished attention and followed by a period of one and one-half days' duration manifested by neglect of his duties, forgetfulness, aggressiveness, delusions of grandeur, and terminating with a deep sleep leaving in its wake an amnesia for the whole period of one and one-half days.

In another case (Bonhoeffer) marked associative and combinative weakness with lessened perceptibility, poor orientation in place and time, confabulations, and dull euphoric feeling-tone, thus similar to a Korsakow symptom-complex, were noted to follow a delirious state. Anxious feeling-tone, false sense perceptions and catatonic symptoms were accompanying features of interest.

Again in another instance a mixture of manic and amentia signs was observed. The latter, with increasing incoherence and associative weakness, ultimately dominated the picture.

The simple acute exhausting factors: Overstrain, starvation, loss of sleep, while producing certain manifestations obtainable also experimentally, do not give rise to the psychosis designated heretofore as exhaustion psychosis.

Amentia.—This is one of the disease pictures which exhausting conditions, such as the cachexias, severe anemias and also infectious diseases may produce. Amentia or an amentia-like state is, according to Bonhoeffer, characterized by a certain degree of clouding of the sensorium and marked incoherence of thought. The simple combinative everyday acts fail. Orientation in time and place is very difficult or absent; more complicated mental tasks are still more interfered with, or impossible.

There is a primary disturbance of the current of thought which is interfered with by a tendency to illusion, compulsive registration of sensory perceptions, sometimes association according to rhymes and assonances, false sense perceptions particularly in optic and auditory domains. They are scenery-like, dream-like, delirious in nature, or confined in definite form to single sensory domains. Incoherent delusions, often of apparently primordial onset occur. They are frequently of the anxiety type or delusions of interference or grandeur, fantastic and absurd. Recapitulation of indifferent reminiscences noted. Like the stream of thought, the affect too shows sudden changes; euphoria, anxiety, anger, depression, these alternate with each other, mostly with a distinct element of helplessness; but complete lack of affect too may occur. Remnants of a psychic disease insight are very frequent.

Speech and other psychomotor manifestations correspond in the main to the varying pathological processes of consciousness. Episodes of verbosity without other hyperkinesis are frequently observed. Anomalies of the formal stream of thought and movement as described by Bonhoeffer in the catatonic form of fever-amentia, are seen.

The clinical picture according to the predominance either of the hallucinations or the illusionary processes and incoherence, or the flight of ideas, distractibility and liability of affect, or of the psychomotor phenomena, may vary greatly in the concrete case, and one could if one chose distinguish hallucinatory, incoherent, multiform, and catatonic subgroups according to the symptoms.

Amentia is decidedly coordinated with the epileptiform, delirious, stuporous, and hallucinatory syndromes which, like amentia, are often found developing on the soil of infectious processes in the periods of infection as well as of defervescence.

Diseases of the Heart.—It is chiefly the anxiety psychoses that are brought in causal connection with the diseases of the heart by some authors like Wernicke and Stransky. Bonhoeffer rightly points out that while it is suggestive to attribute to cardiac disease the precordial sensations observed in the beginning and course of so many psychoses, if at the same time pathological heart findings are discovered, yet the large number of cases presenting such precordial sensations in the absence of cardiac changes make such a connection by no means a direct and necessary one.

Nevertheless it is hardly to be doubted that combination of psychopathy and organic heart disease leads to a stronger perception of cardiac distress, especially of anxiety sensations. In such precordial anxiety states fugitive anxiety ideas and disturbances of orientation may arise, which often show a distinctly psychogenic note (Bonhoeffer). In psychoses of longer duration, especially in the case of elderly individuals, the possibility of arteriosclerotic cerebral changes will always have to be thought of in causal connection.

The question whether cardiac diseases are more capable than other diseases of arousing, *i.e.* making manifest a predisposition to depressive diseases, needs still further investigation, as does the point whether an endogenous depression may be influenced in its

symptomatology by complications with organic heart disease. But while the causal connection between heart disease and depressive states is subject to some doubt, it is incontestable that diseases of the heart may produce psychotic disease pictures in other ways, probably through autotoxic damage, brought about by disturbances of compensation.

Moodiness, irritability, and apprehensiveness, a feeling of internal unrest, vivid, anxious dreams and poor sleep may be the mild effects of such disturbances from cardiac disease. If psychoses occur, these show a distinct symptomatological kinship with the above-described states. They generally run parallel with the degree of disturbed compensation.

Fischer relates cases in which intellectual retardation, anxiety, disorientation, anxiety ideas and hallucinations, temporary delusional formations, dream-like false sense perceptions, occasionally strong anxious impulse to get away existed.

Where *maniacal states* are found in combination with heart disease, the interpretation of the causal relation between the two may meet with decided difficulties. Manic-depressive antecedents will have to be looked for, and when not found, the possibility still exists of assuming that the circulatory disturbances brought the manic-depressive trend into evidence for the first time.

Bonhoeffer observed that the circulating stasis of cardiac disease may arouse a tendency to hallucinatory processes in patients with a maniac-depressive predisposition or trend, noticing in the same patient purely manic attacks, before the onset of compensatory disturbances due to the heart disease from which she suffered, whereas, after the appearance of grave dropsical symptoms the barely developed maniacal symptoms of the true sort, in the nature of flight of ideas, distractibility, increased interest and elated feeling tone, were completely overshadowed by slight obnubilation and numerous auditory hallucinations of criticising and insulting contents. A disease picture standing between hallucinosis and amentia had developed.

Nevertheless no clinically founded reason exists for making a subdivision of circulatory psychoses (Bonhoeffer).

Chronic uremia may cause some difficulty in the differential diagnosis from general progressive paralysis and brain tumors, especially because of the combination of focal symptoms with symptoms of mental defect. The patients complain of fatigue, feeling of weakness, poor, restless sleep, headache, and occasional vomiting. Objectively a retrogression of the working capacity, a change of character in the direction of irritability, in other cases in the nature of indifference and loss of interest are noted. A marked euphoria may also be observed. A light degree of obnubilation, disappearing when attention is fixed, may be noted from the beginning. Later it becomes more pronounced. The mental symptoms become coupled with physical ones: ataxic disturbances, stumbling, slurred speech, disturbance of the ocular muscles, pupillary differences, lessening of reaction (retinal changes), Babinsky's sign, the latter sign being always found in the later stage. Fugitive cortical focal symptoms, Jacksonian attacks, monoplegias, hemiplegias, aphasias and hemianopic disturbances, amaurotic attacks, in part surely of cortical origin, may occur.

Acute uremia is typefied in the uremic attack which need not show any distinction from an epileptic one, the differential criteria occasionally mentioned, such as the absence of an aura, the appearance of isolated twitchings, not holding good. There is a correspondence likewise in the psychical symptoms.

Twilight states are observed which in their mode of appearance, degree of motor excitement, phantastic hypochondriacal symptoms and religious delusions of grandeur greatly resemble the epileptic ones, appearing preferably after a convulsive seizure and terminating, as a rule, with a sleep and complete amnesia or hazy recollection for the period of the twilight state.

The uremic deliria may occur also independently of convulsive seizures, not differing essentially from deliria of other etiology. They comprise auditory and visual and combined visual-tactile hallucinations in the form of dream-like representations of situations; also delusions of interference. On the motor side there may be a purposeless hyperactivity, loud roaring, unreasoning efforts to get away. Consciousness may be disturbed in various degrees, from normal power of attention or slight distractibility to coma. The affect reactions are exaggerated and spasmodic. Clinging to objects or persons as well as negativistic repulsion may occur.

Uremic psychoses of the *amentia type* have also been observed; namely, incoherence, distractibility, tendency to rhyming and sound associations, visual hallucinations, misidentifications, bound-like changes of affect; increased motor activity of a disordered kind, echopraxia, echolalia.

Pronounced motor negativism and other catatonic symptoms were frequently noted by Bischoff and Ascoli.

Eclampsia.—While almost without exception the onset of psychic disturbances is preceded by the appearance of the eclamptic seizures, the number and kind of the latter has apparently little bearing on the development of the former. Neither has the percentage of albumin in the urine any definite relation to the occurrence or severity of the psychic symptoms. The psychotic states described were almost invariably twilight and delirious states, showing marked fluctuations in the intensity of the symptoms.

In more lucid cases the high degree of associative weakness with perseveratory and dissociative elements and flights of ideas were notable features. In cases of greater clouding of consciousness delirious prehensile movements were often the only other mental, *i.e.* psychomotor manifestations.

Types with marked affective coloring and abundant false sense perceptions and phantastic dream-like life-scenes, mixtures of delirious and ecstatic religious states, have been described by Bonhoeffer. The similarity of the eclamptic with the epileptic deliria and twilight states is pointed out by all observers. A characteristic but not pathognomonic feature is the retrograde amnesia comprising a longer or shorter period preceding parturition. No certain, *i.e.* reliable differential diagnostic criteria exist between the epileptic and eclamptic mental states.

Diabetes Mellitus.—Actual diabetic psychoses, *i.e.* psychoses which can be attributed to the diabetes as the cause, are rare. It must not be left out of sight that many authors claim that a strongly depressive affect can cause glycosuria. Schultze and Knauer found glycosuria very frequently in states of depression, and it often kept pace with its disappearance. In view of the frequency with which diabetes develops on the soil of a neuropathic diathesis, the statistical conclusion that 1.2 to 1.7 per cent. of diabetics become affected with psychoses loses much of its value as to a direct causal relation of the diabetes to the psychosis.

Arteriosclerotic diabetes often is wrongly considered as a cause of the psychic disturbances found, when as a matter of fact diabetes and psychosis have a common cause responsible for both. Thus the depressive anxiety psychoses of the involutional period, declared to be diabetes psychoses, are most probably arteriosclerotic psychoses (Bonhoeffer). Observations to the contrary need verification.

What causes the relative rarity of the diabetes psychoses in view of the relative frequency of diabetes we do not know. Nevertheless, with in-

creasing quantity of sugar in the urine—frequently psychic, nervous symptoms of a general nervous nature and mostly of a neurasthenic character are observed; irritability, flaccidity, feeling of physical weakness, of lessened capacity for work, headaches, head pressure, hypochondriacal complaints. They are often favorably influenced by diet, thus indicating a causal dependence on the diabetes. Chronic apathetic states going as far as narcolepsia have been reported.

The neurasthenoid symptoms above mentioned may be added to by diminution of the faculty of registering perceptions, impairment of memory for recent events, alterations of character in the sense of miserliness, of moodiness and apprehensiveness. These are evidently chronic changes attributable to arteriosclerosis or a premature senility.

Sometimes the symptoms strongly arouse the suspicion of general progressive paralysis of the insane. Laudenheimer has described a syndrome which he calls diabetic pseudo-paralysis, showing a characteristic initial stage of manic feeling tone, financial overestimation, dissolute mode of life, followed by a mixture of euphoric dementia, attended by disturbances of the pupils and of speech and by faciolingual paresis. Antidiabetic treatment led to improvement but not to a cure.

Redlich has also reported a case. It is nevertheless open to some doubt whether the cases were not actual cases of general progressive paresis, in spite of the improvement under antidiabetic treatment. In view of the frequent causal relation between lues and diabetes the Wassermann reaction would not be of much differential diagnostic value.

Uric Acid Diathesis.—A causal relationship with gouty manifestations is claimed for certain depressions by some authors who were struck by observing symptoms of depression often attending attacks of gout (Ebstein, Lange). This question needs further investigation. Probably where states of depression and the uric acid diathesis coexist, an endogenous factor will be found to be the cause for both diseases.

Exophthalmic Goiter.—In interpreting the psychoses associated with Basedow's disease, again the question of whether the disease is due to the psychosis or caused by it, or whether they are simply coincident or due to a common cause, needs ventilation. Kocher states that sanguinics are more predisposed to become affected with hyperthyroidism, explaining this by an *ab ovo* stronger activity of the thyroid gland. But as we often find a manic-depressive trend in sanguinics, an endogenous predisposition for both might be the common cause, or else, as Schroeder assumes, the manic-depressive trend may be the primary factor causing the Basedow. Schroeder indeed observed that rather frequently Basedow symptoms only develop in the course of psychoses, having noted particularly in manic-depressive cases that the Basedow developed during the psychotic attack and disappeared again after its termination.

There are also many *catatonias*, with widening of the palpebral fissures, accelerated pulse, fine tremor, sweating, and trophic disturbances, that can give cause for assuming a Basedow.

The relatively frequent combination of Basedow's disease and hysteria is probably best explained by assuming a common neuropathic soil for the two. On the other hand, if, as seems to be well established now, Basedow's disease is the result of disturbed thyroid function, its tendency to produce mental symptoms becomes very plausible, and the pressure of exophthalmic goiter for several years before the development of psychotic symptoms would not militate against considering the latter as due to the former.

The usual mental symptoms of Graves' disease resemble greatly those observed in subacute and chronic intoxications. Poor sleep, nocturnal and general apprehensiveness, restless dreams, palpitation, hyperesthesia of sight and hearing, lack of emotional control and usually a feeling of physical weakness and of lessened capacity for mental work and for concentration are found. A peculiar haste and restlessness distinguish the Basedowian from the neurasthenic.

A euphoria much like the one in general paretics may occur and may associate itself with other physical signs suggestive of general paresis, such as scanning speech, paralytic attacks, leaving temporary focal symptoms in their wake, etc. Psychically one notes deliria when the sensorium is much clouded and systematized delusions, on the pattern of Wernicke's hallucinosis when there is greater lucidity; exaggerated greediness for food, and neglect of appearance similar to that of paretics, are sometimes seen.

Monoplegic and hemiplegic manifestations are mentioned by Möbius, dysphagias by Müller and others. A marked choreatic unrest is pointed out by Bonhoeffer and Dinkler. Experience shows that particularly the more acute cases of Basedow's disease and the grave cases associated with marked emaciation are the ones in which the psychic symptoms become prominent. The psychic disturbances noted after thyroid operations on Basedowians have nothing specific unless it be their great acuteness. Also the element of motor excitement, incident on the hyperthyroidism and coupled with distractibility and eroticism deserve some mention.

Tetany.—Psychic disturbances are rarely seen in this disease. Frankl-Hochwart and Kraepelin observed states of anxious excitation, with false sense perceptions and disorientation. Bonhoeffer found in one case of tetany a state of about two months' duration, characterized by somnolence, grouchiness, greatly retarded reaction, great desire for sleep, extreme motor unrest with movements varying between choreatic unrest and jactatian, the whole picture suggestive of acute myxedema. In another case of tetania strumipriva, with subsequent implantation of epithelial bodies (parathyroids), Bonhoeffer found a state of restlessness, apprehension, and disorientation, followed by alternate phases of somnolence and of delirious manifestations of an anxiety type. Poor registration of perceptions, misidentification of persons, hazy recollection of the recent past, masked by confabulations, were noted, also a dull euphoria, with "Witzelsucht" (tendency to make jokes and puns). Improvement set in after four days, leading gradually to recovery.

Myxedema.—The mental retardation characterizing this state is found also in the psychoses accompanying it. Acute psychoses on the basis of a myxedematous mentality are not rare in countries where myxedema is relatively frequent. Aside from the mental retardation mentioned, they have nothing characteristic. Of interest is the fact that one observes also chronic psychoses, attended with false sense perceptions and delusions of interference and receding under thyroid treatment. Pilcz found all sorts of forms of mental disturbance, manic and melancholic states, delusions of persecution and grandeur, hallucinations, confusion, to occur in connection with myxedema, but he, nevertheless, with Bonhoeffer, points out one special feature, namely, the lack of emotion.

Bonhoeffer sums up the characteristics of thyrogenous acute psychotic states as follows: In all there are hallucinatory delirious and clinical pictures. In Basedow's disease excitation and a mild manic feeling tone predominate. The myxedematous mental retardation is imprinted also on the acute myxedematous psychoses, even if motor excitement coexists. Tetany appears not to predispose much to mental disease. If mental disturbances occur, the clinical picture with its predominately stuporous symptoms and the retardation of the mental processes comes nearest the myxedematous pictures.

Gastrointestinal Diseases.—The gastric symptoms and intestinal sluggishness, the menstrual disturbances and the cardiac neurotic symptoms seen in states of mental depression are to all appearance coordinated with the depression and not the cause of the latter. On the contrary, the frequency of the gastrointestinal disturbances even suggests their dependence from the depression, in part at least, a view greatly supported by Pavlov's and Cannon's experimental observations that depressive affects inhibit the gastric and intestinal functions.

Nevertheless the existence of gastrointestinal autotoxic psychoses cannot be denied off hand and in that respect, among others, psychotic states of the amentia-type claimed by v. Sölder, v. Wagner and others, to be a result of long-continued constipation, are worth mentioning.

The acute infectious cases of enteritis may be attended by the various psychoses described under the heading of the infectious diseases, particularly frequently the Korsakow states.

Regarding *diseases of the liver and the gall-ducts*, the fact deserves registering that in children with icterus cataleptic symptoms with diminution of spontaneousness, apathy and mild clouding of consciousness have been noted. Dream-like, hallucinatory twilight states may occur with icterus.

Icterus gravis is always attended by grave cerebral and mental symptoms; progressive obnubilation, or grave delirious states, epileptic excitations and dementia-like pictures, with subsequent sopor, and coma, may result (Emminghaus).

After operations on the gall-ducts psychoses of short duration have been observed according to Urbach. They were delirious states with disorientation, motor unrest, and emotional lability.

Addison's Disease.—The mental disturbances of Addison's disease are not of one order and not pathognomonic. A certain importance must be attributed to the symptom of asthenia often present from the very beginning. The ordinary day's work and later quite slight tasks fatigue them physically to the utmost. Some doubt exists whether this is an actually psychic symptom. Irritability, emotional weakness, somnolence and insomnia, depressions and apprehensive states of long duration have been described. In one case of Bonhoeffer's, anxiety of the character of a phobia (shaded the windows, wore dense veils, went out evenings only) developed on the basis of an Addison's disease, proved so by autopsy; but Bonhoeffer interpreted it as a psychopathic reaction of a neuropath.

Diagnosis, Prognosis, and Treatment.—The diagnosis and prognosis have, if not fully, already been discussed under the respective headings, that is, with the general or organic diseases underlying them. For supplementary information in these fields the reader is referred to other psychiatric articles treating the subject, and to articles on the diseases mentioned. This has also reference to the treatment, to which the remarks made under the heading of the treatment of the psychoses attending infectious diseases also apply, that is, the treatment has to be governed by the principles underlying the treatment of these physical diseases connected with them and by the general principles applied in the treatment of the psychoses at large, special information to be found in the articles on such psychoses and on the physical diseases that have been discussed here.

B. Onuf (Onufrowicz).

Pterygium.—See *Conjunctiva, Diseases of.*

Ptomaines are basic, nitrogenous compounds formed from protein by the action of bacteria. On account of their basic nature they may also be regarded as putrefactive alkaloids. At one time it was thought that disease was caused by bacteria through the production of these ptomaines. It was soon demonstrated, however, that the ptomaines possible of isolation from cultures of pathogenic bacteria could not be held responsible for the toxic effects produced by injection into animals of the original culture. Not only were the ptomaines thus isolated far less poisonous than the culture itself, but they did not produce the symptoms and anatomical alterations characteristic of the diseases that the pathogenic organism caused. As a rule, the ptomaines are not very toxic and, on the other hand, very poisonous ptomaines may be formed by non-pathogenic bacteria. Twenty-five years ago many laboratories were engaged in the study of ptomaines which promised to clear up the chemistry of bacterial poisoning. To-day very little work of this character is being carried on owing to the clearer conception gained of the real significance of ptomaines. Interest in ptomaines has not been entirely dropped, however, for at times poisonous ptomaines enter the body and produce serious symptoms which many times culminate in death. As a rule, they are present in food in which they have been produced by bacterial decomposition, although at times these bodies may be formed by putrefaction in the gastrointestinal tract. In the decomposing tissues in gangrene ptomaines may also be produced. Poisoning by food is not uncommon, but it is not always caused by the presence of ptomaines. The most likely source of ptomaine poisoning is from imperfectly preserved canned meats, sausages, decomposing fish, cheese, ice-cream, and milk.

The basic character of the ptomaines is due to nitrogen-containing radicals, principally amino groups. Although most ptomaines are formed from protein upon which bacteria grow it is probable that the decomposition of the bacteria themselves may furnish a portion of the ptomaines produced. Some of the ptomaines contain oxygen but most of them are either poor in oxygen or else oxygen is absent. As distinct from toxins the ptomaines are not specific for the nature of ptomaines formed depends not only upon the character of the bacteria leading to their formation but equally upon the culture medium of the bacteria, the temperature, the duration of the process, and the quantity of oxygen furnished. Under different conditions the same organism may produce totally different types of ptomaines, whereas with the pathogenic bacteria, as for example, the diphtheria bacillus, the toxin produced has quantitatively the same properties no matter upon what medium the organism may be grown. Unlike the toxins, an immune serum capable of antagonizing their action cannot be obtained with ptomaines by their injection into animals.

"It is more than probable that most, if not all, ptomaines result from the cleavage action of bacteria on the constituents of the medium in which they grow, and it follows from this that the kind of ptomaine found in a given case will depend upon the stage of the bacterial disintegration of the constituents of the medium. Regarded as the results of cleavage action, ptomaines are transition products in the processes of bacterial decomposition. They are temporary forms through which matter passes while it is being changed, by the activity of bacterial life, from the organic to the inorganic state. Complex organic substances, as muscle and brain, are broken up into less complex molecules, and thus the process of chemical division goes on until the simple and well-known final products, carbonic acid gas, ammonia, and water, result; but the variety of combinations into which an individual atom of carbon may enter during this long series of changes is almost unlimited, and with each change in combination there is more or less alteration in nature. In one compound the atom of carbon may exist as a constituent of a highly poisonous substance, while the next combination into which it enters may be wholly inert."

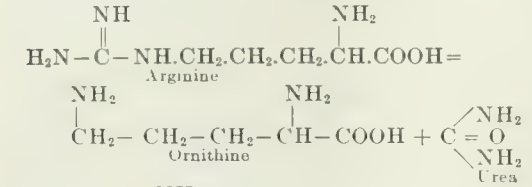
The ptomaines in general partake of the chemical nature of amines or substituted ammonias. Some of the simpler forms are as follows:

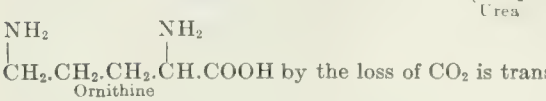
Methylamine $CH_3.NH_2$
Dimethylamine, $CH_3.NH.CH_3$
Trimethylamine, $CH_3.N.CH_3$

CH_3

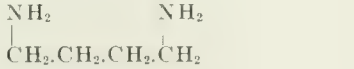
These compounds, products of the decomposition of putrefying flesh, possess very slight toxic properties and therefore undoubtedly are of little importance in ptomaine poisoning. Compounds similar in structure to the above amines but containing ethyl, butyl, propyl, etc., groups in place of the methyl group may also be present.

Of more significance pathologically are the diamines, cadaverine, and putrescine. They are of particular significance because they may be formed in the intestinal tract, and are sometimes present in the urine in cystinuria. They are but slightly poisonous, although they may cause necrosis when injected subcutaneously. At times the stools in cholera contain these diamines. Their mode of formation is as follows, the process involved being putrefaction. In the protein molecule a group designated as the arginine molecule occurs. By means of the ordinary digestive ferments arginine is formed from protein. Under the influence of putrefactive organisms arginine gives rise to ornithine from which in turn putrescine is formed, thus:

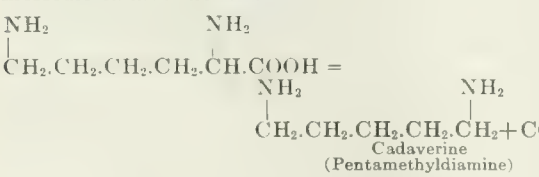




formed to putrescine, tetramethylenediamine:



From lysine also a constituent part of the protein molecule cadaverine is formed.



Ethylidenediamine, $CH_3.CH\langle^{NH_2}_{NH_2}$, has been detected in the gastrointestinal contents and is a base possessing a slight degree of toxicity.

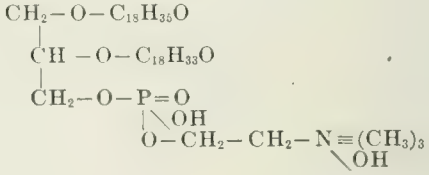
More recently several compounds have been isolated from putrefaction mixtures and from the intestinal contents which in the future may be found to possess considerable importance in their relation to pathological processes in the body. A derivative of tyrosine, p. oxyphenylethylamine has been isolated from putrefying placentas. Also isoamylamine may be obtained from a similar source. The formation of these compounds as a result of putrefaction has led to the suggestion that they are normally present in the large intestine and may be absorbed from it. The compound p. oxyphenylethylamine is of particular importance for two reasons—in the first place because of its physiological action, and in the second place because of its close structural resemblance to epinephrine. Like epinephrine it has a marked influence upon the true sympathetic system. It is also of interest to note that p. oxyphenylethylamine is one of the substances which give to ergot its characteristic action on the uterus.

By the putrefaction of histidine, an amino acid formed from protein by digestion, may be formed beta-iminazolylethylamine, a base which in some respects resembles p. oxyphenylethylamine in physiological activity. In addition to the reactions possessed in common with p. oxyphenylethylamine, beta-iminazolylethylamine is capable of calling forth symptoms practically identical with those induced by injections of peptone solutions, or by serum or other protein in the sensitized guinea-pig, that is, producing anaphylactic shock. The base has also a mild, direct stimulant effect on the activity of the salivary glands and the pancreas. This secretory action, being paralyzed by atropine, may be regarded as a weak action of the pilocarpin type; the association has some interest in that pilocarpin also contains an iminazole group. Beta-iminazolylethylamine more recently has been found in the intestinal contents.

The choline group of ptomaines may also be regarded as substituted ammonias and they are of significance because of the toxicity of some of them. Their chemical structures and relationships are as follows:

Choline, $CH_2OH-CH_2-N(CH_3)_3-OH$
Neurine, $CH_2=CH-N(CH_3)_3-OH$
Muscarine, $CH(OH)_2-CH_2-N(CH_3)_3-OH$
Betaine, $COOH-CH_2-N(CH_3)_3-OH$

Choline is of importance because indirectly it is a primary cell constituent forming the nitrogenous portion of the lecithin molecule. There are numerous lecithins but the general structure may be seen from a typical example, stearyloleyl lecithin.



Putrefaction of lecithins splits off choline, as does autolysis of brain tissue and its presence therefore in tissues under pathological conditions is easily understood. Choline is somewhat toxic producing marked fall of blood pressure when injected into the blood stream and in this respect has a well-marked antagonism to adrenalin. Choline may be transformed into neurine, a base highly poisonous, and this fact causes choline to become a possible source of marked intoxication. It is conceivable that in the changes which choline undergoes in the alimentary canal neurine is produced giving rise to symptoms which may be ascribed to poisoning from food. During muscular fatigue choline and neurine may arise as a direct result of the increased cellular activity, and it has been suggested that the presence of these compounds may be responsible, in part at least, for some of the symptoms characteristic for fatigue. Muscarine, the mushroom poison, is markedly toxic and a body apparently identical with it has been isolated from a mixture of putrefying flesh. Betaine is a constituent of many plant tissues, and is found in the tissues of some of the lower animals. It is practically non-poisonous.

Muscarine and neurine are more poisonous than choline and their mode of action is quite similar. The injection subcutaneously in man of one to three milligrams of muscarine causes salivation, rapid pulse, reddening of the face, weakness, depression, profuse sweating, vomiting, and diarrhea. Neurine exerts a similar

influence. In fatal cases respiration ceases before the heart stops. Both poisons may be counteracted by atropine and in their stimulation of secretion resemble physostigmine.

Some of the less well-known ptomaines are mytilotoxine, the specific poison of the toxic mussel which is formed in the animal during life; typhotoxine, a ptomaine isolated from cultures of typhoid bacillus producing a paralytic condition when injected into animals; tyrotoxicon, isolated from poisonous cheese, ice cream, and milk; peptotoxine a poisonous base found in some preparations of peptones.

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Ptyalin.—See *Saliva.*

Puberty is a term used to designate the initiatory and formative period of sexual development. The term adolescence is a broader term which covers the entire period of sexual development including puberty and extending from thirteen to twenty-three in females and from fourteen to twenty-five in males. The period of puberty is sometimes called the period of early adolescence.

Age.—The average age of puberty in the male is 14.3 years and in the female it dates from the first menstruation, the average age of which function is 13.7 years, although it may be established as early as ten years or as late as eighteen years and still be normal in its manifestations.

Race and climate may hasten or retard the advent of puberty. Reading erotic literature, listening to unclean suggestion, or even a too early participation in social life are hastening influences upon puberty, while it may be retarded not only by cold climate and phlegmatic race but by an anemic condition.

The *pubescent period* begins a year or even a year and a half before the first appearance of the menses.

Physical Changes.—A general physical disturbance takes place at puberty as shown by the rapid growth in height; the elongation of the vocal cords; the increased pilosity; the development and growth of the reproductive organs, and a profound disturbance of the nervous system. The bones are then most plastic while muscles, glands, blood-vessels, and indeed all organs share in the general disturbance.

Dr. G. Stanley Hall says (Adolescence, vol. i., p. 240): "many special cases seem to show that loss of weight or arrest of growth at the age when it should be most rapid is a danger signal of peculiar value because it precedes all others."

Psychic Changes.—The mental changes are no less marked than the physical. Ancestral traits appear. The child may be erratic, difficult to understand, and difficult to approach. His mental attitude toward others is changed because he now feels his relation to society. Altruism dawns, egoism wanes.

Periodic Phenomena.—The most notable accompaniment of puberty in the female is *menstruation* (*which see*). In the male there is, beginning with puberty and lasting throughout the sexual life, a periodicity analogous to that of the female. The seminal vesicles possess glandular walls and retain the secretions of these walls for varying periods of from one to four weeks normally. The retained secretion distends the walls, and through pressure stimulates nerves which pass to the erection center, which is in turn excited. By day erotic emotions are easily aroused; at night when the subject sleeps he may experience an erection accompanied by an erotic dream culminating in a "nocturnal emission." In this way the pressure of accumulating vesicular secretion is relieved. The subject should then pass another period free from sexual impulses. The nocturnal emission coming without sexual excitement causes no loss of spermatozoa and hence no depletion.

After the establishment of pubescence the male testes form spermatozoa rapidly under sexual excitement and slowly at other times. In neither case do the spermatozoa pass into the seminal vesicles; they are retained in the testes, the vasa differentia and ampullæ. The testes form not only the spermatozoa but also a milky fluid in which they float.

The secretion of the testes contains a mysterious principle whose reabsorption gives to the male those characteristics which we recognize as distinctive of virility, while the ovarian secretion of the female produces the peculiarly feminine qualities.

Pathology of Puberty.—During pubescence the trunk is relatively the shortest, the thorax relatively the narrowest, and the heart relatively the smallest while at the same time the child is growing most rapidly (the male makes the most rapid growth from fourteen to seventeen—the female from twelve to fourteen. It thus happens that the heart often seems inadequate to the need. Children with such heart weakness should be guarded against violent exercise, shielded from fright or worry but be given an abundance of pure air.

The nervous disturbance mentioned above may cause an irritability of temperament, unreasonable fits of laughing or crying, or sometimes St. Vitus dance.

Hertel (quoted by G. Stanley Hall, Adolescence, vol. i., p. 243) found that forty per cent. of the children whom he observed at the age of puberty were "sickly." The diseases most common after puberty were anemia, nervousness, headache, and eye diseases, a condition which ought not to be. The diseases most prevalent during puberty are chlorosis, anemia, goiter, hysteria, epilepsy, and a peculiar form of chorea. Digestive disturbances at this time are sometimes responsible for morbid conditions which appear later. School work should be lightened from thirteen to fifteen. Nine hours of sleep should be demanded and a hearty appetite secured. JEANETTE W. HALL.

Public Health Service.—The United States Public Health Service is a Bureau of the Treasury Department, presided over by the Surgeon General of the Public Health Service. This Service, together with several others, is under the charge of an Assistant Secretary of the Treasury, who in turn is responsible to the Secretary of the Treasury for its general conduct.

HISTORY.—At the first session of the First Congress of the United States, on July 20, 1789, a committee was appointed in the House of Representatives for the purpose of drawing up and introducing a bill to provide for the establishment of hospitals for sick and disabled seamen. This measure failed to be reported by the committee, and the matter came up again in the Second Congress, January 21, 1793, and in the Third Congress on December 13, 1793. It did not, however, make any progress on account of the opposition of the representatives from Massachusetts and some of the other States. On February 28, 1798, Mr. Robert Livingston, a representative from New York, reported a bill from the Committee on Commerce and Manufacturers for the relief of sick and disabled seamen. After much argument and debate the bill passed the House of Representatives on April 9, 1798. It reached the Senate on April 13, 1798, and passed that body on July 14, 1798. President John Adams signed the bill, thus making it law, on July 16, 1798. This act was amended by the acts of March 2, 1799; May 5, 1802; February 26, 1811; July 20, 1846; April 29, 1864; June 29, 1870; February 10, 1871; June 2, 1872; and March 3, 1875. The act of July

16, 1798, was, in brief, a form of sickness insurance for sailors. It provided a tax of twenty cents per month on seamen employed on American vessels engaged in foreign and coast trade, and out of the fund thus created the President was authorized to provide for the temporary relief and maintenance of sick and disabled seamen in hospitals. He was also authorized to appoint directors of marine hospitals at the various ports. In this way a number of famous American physicians became officers of the Marine Hospital Service, as it was then known. Among these were Benjamin Waterhouse, who introduced vaccination into the United States, and Daniel Brainard, who was the founder of Rush Medical College. Previous to this time, in 1788, the State of Virginia had built a marine hospital at Norfolk, but in 1790 the State legislature authorized its transfer to the Federal government. Massachusetts erected a marine hospital at Vineyard Haven in 1798; this continued in operation until 1826. By 1802, federal marine hospitals had been established at Norfolk, Boston, Newport, R. I., and Charleston, S. C., the first to be erected being at Washington Point, Norfolk, Virginia, in 1800. During the years which followed, relief stations of various sorts were established at various ports in the United States. These not only included the seaports, but the ports on the Great Lakes as well, and during the great expansion of river traffic marine hospitals were built and put in operation at various places on the Mississippi and its tributary rivers. At this time the benefits were also extended to those employed on rafts and canal boats, but by a later enactment of Congress the latter were exempted from the payment of duties and consequently became ineligible for hospital and out-patient relief. In 1799 the benefits of marine hospitals were extended to officers and men of the United States Navy, but in 1811 the medical corps of the Navy was formed, and since that date that institution has cared for its sick and disabled personnel. In many ports the care of the Naval personnel in marine hospitals continued until 1821 and many seamen and marines from the U. S. frigates "Constitutional," "President," "Chesapeake," "Congress," and "United States," and the brigs "Syren" and "The Hornet" were thus treated.

The amount of money collected by the hospital tax, twenty cents per month from each sailor, was found to be insufficient and from 1840 to 1872 Congress made a deficiency appropriation for each year, excepting 1846 and 1854, ranging from $12,000 to $275,000. From the breaking out to the close of the Civil War, the hospitals were very largely turned into military hospitals. During the reorganization period which followed it became evident that the laws under which the Service was operating were inadequate to meet the demands made upon it. After several legislative attempts, an act to reorganize the Marine Hospital Service and to provide for the relief of sick and disabled seamen passed Congress and was approved by President Grant on June 29, 1870. By 1871 the reorganization of the Service was completed. This was effected by the first Surgeon General, John M. Woodworth, an officer who had served with great distinction during the Civil War. Up to this time officers could not be moved from station to station and while the Service exercised a national influence it was in reality a loosely correlated chain of local hospitals under the direction of the general government. This was entirely changed by the act of 1870. Surgeon General Woodworth continued as the head of the Marine Hospital Service, then a relatively small corps, until his death, on April 3, 1879. He was succeeded by Surgeon General John B. Hamilton, who continued the work of enlarging and expanding the activities of the Service until May 27, 1891, when he was succeeded by Surgeon General Walter Wyman. Surgeon General Walter Wyman died on November 21, 1911, and was followed by Surgeon General Rupert Blue on January 13, 1912.

By reason of its close affiliation with shipping, the Service came constantly in contact with epidemic diseases from abroad. As a result, whenever there were widespread epidemics it was called upon for advice and assistance in their extermination, and when the Federal government began the assumption of quarantine this function was naturally imposed upon the Marine Hospital Service. This occurred during the term of office of Surgeon General Hamilton, and was very widely extended by Surgeon General Wyman. By the act of 1889 the officers of the Service were placed on a commission basis. The Service continued under the name of the Marine Hospital Service until July 1, 1902, when President Roosevelt signed an act to increase the efficiency and change the name of the United States Marine Hospital Service to that of the United States Public Health and Marine Hospital Service. In the 104 years which had elapsed since its foundation, many new duties had been imposed on the Marine Hospital Service. It had built up an efficient series of hospitals and relief stations throughout the United States; it had established the Federal quarantine system; it had conducted epidemic campaigns against yellow fever, cholera, and smallpox; it had taken over the medical examination of arriving aliens; it had established a system of public health reports covering the entire globe; it had founded a hygienic laboratory, and had organized itself into a mobile, commissioned, sanitary corps. At the time of the passage of the act of July 1, 1902, it was intended that the Service should be called the United States Public Health Service, but public sentiment at that time had not arrived at the point of creating an organization whose chief function was the protection of the national health. On the same date an act was passed regulating the sale of viruses, serums, toxins, and analogous products in the District of Columbia, and to regulate the interstate traffic in such articles. The enforcement of this act has brought about the licensing of the manufacturers of the various bacteriological products which are used in the treatment of disease, the establishment of standards of potency for diphtheria and tetanus antitoxins, and has acted as a public health measure of far-reaching importance.

In 1832 the Secretary of the Treasury was authorized by Congress to employ, if it should be necessary, additional revenue boats and revenue officers, to aid in the execution of quarantine and health laws of any State and the regulations made pursuant thereto. In 1866, during its first session, the Thirty-ninth Congress by a joint resolution authorized the Secretary of the Treasury to make and carry into effect such orders and regulations of quarantine as in his opinion might be deemed necessary and proper in aid of State or municipal authorities, to guard against the introduction of cholera into the ports of the United States. Officers of the Marine Hospital Service were utilized in carrying out the purposes of these acts. The creation of the National Board of Health, on March 3, 1879, transferred a portion of the function of quarantine to that body, but by the act of August 1, 1888, the function and administration of quarantine was revested in the Marine Hospital Service. In the meantime, on August 7, 1882, there had been created a fund which has since come to bear a very important relation to the sanitary defenses of the United States. It is called the fund for the prevention of the introduction and spread of contagious diseases. As originally enacted, the President of the United States was authorized in case of actual or threatened epidemic to use a sum not exceeding $100,000 for aid of State and local boards of health, or otherwise, at his discretion, in preventing and suppressing the spread of epidemics. This act was re-enacted on March 3, 1883, and by the act

approved July 7, 1884, it was provided that the President might also expend the money in maintaining quarantine at points of danger. The act approved March 3, 1885, reappropriated the unexpended balance and added $300,000 to the fund. The expenditure of this sum, however, was authorized only in the case of threatened or actual epidemic of cholera or yellow fever. In 1891, smallpox was added to the list, as was also plague the following year. In 1902, typhus fever was included in the list and in 1912, trachoma. The President is authorized to expend this money in aid of State and local boards, or otherwise, at his discretion, in such emergencies, in the execution of any quarantine laws which may be in force. The expenditure of this fund is under the direction of the Surgeon General of the Public Health Service.

The act of April 29, 1878, which followed close upon the outbreak of yellow fever which at that time completely paralyzed the external commerce and internal administration of the entire South, provided for consular bills of health and for reports by the consular officers to the Surgeon General of the sanitary condition of the ports at which they were stationed. By this same act, the Surgeon General was charged, under the direction of the Secretary of the Treasury, with the execution of the provisions of the quarantine law and the promulgation of rules and regulations necessary for the conduct of quarantine. It was expressly provided in this law that such rules and regulations should not be in conflict with or impair any sanitary or quarantine laws of any State or municipality. Congress provided the Surgeon General with appropriation for the publication of bulletins of health by the act of March 3, 1879.

It will be seen from the foregoing that the health functions of the Public Health Service were the result of a gradual accretion of legislative acts. The first session of the Fifty-first Congress, in an act approved March 27, 1890, brought about a new phase in our public health policy. Up to that time, aside from the work of eradicating epidemic outbreaks within the States, the National health authorities had very largely concerned themselves with questions of maritime quarantine, leaving out of consideration the matter of the prevention of the introduction of contagious diseases from one State or Territory into another, or from any State or Territory into the District of Columbia, or from the District of Columbia into any State or Territory. The act referred to provided that when it was made to appear to the satisfaction of the President that cholera, yellow fever, smallpox, and plague, existed in a State or Territory or the District of Columbia, and that there was danger of their spread into other States, Territories, or the District of Columbia, he was authorized to cause the Secretary of the Treasury to promulgate such rules and regulations as would control and prevent such spread. The President was further empowered to employ such assistants as might be necessary for this purpose. The preparation of these regulations was made the duty of the Surgeon General of the Marine Hospital Service, under the direction of the Secretary of the Treasury. Penalties were provided for the infraction of such rules and regulations and the law specifically included in its penalty clause common carriers and their servants. This was the beginning of the policy for the control of disease in interstate traffic and was extended in 1893 to include other diseases than the major pestilences. This act was entitled "an act granting additional quarantine powers and imposing additional duties on the Marine Hospital Service." It includes not only the measures to be taken at ports of arrival and departure to prevent the introduction of disease into the United States, but also provides for the enforcement of quarantine between the States. It provides for the cooperation of the Service with State and municipal boards of health in the execution and enforcement of the rules and regulations of such boards and in the execution and enforcement of the rules and regulations made by the Secretary of the Treasury to prevent the introduction of contagious or infectious diseases into the United States from foreign countries, and into one State or Territory or the District of Columbia from another State or Territory or the District of Columbia. This is an act of very great importance and its careful study is commended to anyone interested in the furtherance of the National protection of the public health. It gave to the Surgeon General additional authority to collect morbidity and mortality statistics in the United States and foreign countries, and for the publication of data so collected in the public health reports. It also provides for the voluntary cession by a State of its quarantine establishments to the Federal government.

The act of July 1, 1902, previously referred to, did more than merely change the name of the Service. It fixed the salaries of the officers, authorized the President to utilize the Service in times of threatened or actual war in such manner as would promote the public interest, provided for an advisory board of the Hygienic Laboratory, and established the divisions of chemistry, zoology, and pharmacology in the above-mentioned laboratory. It also provided for annual conferences, to be called by the Surgeon General, between the Federal Public Health Service and the State and Territorial health authorities. The Surgeon General was further authorized to collect morbidity, mortality, and vital statistics.

In 1895 an appropriation was made by Congress for the experimental investigation of the treatment and prevention of smallpox. In 1899 another appropriation was made to investigate the origin and prevalence of leprosy in the United States. In 1900 the quarantine function of the United States was extended to Porto Rico and Hawaii. In 1905, Congress created the Yellow Fever Institute, which has been the means of disseminating much knowledge of a public health nature. On March 3, 1905, Congress provided for the investigation of leprosy, with special regard to the care and treatment of the disease in Hawaii. This brought about the establishment of the Leprosy Investigation Station. In 1906, a law was enacted which resulted in the cession to the United States of practically all of the southern quarantines. On March 4, 1911, Congress provided for the admission into marine hospitals, for study, persons with infectious or other diseases affecting the public health. This made of the marine hospitals public health hospitals. On August 13, 1912, the Sixty-second Congress passed an act entitled, "An act to change the name of the Public Health and Marine Hospital Service to the Public Health Service and increase the pay of officers of said Service and for other purposes." This law provides that the Public Health Service may study and investigate the diseases of man and conditions influencing the propagation and spread thereof, including sanitation and sewage, and the pollution, either directly or indirectly, of the navigable streams and lakes of the United States, and for the issuance of information from time to time in the form of publications for the use of the public.

Organization.—The Public Health Service consists of commissioned officers, as follows: The Surgeon General, six assistant surgeon generals, ten senior surgeons, surgeons, passed assistant surgeons, and assistant surgeons. It also includes chiefs of divisions of the Hygienic Laboratory, quarantine inspectors, acting assistant surgeons, internes, pharmacists clerks, pilots, marine engineers, female nurses, and attendants. At the present time there are 195 commissioned officers, and a total personnel of some 1,600 people.

The Service is organized into six divisions,

Scientific Research.

Domestic Quarantine.

Marine Hospitals and Relief.
Foreign and Insular Quarantine.
Sanitary Reports and Statistics.
Personnel and Accounts.

Each of these has its separate functions, but each is closely integrated with the other divisions. In addition to the chiefs of these divisions, who are assistant surgeon generals, the Surgeon General has as his advisors the Annual Conference of State and Territorial Boards of Health and the Scientific Advisory Board of the Hygienic Laboratory. The latter consists of eight scientists eminent in laboratory work in its relation to public health and detailed from other departments of the Government and from endowed institutions. The board may be called into conference with the Surgeon General at any time, the meetings not to exceed ten days in any one fiscal year.

Division of Scientific Research.—Through the Division of Scientific Research and Sanitation are conducted the scientific investigations of the Service and the operations of the Hygienic Laboratory at Washington, established for the investigation of contagious or infectious diseases and matters related to the public health. Among the diseases of man which have been investigated in the several laboratories and in the field operations under the direction of this division are beriberi, diphtheria, endemic goiter, hookworm, leprosy, typhoid fever, malaria, pellagra, tuberculosis, typhus fever, yellow fever, plague, certain occupational diseases, and many other conditions affecting the public health. Studies of sanitary conditions have also been made as well as systematic investigations of rural sanitation, school hygiene, industrial hygiene, health organization and administration, the pollution of river and coastal waters, the pollution of shellfish beds, the disposal of sewage, the treatment of industrial wastes, etc. Special investigations of pellagra have been made through this Division since the discovery of the disease in the United States in 1907. In this work commissioned officers, biochemists, dieticians, and psychiatrists have been utilized, and as a result of these studies the disease has been proven to be of dietary origin. Many other problems have been studied by the Division of Scientific Research, including the distribution of trachoma in the Appalachian region and in Porto Rico, and the migration of tuberculous persons. Laboratory and clinical studies of tuberculosis, particularly with regard to its relation to industries, have also been made. Among the other industrial studies may be mentioned the sanitary survey of Indiana industries employing women labor, trachoma among steel millworkers, mine sanitation studies, and cooperative research with the Industrial Relations Commission. School hygiene and the physical and mental status of school children have also been the subject of intensive studies. The work of this division is carried on not only by commissioned officers of the Service but by other scientific workers, including epidemiologists, sanitary engineers, bacteriologists, chemists, and experts in other lines. From this division are issued the bulletins of the Hygienic Laboratory and the Public Health Bulletins.

The personnel of the Hygienic Laboratory consists of the Director, Assistant Director, a professor of zoology, of pharmacology, of chemistry, twenty medical officers, pharmacists, sanitary chemists, sanitary engineers, and sanitary bacteriologists, technical assistants, artists, and attendants. Notable achievements of the Hygienic Laboratory are the discovery of the transmission of typhus by head lice, the identity of the disease with Brill's disease, the reproduction of measles in monkeys, and the studies upon anaphylaxis. A course of instruction is given each year to student officers. The curriculum includes laboratory work in pathology, bacteriology, zoology, pharmacology, and chemistry, in addition to didactic lectures on subjects particularly concerned with Service organization and work. The library of the Hygienic Laboratory consists of some 3,500 volumes and over 2,000 reprints. A branch of the laboratory is maintained at Ellis Island, the most important immigration station of the United States, for the purpose of making studies in which clinical subjects and material are needed. In the administration of the act of July 1, 1902, regulating the sale of viruses, serums, toxins, and analogous products, the Hygienic Laboratory inspects the various manufacturing plants and makes recommendations to the Sanitary Board of the Public Health Service with regard to the issuance and renewal of licenses. The laboratory prepares and distributes to State boards of health antirabic virus, and in addition makes special studies of the disease itself. In the Division of Pathology and Bacteriology the various diseases of man are investigated. The Division of Zoology cooperates with the International Commission of Zoological Nomenclature and prepares the Index Catalog of Medical and Veterinary Zoology. In the Division of Pharmacology the standardization of drugs, the digest of comments on the Pharmacopœia of the United States and on the National Formulary, the digest of laws relating to the possession, manufacture, sale and use of poisons and habit-forming drugs, and similar subjects, receive attention. The Division of Chemistry studies a great variety of subjects, including laboratory investigations, and analyses, industrial waste investigations, sewage disposal investigations, and various other activities of a public health nature.

The Division of Scientific Research also maintains the Leprosy Investigation Station in Hawaii, where laboratory and clinical studies of the disease are made. The Division is directly responsible to the Surgeon General for the conduct of the Annual Conference of State and Territorial Health Authorities with the Public Health Service. A great variety of subjects are discussed at these conferences, including morbidity reports, school hygiene, rural sanitation, education in public health matters, industrial camp sanitation, railway sanitation, and quarantine procedure, both in its relation to maritime and interstate quarantine. This Division also carries on the correspondence relative to meetings of scientific and sanitary associations and congresses, including the International Sanitary Conference of the American Republics and the International Office of Public Hygiene.

Division of Domestic Quarantine.—The Division of Domestic (Interstate) Quarantine is charged with the carrying out of section 3 of the act of February 15, 1893, and the other quarantine acts looking to the prevention of the interstate spread of disease. Under the authority of this act, the Secretary of the Treasury issues what are known as Interstate Quarantine Regulations. These cover a variety of subjects relating to the sanitary condition of interstate vehicles, including cleaning and ventilation of such vehicles, furnishing adequate toilet facilities, prevention of spitting, and the prohibition of common towels and common drinking cups. The regulations require the furnishing of pure food and drink to interstate passengers, prohibit the transportation of milk from localities where certain diseases exist, require the certification of water and ice, regulate the transportation of persons having certain diseases, such as plague, cholera, typhoid fever, tuberculosis, yellow fever, smallpox, etc., and provide for the reporting of communicable diseases by Interstate Sanitary Officers, State, Territorial, and other health authorities.

The operations for the prevention of the interstate spread of infectious diseases are carried on by this Division. For this purpose the United States has been divided by the Secretary of the Treasury into twelve Interstate Sanitary Districts, each under the charge of a commissioned medical officer. Each district is supplied with adequate laboratory apparatus

for the carrying on of bacteriological and pathological investigations, and to each is assigned a corps of commissioned and non-commissioned officers and a sanitary engineer. The duty of the Interstate Sanitary Officer is to cooperate with the State and local health authorities in his district in the enforcement of the Interstate Quarantine Regulations and to make special investigations to determine whether infractions of the regulations are being committed. In this way very thorough surveys have been made, for example of the waters supplied to passengers on steamships on the Great Lakes, and similarly to determine whether or not potable water was being furnished to passengers on steamships on the great rivers of the United States. In order that there might be a standard by which to judge such waters the Secretary of the Treasury appointed on January 14, 1913, a board of experts, both from within and without the Public Health Service. This board after due deliberation, during which time extensive investigations were carried on, promulgated what is known as the standard of purity for water served by common carriers to passengers in interstate traffic. The application of this standard in the various Interstate Sanitary Districts not only results in insuring to passengers pure water to drink, but also acts indirectly as a measure to bring about the purification of many local water supplies. In addition interstate trains and vessels carrying passengers are inspected to determine whether or not they are maintained in a sanitary condition.

All epidemic operations of the Public Health Service are carried on through the Division of Domestic Quarantine, as for example, the plague suppressive measures in Porto Rico, New Orleans, California, and the State of Washington, and the investigation and eradication of Rocky Mountain spotted fever. In order that the servants of the Government may not spread typhoid fever or smallpox the Secretary of the Treasury has offered to all employees of the general government engaged in interstate travel, or in handling mail or packages destined for interstate traffic, free vaccination against either one of these diseases at such stations of the Service as may be designated by the Surgeon General of the Public Health Service. A large number of employees have availed themselves of this offer. As a means of maintaining the sanitary conditions under which Government employees work, President Taft issued an Executive Order on March 15, 1912, No. 1498, calling upon the Public Health Service to make monthly inspections of all Government buildings used by the executive departments at the seat of government, except the Departments of War and the Navy. These inspections have resulted in many sanitary reforms. In addition this Division has inspected lighthouse vessels and stations and has conducted the sanitary work of the various great expositions in order that they may not serve as starting-points for epidemics among people who have congregated there. Inasmuch as a large part of the work of the prevention of the interstate spread of disease hinges upon the education of the general public, the Division of Interstate Quarantine has charge of the educational propaganda of the Public Health Service. In furtherance of this end a stereopticon loan library has been established at Washington. Sanitarians, State and municipal health officers, educators, social workers, and others may secure the loan of slides from this library upon application to the Surgeon General. Inasmuch as the stereopticon loan library contains some 10,000 slides it is possible to carry on this important educational work very effectively. In addition there is issued very frequently health news to the various newspapers throughout the country. This is prepared in form suitable for publication and is sent to some 8,000 newspapers. In this way sanitary education is carried to many people who could not be reached in any other way.

The Division of Interstate Quarantine also prepares sanitary exhibits for the various expositions, and fairs which are held in different parts of the country. The exhibits consist of models, pictures, charts, and other material, so arranged and labelled as to be easily understood and to convey effectively lessons in personal hygiene and public sanitation. For example, the exhibit which was shown at the Panama-Pacific International Exposition covered 5,252 square feet of floor space and represented an expenditure of $20,000. When exhibits of this kind are made, a commissioned officer is placed in charge, who not only demonstrates the exhibit proper but also gives stereopticon lectures upon various sanitary and hygienic subjects.

Division of Marine Hospitals and Relief.—The Public Health Service operates twenty-three marine hospitals, all of which are owned by the Government, and maintains 120 other relief stations where hospital and dispensary relief is furnished to seamen. During the fiscal year ended June 30, 1914, 53,226 patients were treated at the various marine hospitals and relief stations of the Service. Of this number, 14,469 were treated in hospitals and 38,757 at dispensaries. The following persons are entitled to the benefits and facilities of the hospital and relief stations of the Service: Those employed on board in the care, preservation or navigation of any registered, enrolled, or licensed vessel of the United States, or in the service of those on board engaged in such care, preservation or navigation, officers and crews of the lighthouse establishment, officers and crews of the Coast Guard Service, seamen employed on the Mississippi River Commission, seamen employed on the vessels of the Engineer Corps of the Army, keepers and crews of the United States Life Saving Service, officers and seamen of the Coast and Geodetic Survey, seamen employed on yachts, provided the said yachts are enrolled, licensed, or registered as vessels of the United States, and seamen employed on United States transports or other vessels belonging to the United States Army when not enlisted men of the Army. Seamen from wrecked vessels and seamen employed on merchant vessels of the United States returned to the United States from foreign ports by United States consular officers may also be treated if sick or disabled. Applicants for treatment must present a master's certificate or a discharge from a United States shipping commissioner showing that the applicant for relief has been employed for sixty days in continuous service prior to his application for relief. Owners and accredited commercial agents of vessels may also issue such certificates. Officers and enlisted men of the United States Army and Navy and civilian officers and crews of naval auxiliary vessels may be admitted for care and treatment as patients of the Public Health Service upon the written request of their commanding officers. The cost of such treatment is paid by the Service in which they are employed. Foreign seamen may be also treated upon the application of the consular officer of the nation under whose flag they are sailing or upon the application of the masters of the vessels upon which such seamen served. Bills for such treatment are collected by customs officers from the ship from which the patients came or from the consular officer of their government. In addition to the foregoing, special cases are admitted to the marine hospitals for the purpose of scientific study. Commissioned officers of the Public Health Service are detailed for service on United States Coast Guard vessels, and in this way not only protect the health of the officers and enlisted men of that Service but also afford medical relief to the natives of Alaska, Porto Rico, and Hawaii, and to deep sea fishermen on the Newfoundland Banks. The officers of the Service also make physical examinations for original or renewal licenses as master, mate or pilot, and of applicants desiring to enter or already engaged in the Steamboat Inspection Service, merchants' service of the United

States, the Coast Guard Service, the Life Saving Service, the Coast and Geodetic Survey, the Lighthouse Service, the Immigration Service, Civil Service Commission, the Isthmian Canal Commission, and the Philippine Government. Foreign seamen are also examined as to physical fitness for duty upon application of their consular officer. In the Division of Marine Hospitals and Relief is maintained the Purveying Depot of the Public Health Service, in which are purchased and issued drugs and chemicals, surgical instruments and appliances, beds, bedding, and similar articles. The Public Health Service maintains as a marine hospital a tuberculosis sanatorium at Fort Stanton, New Mexico. This institution treats about 350 patients per year. It is situated on a large Government reservation of about forty square miles and is supplied with a large beef and milch herd and excellent gardens. Adequate arrangements are made for the proper treatment of the patients, including dental work. Patients and attendants have an amusement association, operating a weekly moving-picture show; a baseball team is kept in operation. There are golf links, a library, church, and many other means of keeping patients amused and interested.

Division of Foreign and Insular Quarantine.—The United States Public Health Service is responsible for the conduct of the maritime quarantines of the continental United States and its insular possessions. It is also responsible for the medical inspection of arriving immigrants to determine their physical and mental fitness for entrance at ports in the United States and its dependencies, Porto Rico, Hawaii, and the Philippines. The Service maintains maritime quarantines at fifty stations in the United States and annually inspects about 9,000 vessels and 700,000 passengers and crews at such places. The Philippine Islands' quarantine stations are maintained at Manila, Cebu, Iloilo, Zamboanga, Jolo, Cavite, and Olongapo. In Porto Rico quarantine stations are maintained at San Juan, Ponce, Mayagues, Arecibo, Aguadilla, Fajardo, Humacao, Arroyo, Guanica, and Jovos, and in Hawaii at Honolulu, Hilo, Mahukona, Kahlului, Lahaina, Makaweli, and Koloa.

The Public Health Service also maintains what is known as foreign quarantine, and for this purpose officers are stationed at Puerto Barrios, Guatemala; Puerto Cortez, Honduras; Callao, Peru; Guayaquil, Ecuador; Yokohama, Japan; Havana, Cuba; Hongkong, China; Kobe, Japan; La Guaira, Venezuela; Shanghai, China; and Naples, Italy.

The duties of officers detailed at foreign ports are as follows:

1. The determination of the sanitary history of all vessels destined for ports in the United States, its possessions, and dependencies.

2. The inspection of vessels, crews, and passengers and the certification of freight, with special reference to the opportunities afforded of infestation of either vessels or freight by rodents.

3. The fumigation of ships for the destruction of rats and mosquitoes, or the disinfection of ships when necessary in the event of actual infection.

4. The observation, when necessary under detention, of intending passengers for ports in the United States and its dependencies.

5. The rendition of reports by means of cable or telegraph, when necessary, as to the health and sanitary conditions of the foreign port and, when possible, of the country contiguous thereto.

6. The certification, in conjunction with the United States consular officer, of the bills of health issued, said certificates to be made just prior to the departure of the ship and to cover the requirements provided for by the United States quarantine regulations.

The medical inspection of immigrants is conducted both at home and abroad. Officers of the Service stationed in the American consulates in foreign ports make inspections of departing aliens at the request of the Department of Commerce, in connection with their quarantine inspection of steerage passengers destined for the United States. The function of medical officers stationed in foreign ports is not to reject aliens found suffering from any of the mental or physical diseases deportable under the immigration laws of the United States, but merely to notify the proper authorities in the foreign ports that immigrants suffering from these diseases are liable to be deported upon their arrival in the United States. Immigrants desiring to enter the Philippines and other dependencies of the United States are similarly examined, and if found to be suffering from certifiable diseases are so certified to the immigration authorities. At all immigration stations certificates may be issued for idiocy, imbecility, feeble-mindedness, epilepsy, insanity, loathsome contagious or dangerous contagious diseases, diseases or defects which affect ability to earn a living, trachoma, tuberculosis, favus, syphilis, tinea tonsurans, and gonorrhea. In the continental United States, eighty-seven stations are maintained for the medical inspection of immigrants. The number of immigrants examined naturally varies, but during the fiscal year ended June 30, 1914, 1,485,957 immigrants were inspected by the Public Health Service at ports of the United States and its dependencies. Of this number, 41,250 were certified for physical defects.

Division of Sanitary Reports and Statistics.—The activities of the Division of Sanitary Reports and Statistics may be roughly classed under three heads

1. The securing and publishing in suitable form of information necessary for health officers and health workers which cannot properly or effectively be collected by them and without which rational health administration is impossible.

2. The issuing of educational pamphlets for general use in the form of supplements to the Public Health Reports.

3. The publication in the Public Health Reports of information relating to health matters with the special object of keeping the health officers of the country informed regarding new discoveries in the control and prevention of disease.

Especial attention is given to the collection of data bearing upon the prevalence and geographic distribution of dangerous communicable diseases in the United States. This means the collection of proper morbidity reports which are even more important from a public health standpoint than mortality reports. An important function of this division is the assembling of data regarding sanitary legislation. This enables the various sanitary authorities throughout the United States to make drafts of sanitary legislation which will best serve the interests of their respective communities. The issuance of the Public Health Reports is a particularly important function which is exercised pursuant to the acts of Congress approved February 15, 1893, and August 14, 1912. Through this publication, which is made weekly, Federal, State and local health authorities are kept currently informed, to the extent that the information is available, of the prevalence and geographic distribution of the dangerous communicable diseases, both at home and abroad. This serves to give timely warning of the approach of epidemics and the need and nature of sanitary measures required for the protection of the various portions of the United States. Supplements to the Public Health Reports are issued as pamphlets. These generally relate to personal and community hygiene and are educational in character and intended for distribution. In addition, the articles which appear in the Public Health Reports, and for which there is an additional demand, are reprinted in pamphlet form. This division also drafts model laws and publishes current court decisions relating to sanitary legislation. To secure prompt and complete reports of the occurrence of diseases dangerous to the public health, collaborating epidemiologists have been appointed

in many of the States. The duties of these officers are to report by telegraph whenever there is an unusual outbreak or sudden increase in the number of cases of smallpox, typhus fever, scarlet fever, poliomyelitis, diphtheria, and epidemic cerebrospinal meningitis, and to report by telegraph whenever cases of cholera, typhus fever, yellow fever, plague, or Rocky Mountain spotted fever occur within their, State; and to make monthly reports of the number of cases of notifiable diseases reported in the State during the preceding calendar month. Supplementing the collaborating epidemiologists are the other officers of the Service and the various State and municipal health officers.

The publications of the Service are many and varied in character. The bulletins of the Hygienic Laboratory are of a technical nature and are chiefly of interest and value to those pursuing scientific work relating to disease and the public health. The Public Health Bulletins are documents covering various phases of sanitary and public health work and are of general and special interest. The Public Health Reports have already been referred to, as well as the reprints and supplements thereto. The Surgeon General issues an annual report and in addition there are a number of miscellaneous publications of laws and regulations, official lists of officers and stations of the Service, and similar material of an executive nature. Publications are designed for free but judicious distribution while the supply lasts. When the supply has been reduced to a certain point the remaining copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The service publishes periodically a list of its publications. It also maintains a mailing list and persons desiring to receive publications as soon as they are issued may have their names placed upon this list upon making application and stating a proper reason therefor.

During the fiscal year ended June 30, 1914, the Public Health Service issued in addition to the weekly issues of the Public Health Reports 111 different bulletins and pamphlets on health subjects and distributed a total of 1,487,015 copies.

Division of Personnel and Accounts.—The Division of Personnel and Accounts is charged with the duty of the assignment and special detail of officers, the convening of boards and the accounting of the expenditures from the various appropriations of the Service. In this division boards of examination of candidates for commission as assistant surgeon, as well as boards for the promotion or investigation of the conduct of officers, are convened.

The officers of the Public Health Service are commissioned by the President by and with the advice and consent of the Senate, and their continuance in office is dependent only on their good behavior and attention to duty. Persons desiring to enter the Public Health Service must be between twenty-three and thirty-two years of age, citizens of the United States, graduates of a reputable medical college, and they must have served in a hospital for one year, or engaged in private practice for not less than two years.

The right to be recommended for a commission in the United States Public Health Service is determined by a thorough examination before a board of medical officers. In order to appear for this examination, candidates must be invited by the Surgeon General of the Service. This invitation is secured by the candidate filling out a blank stating his name, age, place and date of birth, marital condition, the college from which he is graduated and his height and weight. The candidate must also certify that he is free from any ailment which would disqualify him for service in any climate. The application must be accompanied by at least two recommendations as to his character and professional ability, and at least one of these must be signed by a physician.

Examinations are held in various parts of the United States, and consist of a thorough physical examination, an oral examination in the various branches of general education, and a professional examination in writing in the following subjects: Anatomy, physiology, chemistry, materia medica and therapeutics, practice of medicine, surgery, obstetrics and diseases of women, pathology and bacteriology, and hygiene and sanitation. A clinical examination is also given in which medical and surgical cases are examined by the candidate, their histories written, the diagnosis made, and the treatment outlined. As a part of the examination in pathology and bacteriology certain microscopic preparations must be recognized. Candidates are required to make a general marking of eighty per cent. in all branches. In case of failure to pass the examination, another opportunity may be given to appear before the examining board at the expiration of one year.

Candidates who are invited to take the examination report to the chairman of the examination board at a specified hour on a certain day, usually at 10 A.M. on a Monday. The board of examiners makes a record of the name, age (in years and months), nativity, marital condition, the number of children of the candidate, the diseases from which he has suffered, and the effect which they have had upon his general health. Careful inquiry is also made into his family history to determine whether or not the candidate has any inherited tendency toward disease or conditions which might incapacitate him for active service.

The candidate is then required to strip. His height and weight are taken and the examiners note his general appearance and complexion. There then follows a careful examination of the skin, hair, superficial glands, head, face, speech, eyes, eyelids, eyesight, color sense, ears, hearing, nose, teeth, palate, fauces, neck, chest, lungs, heart, scrotum, testicles, penis, anus, spine, the reflexes, upper and lower extremities, agility, temperature, and evidence of successful vaccination within five years. The urine is also tested, and a microscopic and serological examination of the blood is made. In the event that there is reason to believe or suspect the presence of animal parasites there may also be made an examination of the stools. It is thus seen that physical soundness is a prerequisite. In the event that the board of examiners finds that the candidate is not up to the physical standard, it terminates his examination.

The candidate is next required to write a short autobiography, in which he states concisely whether he is married or single; the date and place of his birth; the school, institution, or college at which he received his general education, the several branches studied, including his knowledge of general literature and of the ancient and modern languages; the exact title of the medical school or schools at which he received instruction and the date of his graduation; the time when he commenced the study of medicine; the opportunities he has had of engaging in the practice of medicine, surgery, and obstetrics, or of receiving clinical instruction; whether he has been a resident physician or interne in a civil or military hospital, and the opportunities which he has had for doing public health work. The applicant is required to append to this statement his name in full, his postoffice address, and his local address at the date of the examination.

The candidate is then given an oral examination lasting about one hour in the general common school and college branches. The board has previously looked over the autobiography of the candidate, and unless he claims special knowledge of the languages and higher sciences he is not examined in these. If, however, the candidate desires to demonstrate to the board his proficiency in any foreign language or higher science, he may do so, and the board will give him credit for this knowledge. The idea of the oral examination is not entirely to discover what the candidate

does or does not know, but also to determine the character of his mental processes, whether he has the ability to think quickly and act quickly, and whether he has been using his brain for the purpose of memorizing things or to think with. Questions are asked in American history on almost any phase of the subject. The examination in general history is broader. The examiners do not expect candidates to know the exact dates at which the Punic Wars occurred, but if the applicants show that they have been educated in the broadest sense it will naturally count in their favor. Again it may be stated that this preliminary examination is for the purpose of determining the candidate's ability to use his brain for the purpose of reasoning. For example, the candidate is usually asked some questions regarding current events to show whether he is a man whose interests in general matters are live and keen. For the same reason questions are given in geography. (This is of importance also because of the maritime work of the Public Health Service.) Questions are then put in general literature, principally American literature. None of the questions can be regarded as catch questions.

The written examination then commences. The questions are broad and are calculated to give the candidate ample opportunity to demonstrate his real understanding of the subject. A premium is not placed upon feats of memory and candidates may show their judgment as to the relative value of certain facts by stating essentials and omitting non-essentials. Usually five or six questions are given on each branch.

After passing the examination, the successful candidates are recommended to the President for commission, who in turn nominates the young physicians to the Senate. Upon confirmation by the Senate, the candidates take the oath of office and become assistant surgeons. The pay in this rank is $2.000 per annum, and when serving where quarters are not received from the Government, assistant surgeons are entitled to commutation therefor at the rate of $30 per month; in other words, $2,360 per annum or the equivalent thereof, is the salary of this grade. Newly appointed officers are usually assigned to some large station, such as a marine hospital, for a time; the following schedule of assignments being followed where possible: United States marine hospital, three months; quarantine station, four months; immigration station, five months; and the Hygienic Laboratory, six months. In this way the officer becomes thoroughly familiar with the various branches of the Service, and at the same time the Service definitely ascertains the line of work for which the officer is best fitted.

At the end of four years' service officers are examined for promotion to the grade of passed assistant surgeon. This examination consists of three parts: A. physical; B. record while in the Service; and C. professional. The professional examination consists of written and practical tests in the following branches: (1) Practice of medicine, (2) practice of surgery, (3) obstetrics and diseases of women, (4) hygiene, (5) epidemiology, (6) pathology and bacteriology, and the regulations of the Service. In order to be recommended for promotion, an average grade of eighty per cent. must be received, and not less than seventy per cent., in any of the written branches. Should a candidate for promotion fail to achieve the required grade, he will be eligible for re-examination at the expiration of one year, but should he again fail he is not allowed a third examination and will be reported to the Secretary of the Treasury as not qualified for promotion. An assistant surgeon so reported is requested to tender his resignation. This occurs very rarely. Passed Assistant Surgeons receive pay at the rate of $2,400 per annum, with commutation at the rate of $40 per month, or an annual pay of $2,880, or the equivalent thereof. At the end of five years' service, an additional ten per cent. of the base pay is allowed, and for each five years thereafter up to twenty years' service an additional ten per cent. is added to the base pay. This is called a longevity increase, and the maximum which may be received by reason of this addition is as follows: Assistant surgeon general, $5,000; senior surgeon, $4,500; surgeon, $4,000.

Passed assistant surgeons at the expiration of twelve years' commissioned service are eligible to examination to determine their fitness for promotion to the grade of surgeon. This examination consists of (a) physical, (b) record while in the service, and (c) professional. The latter consists of examinations in writing on the practice of medicine, surgery, hygiene, hospital and quarantine management, and the regulations of the service. Candidates for promotion must also show themselves thoroughly familiar with the various publications of the service. In addition to the foregoing, candidates must prepare prior to the examination a thesis of not less than 5,000 words on some professional subject of their own selection. This thesis is presented to the board at the time of the examination. If a passed assistant surgeon is so unfortunate as to fail in his first examination for promotion to the grade of surgeon, he is not given another examination until the expiration of one year. If he should fail in this second examination, he is carried on the roster of the service as "not in line of promotion."

When vacancies occur in the grade of senior surgeon, the ranking surgeon is ordered before a board and given a thorough physical examination, and a written examination to determine his proficiency in all the regulations of the service and familiarity with the publications of the service. In addition, candidates for promotion to senior surgeon are required to present a thesis of not less than 5,000 words. Should a candidate for promotion to the grade of senior surgeon fail, he is allowed a second examination when the next vacancy occurs. If, however, he fails in this examination he is carried on the official roster of the service as "not in line of promotion."

Officers receive one month's leave per annum on full pay, and they may accumulate this leave to the amount of four months. Extended leave on half pay may be granted by the Secretary of the Treasury. Officers are also granted sick leave when taken ill in line of duty. Should an officer become unable by reason of disease or accident, not the result of his own bad habits, to perform his duties, he is, after the expiration of his ordinary and sick leave, carried on "Waiting orders" status. Officers on waiting orders receive three-fourths of their pay.

Officers of the Public Health Service wear a distinctive uniform which they are required to provide at their own expense.

The seal of the Service is a crossed fouled anchor and caduceus, indicating medical relief for the sailor in distress. This is surrounded by a circle bearing the words "U. S. Public Health Service, 1798–1912." The corps flag is yellow with the crossed caduceus and anchor in blue. The Surgeon General's flag is deep blue with caduceus and anchor in white.

The professors of the Hygienic Laboratory are appointed by the Surgeon General with the approval of the Secretary of the Treasury. Commissioned medical officers may be detailed in charge of the Divisions of Chemistry, Zoology and Pharmacology. It is provided by law that the Director of the Laboratory shall be detailed from the commissioned medical corps of the Public Health Service and while thus serving shall have the pay and emoluments of a Senior Surgeon. The other employees of the Public Health Service are appointed under civil service rules and regulations.

W. C. Rucker.

Puerperal Infection.—*Synonyms:* puerperal sepsis, puerperal septicemia, puerperal fever. This is a term applied to those infectious processes which arise from the invasion of wounds of the generative

tract during labor or the puerperium by a variety of pathogenic microorganisms. The infectious process may vary greatly in extent and effect, from a localized superficial lesion limited to the site of the injury without or only slight constitutional disturbances, to an invasion of the lymphatic, vascular and cellular tissues not only of the generative tract but of the entire body, accompanied by more or less severe general disturbances.

The most satisfactory classification of the various forms of puerperal infection is that proposed by A. W. W. Lea in his monograph (London, 1910), which is based on the anatomical distribution of the lesions, although various combinations of these types may exist. This is as follows:

1. The localized inflammation at the entrance point of infection as a result of wounds of the perineum, vagina, vulva, cervix, or mucous membrane of the uterus.

2. Infective processes arising as a result of extension of inflammation to the surrounding tissues by the lymphatic or vascular channels, or by direct continuity of surface. He includes here vulvar lymphangitis, phlegmon vulvæ, gangrenous vaginitis, paravaginitis, lymphatic metritis, thrombophlebitic metritis, dissecting metritis, abscess of the uterus, salpingitis, pyosalpinx, oophoritis, abscess of the ovary, peritonitis (local or diffuse), metrophlebitic thrombosis, and phlegmasia alba dolens.

3. The general conditions of the body produced by infection, which are of two main types: (*a*) Toxemia, in which the soluble products of bacterial activity alone enter the blood and lymph streams and may be derived from the organic products of decomposition such as leucomaines, ptomaines, or other poisonous products which arise from the anerobic putrefactive bacteria, or may be the bacterial toxins and endotoxins of pathogenic organisms. (*b*) General blood infection or bacteriemia, in which the organisms themselves enter the blood and lymph streams in considerable number. This presents two characteristic clinical features; septicemia, or simple bacteriemia in which the organisms circulate freely in the blood stream and multiply in the capillaries and blood-forming organs; and pyemia, or thrombophlebitic bacteriemia, in which the organisms multiply mainly in thrombosed vessels and enter the blood stream only from time to time as infective emboli.

History.—The teaching of Hippocrates that puerperal fever was due to the suppression of the lochial discharges and could be most satisfactorily treated by purgation remained practically unchallenged until Mercatus in 1570 claimed that putridity of lochia was the cause of the disease and was due to an inflammation of the womb following labor. Various other ideas were gradually superseded by the theory of the contagious character of the disease as observed in various maternity hospitals and very accurate descriptions of the same appear in the literature of the latter half of the eighteenth century both in England and on the continent of Europe. Comparatively little progress was made, however, until Dr. Oliver Wendell Holmes in 1843 brought out his classical essay containing evidence that the disease was carried from patient to patient by doctors and nurses. Three years later were published the views of Semmelweiss who maintained that the essential cause of puerperal infection was the introduction of decomposing organic animal matter into the puerperal genital tract from outside sources and could be prevented by disinfection of the physician's hands, instruments, dressings, etc. After a prolonged period of opposition and controversy the views of Holmes and Semmelweiss were finally confirmed by the discovery of the specific organisms of infection by Pasteur and Lister, which form the basis of our present-day knowledge of the bacteriology of puerperal infection.

Etiology.—The simplest conception of puerperal sepsis is that of a wound infection, it being taken for granted that the vagina and usually the cervix may harbor a variety of pathogenic organisms. The recently emptied uterus and the vagina present in all but exceptional instances varying degrees of solution of continuity of the lining mucosa, which offer a favorable field for the invasion of microorganisms. The retention of blood clots and membranes also furnishes opportunity for the propagation of the same. Again incomplete contraction of the uterus with corresponding relaxation of the lymphatic and venous channels presents similar points of invasion.

The vulva and vagina in a healthy woman normally contain an abundance of microorganisms, and although Krönig, Williams, and others have published observations to the effect that if vulvar contamination is avoided no pyogenic organism will be found in the vagina during pregnancy, others have shown that organisms indistinguishable from pyogenic streptococci, together with diplococci and colon bacilli, may be present, especially in the lower portions of the vagina. The cervix may likewise be the site of similar bacterial contamination but the cavity of the uterus is generally believed to be free from organisms during normal pregnancy. Widely differing results have been obtained from studies of the bacterial content of the puerperal period. Although the earlier observers believed the lochia sterile in from seventy to eighty per cent. of cases, later investigations with more carefully developed culture methods, have shown the presence of pyogenic organisms after the third day in two per cent., which often disappear spontaneously at a later period. Streptococci in normal lochia were found by Bumm and Sigwart in from fifty to seventy-five per cent. of the cases examined, and Stolz claimed that in over thirty-five per cent. of cases never examined these could be found after the fourth day, although ordinarily they diminished spontaneously at a later time. Nicholson and Evans claimed from their studies that the upper part of the uterus is sterile in normal cases during the puerperium and that streptococci are never present without causing symptoms, while ascendance of the gonococcus is an event of comparative rarity notwithstanding the frequency of this organism. The question whether saprophytic organisms in the general tract may after delivery assume pyogenic characteristics is still unsettled. Much significance has been attributed in recent years to the hemolytic power of the streptococcus as an indication of virulence. In a series of 100 cases reported by Schmidt hemolytic streptococci were discovered in the vaginal secretions before delivery in seven per cent., and in the same cases on the fourth day of the puerperium they were present in no less than sixty-eight per cent. When tested as to their virulence, however, according to Fromme's method, they were found to be of a non-virulent hemolytic type. The morbidity of the cases in which the organisms were present in the lochia was slightly higher than in those cases in which no streptococci were detected. Later investigations by Sigwart, Bondy, and Polani have also demonstrated the frequency with which hemolytic streptococci are present in the lochial secretions in afebrile puerperal cases. It is probable that hemolysis is often produced by organisms possessing very little virulence, or the patient is furnished with considerable resisting power. It is not possible, therefore, to claim that hemolysis forms an absolute distinction between saprophytic and slightly virulent organisms and those which are pathogenic. It is probable, however, that if hemolytic streptococci are discovered in a case of fever after delivery they are the causal agents of the infection.

The microorganisms of puerperal infection may,

according to Lea, be divided into three groups. The first includes the pyogenic bacteria, which are the organisms usually found in surgical wound infection, of which the *Streptococcus pyogenes* is the most frequent. More rarely the *Staphylococcus pyogenes*, the *Bacterium coli commune*, or the *Bacillus pyocyaneus* is present. The second group includes organisms of certain specific diseases of which the most important is the gonococcus. The pneumococcus, diphtheria bacillus, typhoid bacillus, and the tetanus bacillus are also found in rare instances. Anaerobic putrefactive bacteria constitute the third group and are very numerous, developing freely in the presence of retained secretions or injured tissue. As a rule, they produce phenomena of intoxication from absorption of poisonous products and manifest but little tendency to penetrate into the blood and lymph streams.

Although puerperal infection is due to the entrance of microorganisms into wounds of the generative tract, certain predisposing conditions may be a determining factor, among which are the general health, the local condition of the genital tract during delivery, the character of the labor, placenta previa, fetal death, and retention of the products of conception. Depreciation of vitality by overwork, insufficient food, alcoholism, and bad sanitary conditions diminish the resisting power of the individual, as does also the presence of such chronic diseases as syphilis, tuberculosis, anemia, diabetes, and any form of autointoxication. The immediate environment of the woman in labor as well as the character of the labor itself may influence the production of subsequent infection. Thus premature labor, prolonged and obstructed labor may tend to favor puerperal infection. The low implantation of the placenta favors infection because the open uterine sinuses are nearer the possibly infected cervix and vagina, and the patient is often exhausted by loss of blood. Fetal death follows putrefaction if organisms reach the amniotic cavity, although this is unusual, but as in such cases bits of membrane or placenta are likely to be retained, the chances for infection are somewhat increased. Blood clots, lochial discharges, membranes, or placental fragments offer a very satisfactory culture medium for the invasion of saprophytic and pyogenic organisms, although Winter in a recent paper holds that puerperal infection is not caused by retention of remnants of placenta but that the two conditions merely coexist in many cases. Thus in 149 cases of retention which he observed, the puerperium was non-febrile in sixty-six or forty-four per cent., it was slightly febrile in seventy-five or fifty per cent., and there were eight severe cases of fever with one death although in four of the severe cases there had been operative interference. Winter found bacteria only in the peripheral parts of the placenta and claims that if infection is caused it results from the efforts at removal. Wounds of the perineum and vagina are ordinarily exposed to bacterial invasion during labor or in the early days of the puerperium and it is believed that they are the starting-point in about sixty per cent. of the cases, the infection extending upward into the uterine cavity or the cellular tissue of the pelvis. In exceptional cases the existence of a myoma, cancerous growth, or purulent focus in the adnexa may be the cause of infection.

Puerperal infection is believed to result in three ways, heterogenetic, in which the organisms are introduced from without, autogenetic, in which the organisms have existed in the genital passage, and hemogenetic in which the organisms are conveyed by the blood stream in the absence of any local site of infection. Heterogenetic or external infection is the most common and important, the organisms being introduced usually by the hand of the medical attendant, by instruments, or by dressings. Airborne infection is probably impossible. Although the vulva may be regarded as a potential source of infection, it is only in the presence of a vulvitis, eczema, furunculosis, or Bartholinitis that a probable danger exists. Urethritis, cystitis, or pyonephritis may sometimes constitute the source of an infection and likewise the intestinal tract, especially in the presence of severe constipation or diarrhea. Vaginal examinations, operative deliveries, douches, coitus, and contact infection from dirty clothing or bedlinen offer the most frequent opportunities for the entrance of infective organisms into the genital tract. Autoinfection is stated to include all those infections arising from lesions in or near the genital tract but it is advisable to restrict the use of the term to those which arise from organisms existing in the genital tract of apparently healthy women during normal pregnancy and labor. A great deal of discussion has ensued on this topic and the most extreme views are held. Bumm and Sigwart believe that neither bacteriological observations nor clinical experience have shown the possibility of an autoinfection from organisms in the genital tract, while on the other hand, Ahlfeld, Zangemeister, Pankow, and others believe that this occurs in from three to five per cent. of cases, although a fatal ending is exceptional. How this can be avoided is doubtful because all attempts at disinfection of the vagina before labor have failed to accomplish the desired result, although it has been shown that normal vaginal secretions possess an undoubted bactericidal power. The possibility of hemolytic infection has been proved by animal experiments made by Orthmann and Hellendahl and clinical evidence of the same has also been brought forward. Thus a pneumonia has been succeeded by a uterine infection with the finding of the pneumococcus in the lochia, and streptococcus infection of the throat has also apparently been transferred to the uterus. Henkel has also reported cases of otitis media and mammary abscess which developed fatal streptococcic infection, the organism being detected in the blood stream and in the uterine secretion. It is very difficult, however, in this assumption to preclude the possibility of organisms being introduced from without.

The gonococcus is found in the puerperal uterus in a considerable number of cases, the estimates ranging from five to twenty per cent. Hannes also found in over 1,700 pregnant women examined for gonococcus before delivery that four per cent. were thus infected. Under the influence of pregnancy and the puerperium the virulence of the gonococcus increases and an old or latent infection is liable to flare up. This fact has been advanced as a cogent argument against allowing women to get up soon after labor. The pneumococcus is occasionally found in the genital tract and has been observed in uterine infections. The organism is highly pathogenic with a special tendency to invade the serous membranes and is therefore frequently a cause of pneumonia and peritonitis during the puerperium. Whether the organism is conveyed from without or distributed through the blood channels is undetermined. The diphtheria bacillus is occasionally noted in wounds of the vagina and vulva, but as the resulting membrane closely resembles that of a streptococcic infection a bacterial examination is necessary. The typhoid bacillus has been found occasionally in the uterine infection usually associated with other organisms. Infection by the tetanus bacillus is usually found after operative interference and the infection is of a severe type. The *Bacillus aerogenes capsulatus* is occasionally found and if associated with other organisms produces a very virulent infection. It is quite unusual for a single organism to form the basis of a puerperal infection and in most cases, although the streptococcus may be the primary agent, association with other bacteria is frequent.

Pathology.—Although a great variation exists in the pathological picture presented by puerperal infection there are certain general and local features which are quite characteristic. After a latent period of incubation which varies from a few hours to several days according to the virulence of the organism and its rate of growth, the products of bacterial activity penetrate the tissues of the wound. This is immediately followed by a local reaction due to the destructive action of the bacteria and the absorption of the soluble toxins. The blood-vessels and lymphatics around this area become congested and effusion of serum takes place, accompanied by a migration of leucocytes and a marked proliferation of the connective-tissue cells. This constitutes a protective or granulation layer and is the most effective barrier against further penetration. The surface of the wound becomes coated with a more or less well-defined membrane and the discharge from the same is at first scant but later, when degeneration and necrosis take place, it becomes profuse and purulent. The character of the discharge varies, however, with the type of infection and if putrefactive organisms are present the discharge is offensive. Where the local wound reaction fails to check the invasion, the organisms penetrate the tissues along the lymphatics and reach the nearest lymph glands which consequently become enlarged. Here the organisms may be destroyed in large numbers by the action of the phagocytes and the tissues in this area may be injured; nevertheless the lymphatic system constitutes an important means of defense and frequently checks the extension of the infection. Streptococci and staphylococci are usually the cause of the severer forms of lymphatic infection and if destruction of the tissues takes place the putrefactive bacteria are frequently present. A variable degree of toxemia results from absorption from these infected areas and if the organisms are possessed of a high virulence, the lymphatic channels may be penetrated and the blood stream entered, a condition of general septicemia thus resulting. The increase in the development of the lymphatics of the generative tract during pregnancy favors the spread of infection by this route. Wounds of the vulva and perineum result frequently in swelling of the labia and inguinal gland enlargement. Infection of wounds in the vagina and cervix lead to lymphatic infection of the pelvic cellular tissue in which the process may spread rapidly and become finally purulent. From the endometrium the infection follows the lymphatics of the uterine wall resulting in severe local inflammation with destructive changes that may result in the formation of mural abscesses. In other cases the organisms rapidly penetrate the uterus and invading the peritoneal cavity may produce a local or diffuse peritonitis.

Symptoms.—These vary with the primary site of infection, with the virulence of the organisms and the manner of extension of the disease. A typical case of puerperal infection is usually ushered in on the third day by a chill with a rise of temperature to 103° F. or 104° F. This may be associated with localized wounds in the vulva or vagina but usually an endometritis is also present. General symptoms such as headache, malaise, a coated tongue, loss of appetite, and restlessness usually follow. The lochia are more profuse and foul in the presence of a saprogenic process while in a purely septicemic form they are usually free from odor and not increased in amount. In cases where the cervix is tightly closed or a large flabby uterus is in a position of retroversion, the lochia may be scant or even absent until better drainage is secured. The temperature usually remains at about 103° F., with slight morning remissions, the chills or chilly sensation frequently being repeated. Associated with this we find usually on the second day of the disease more or less tenderness in the lower abdomen, while the uterus is larger than it ought to be and of a doughy consistency. It may be possible to distinguish between sapremic and septicemic infection by the change in the lochia, for in the former variety the foul discharge usually clears up in a few days, the temperature drops, and the local and general symptoms subside. In the more distinctly septicemic types, although the infection may have remained limited to the endometrium in the milder cases, the recovery is slower and the mucosa becomes the seat of subacute or chronic inflammation, a moderate elevation of temperature continuing until the process has subsided. The more severely septic cases, usually of the streptococcic variety, are characterized by a rapid onset, marked prostration, often delirium, with repeated chills, a temperature of 103° F. and over, and a pulse of 120 or more. The subsequent course depends on the manner in which the disease extends. If this occurs along the course of the lymphatics the process leads to a metritis with the production of abscesses either in the uterine wall, the broad ligament, or the pelvic cellular tissue, or it may extend directly to the peritoneum with the production of varying grades of peritonitis, marked by pain in the lower abdomen, which finally becomes general in its distribution. These extensions are usually marked by fresh chills and rises of temperature. The process continues until the local focus is absorbed, incised, or a rupture into the bladder, rectum, vagina, general peritoneal cavity, or inguinal region takes place. In the severer cases of puerperal sepsis of the so-called foudroyant type a fatal issue may come on in ten days or even less, the patient losing weight and strength very rapidly, becoming delirious and finally comatose, with continuous high temperature and presenting the appearance of a very excessive toxemia. In the cases where the Fallopian tube becomes involved in the extension of the process, the resulting salpingitis produces localized pain and tenderness in the affected area. In certain severe cases the abdominal symptoms may not be at all marked. Sometimes the localized process in the uterus results in an excessive gangrene of this organ with an extremely foul discharge and evidences of severe general intoxication without peritoneal involvement.

The clinical picture differs in pyemic cases, the chills come on later in the puerperium, the temperature drops in the morning, but with the dislodgment of emboli further chills and rises of temperature occur accompanied by local symptoms in various organs where an embolus lodges. The bacillus of pneumonia is fairly common in these cases and may be complicated with empyema and its train of symptoms. When the joints become involved these are swollen, painful, and may contain pus. The appearance of areas of pain and redness in the cellular tissues in any part of the body should be noted. If the pelvic veins become involved in the septic process severe chills with rises of temperature to as much as 106° F. may ensue, accompanied by localized pain and tenderness in the region of the veins as demonstrated by vaginal examination. If involvement of the veins of the thigh occurs this is usually during the second or third week of the puerperium and is marked by pain in the leg, a rise of temperature, and subsequent edema of the foot, which extends upward. A variety of other symptoms may arise during the course of a puerperal infection which are dependent entirely on the complicating lesion.

Diagnosis.—Every case of fever coming on within the first two weeks after delivery should lead to the suspicion of a puerperal infection. It has been found that in maternity hospitals about one-half of the cases of pyrexia are due to infection, the remainder are the result of various accidental or complicating conditions. It is necessary to determine the source

of the temperature in every case, however, and for this reason a systematic investigation should always be made. We find that slight rises of temperature are common occurrences during the first forty-eight hours after labor and are not considered pathogenic, but the limit is usually placed at 100° F. In many cases we find a rise of temperature and pulse rate within the first twelve hours after labor and this is often accompanied by a chill. Some have ascribed this phenomenon to the discharge into the blood stream of small emboli from the placental site, others believe that it is due to a condition of muscular fatigue such as would be met with after any severe exertion. This disturbance usually subsides within twenty-four hours. A toxemia of a gastrointestinal origin is frequently the cause of a temperature and usually manifests itself during the first ten days after delivery. An abrupt rise of three or four degrees may result but the pulse remains low and the patient does not appear sick although the tongue may be coated and a slight headache be present. In more severe cases abdominal distention and vomiting may follow. A history of constipation can usually be elicited and after the bowels are thoroughly evacuated the condition subsides. Emotional excitement, fear, and the distress associated with hyperemia or caking of the breasts may cause a rise of temperature which subsides as soon as the cause is removed. Where mastitis is actually present as a cause for the temperature the evidences of the same can usually be elicited. The so-called "milk fever" which was believed to accompany the first appearance of the milk is not accepted at the present time. An actue cystitis, particularly if catheterization or operative delivery has been found necessary, may cause a sharp rise of temperature within the first ten days, accompanied by frequent and painful urination and the appearance of an alkaline urine. Pyelitis frequently complicates pregnancy and may closely simulate a true puerperal infection especially if the process has been present before delivery. In such cases a rise of temperature with an accompanying chill and increase of the pulse rate may be noted at any time during the first three weeks and until the diagnosis is established by the finding of abundant pus in an acid urine, a great deal of uncertainty may exist. A variety of intercurrent affections may bear such a close resemblance to puerperal infection that the diagnosis is difficult, including the various contagious diseases such as typhoid fever, diphtheria, erysipelas, tetanus, malaria, tuberculosis, pneumonia, influenza, meningitis, and appendicitis. It may be necessary to observe the patient carefully for one or two days before a differential diagnosis can be made, although in the cases of appendicitis the prognosis is usually serious enough to demand immediate attention.

An early diagnosis of puerperal sepsis has been attempted, by means of vaccination analogous to the von Pirquet test, by Koehler for which intracutaneous injections of various antigens were used, such as bacterial suspensions, bouillon cultures, and filtrates of streptococci, both in cases in which streptococci were present in the uterus or the blood and in those in which the positive or negative result was subsequently proved. A local reaction at the point of injection was noted in cases with streptococci in the blood. In the presence of localized septic processes limited to the uterus a reaction either failed to appear or was only slightly marked. It was also found that the reaction was weaker in severe cases than in the moderate ones and did not appear in the fatal cases at all.

Prognosis.—The resistance of the individual to the infection constitutes the most important feature in the prognosis of puerperal sepsis and no definite or satisfactory methods have been found for estimating this process. Observations on the alkalinity of the blood, its specific gravity and the contained hemoglobin, likewise the antitryptic power, cannot be relied upon. Wright's estimation of the opsonic index has been more recently employed but is likewise inconclusive. The degree of pyrexia, the character of the pulse, the changes in the blood, and the general appearance of the patient, as well as the character of the local inflammatory processes must be regarded as the deciding factors. Localized infection gives a favorable outlook, whereas the development of a diffuse peritonitis or cellulitis makes the prognosis grave. The presence of organisms in the blood is not to be regarded as necessarily fatal although it is generally assumed that the hemolytic types of streptococci in the blood speak for a fatal issue in about ninety per cent. of the cases. A diminution in the red blood cells below 3,000,000 is generally regarded as unfavorable and likewise the appearance of nucleated red cells. A leucocytosis of from 10,000 to 20,000 polymorphonuclear cells shows satisfactory resisting power, but if the white cell count exceeds 25,000 the prognosis is serious, especially if there are no eosinophile cells present. It is somewhat of value to make a microscopical and bacteriological examination of the lochial discharges, the presence of streptococci being usually regarded as unfavorable although other organisms may also cause severe infections. Hemolysis in respect to the virulence of streptococci has already been referred to but attempts to distinguish the virulent from the non-virulent strains by cultural tests has not thus far been satisfactorily accomplished.

Treatment.—Prophylaxis constitutes the most important element in the therapeutics of puerperal sepsis; in other words, to avoid, if possible, wound infection. As wounds of the genital tract can scarcely be avoided in labor it is essential that the possible infectious element be reduced as much as possible. Surgical cleanliness in the doctor, patient, nurse, dressings, and environment contributes to this result as proved by experience. The question of a full body bath for the patient before labor is still unsettled, but unless the vulva gapes widely there does not seem to be much risk of the bath water entering the vagina. It has been shown that mere scrubbing of the vulvar region is not sufficient and that better results are obtained where this follows removal of the pubic hair by shaving. When possible this should be done the day before or at least as soon as labor begins. In the presence of any purulent foci in the neighborhood of the genitals these should be done away with if possible before labor; thus if a Bartholinitis is found it should be subjected to radical treatment by free incision of the abscess, packing of the cavity, and frequent cleansing of the same. Although antepartum douches are now practically abandoned the controversy over the same is by no means settled and we still meet with the results of cases thus treated in which the observers claim that preliminary douching with weak lysol (0.5 per cent.) or other mild antiseptics reduces the bacterial content of the genital tract. Thus Thaler and Zuckermann claim that systematic vaginal douches with five per thousand lactic acid solution toward the close of pregnancy permit the woman to enter labor with the normal defensive processes in the vagina intact. They claim that a complete transformation of the pathological into the normal type of vaginal flora occurs in ninety-five per cent. of the cases, the aim of the treatment being not to sterilize the vagina but to promote the proliferation of the normal flora until the pathological is crowded out. In a series of cases reported by Schweitzer fever occurred in 7.67 per cent. of 665 women who were given lactic acid douches, while two per cent. had fever in a series of 147 cases who did not receive

these irrigations. While Zweifel considers that good results are obtained with antepartum douches in cases having a pathological secretion, he thinks they are superfluous in normal patients.

The sterilization of the hands of the operator and nurses constitutes one of the most important features in the prophylaxis of puerperal fever. Hand sterilization should be carried out in as simple a manner as possible and the use of strongly alkaline soaps or germicidal solutions avoided. The handling of pus cases and contagious diseases should be omitted by any one undertaking an obstetrical delivery. A simple method of cleansing is to scrub thoroughly the hands and forearms to the elbows with a moderately stiff brush for a period of five minutes in warm or hot running water, using a wooden nail cleaner during the process. After rinsing the hands thoroughly they should be swabbed for two minutes with ninety-five per cent. alcohol. Rinsing in solutions of mercurial salts, carbolic, lysol, iodine, permanganate of potash, and a variety of other antiseptic agents may be substituted for the alcohol where this is found too expensive, but the best results are obtained with the latter. Before undertaking to examine the patient rubber gloves should be put on. The rather thin so-called obstetrical glove is to be preferred. Before using rubber gloves, they should be thoroughly cleaned with soap and water and then wrapped up in a small towel and sterilized by boiling for one minute. They may be kept in the basin with a sufficient amount of water which after being cooled will allow their being slipped on readily. If the dry method of sterilization is preferred the gloves after boiling may be dried, then put in a special receptacle and subjected to steam sterilization for a period of forty minutes. If used in this manner the hands must be dried with a sterile towel after rinsing with alcohol or one of the antiseptic solutions and then thoroughly powdered with sterilized talcum before the gloves are slipped on. Care should be taken in putting on the gloves not to allow the bare skin of the other hand to touch the outer surface of the glove. It is claimed that with the use of rubber gloves the morbidity of puerperal cases has been largely decreased; thus Cragin reports that in a series of 20,000 deliveries at the Sloane Hospital for Women, in 16,000 cases delivered without gloves there were 181 cases of bacteriemia (1.1 per cent.) and 1,525 cases of sapremia (95 per cent.). In 4,000 delivered after the introduction of gloves there were 34 cases of bacteriemia (0.35 per cent.) and 377 cases of sapremia (9.4 per cent.). This shows a marked reduction in the number of cases of bacteriemia but practically no change in those of sapremia. In making a vaginal examination of the patient in labor the labia are held apart by the thumb and first fingers of the free hand while the examining hand is dipped in a half per cent. lysol solution, which while mildly antiseptic has lubricating properties. The vaginal examination should not be relied on to give all the necessary information in a case of labor and if combined with external palpation need not be repeated at frequent intervals. The less the number of vaginal examinations the better the prophylaxis. Rectal examinations during labor have been recommended and in certain clinics are extensively employed, but the vaginal examination affords a more satisfactory result to the average practitioner.

The preparation of the patient has already been described and the immediate surroundings must also contribute to the aseptic conduct of the labor by being sterilized; this refers to towels and other material used for the draping of the patient. A form of stocking-drawer constitutes a simple and excellent means of protection against the skin of the thighs and legs and a towel may be placed over the abdomen and another one under the vulva. During the first stage the patient being up and about, it is not necessary to keep the vulva covered but as the end of the second stage is reached the patient should preferably be kept in bed and the sterile dressings referred to previously applied. After waiting a suitable interval for the separation of the placenta, usually from twenty minutes to half an hour after the birth of the child, an attempt should be made to express the same by simply pushing down gently on the fundus. If the placenta is loose it will be delivered spontaneously, if not, a longer interval should be allowed to elapse. The placenta should be examined after delivery and if portions of membranes or bits of placenta are missing they had best be left *in situ* unless a hemorrhage is taking place. The invasion of the uterine cavity in an attempt to remove placental remnants or bits of membrane is accompanied by a greater danger of septic infection than to leave them in, as in the majority of cases they will be extruded in a day or two without any bad results. If large fragments of the placenta remain, however, and they result in a postpartum hemorrhage it is necessary to remove them with the gloved hand after the vulva has been thoroughly cleansed. Postpartum douches are unnecessary except in the presence of hemorrhage or occasionally after excessive intrauterine manipulations or operative deliveries. An examination of the perineum may be made before the conclusion of the third stage, and the necessary repairs done. An examination for lacerations of the cervix or repair of the same is unnecessary unless a hemorrhage is present, with the uterus well contracted and evidently not the site of the same. An hour or so after the conclusion of the labor the uterine fundus should be massaged and the contained clots expressed, for if allowed to remain in place they may serve as the basis of a later sapremic process. The use of ergot to keep the uterus well contracted during the first few days postpartum has already been referred to. The vulva should be kept covered with sterile pads at least during the first week of the puerperium and these should be changed at least every four hours or oftener if the patient voids or defecates. It is a good scheme to appoint a certain time for these functions.

The treatment of puerperal infection itself may be divided into the conservative and radical. The present-day tendency is toward conservative treatment when infection has occurred and recourse to more radical measures is taken only when necessary, stress being invariably laid on the prophylactic measures already referred to. Taking up first the mild class of cases in which the sapremic element is the chief one, it is essential to provide good and sufficient drainage. This can be secured by having the patient propped up in bed or else having the head of the bed raised. The heavy uterus, particularly in multiparæ, has a tendency to fall backward and it is advisable to keep the patient off her back, directing her to lie on either side and occasionally on her stomach. If one is not satisfied that proper drainage is thus secured a vaginal examination may be made and the exact condition of the cervix and the position of the uterus determined. Very frequently the cervix is contracted and a gentle dilatation with the finger will serve to release the imprisoned lochia. Douches as a rule are not necessary and the intrauterine douche for such cases is contraindicated, as the water may be forced out through the Fallopian tubes into the general peritoneal cavity. Thorough contractions of the uterus should be secured by the administration of ergot, one dram of the fluid extract four times daily. If there is tenderness of the lower abdomen and over the uterus, an ice-bag should be applied to this region. Thorough evacuation of the bowels should be secured by a dose of castor oil followed by one or two enemas as needed. In cases where the lochia are very foul and disagreeable to the patient, a plain two-quart warm-water douche to which a few drops of lysol are added, may be given.

The diet should be light and the patient given plenty of water to drink. In the more severe cases with constitutional symptoms the same general plan of procedure may be followed but in addition special efforts should be made to keep up the nutrition of the patient. When possible, cases of puerperal sepsis should be given plenty of fresh air and it has been successfully proved that the headaches, delirium, and other constitutional disturbances are greatly benefited by the same. The patient can with advantage be kept on the roof, as successfully carried out at the New York Lying-In Hospital and other institutions. A local examination should always be made and if a perineorrhaphy has been done the stitches should be removed in the presence of any tenderness or edema. Alcohol in cases where depression is present is often of service and is preferably given in the form of whisky or brandy in milk. When stimulation is required, camphor and digitalis give the best results; no particular value attaches to strychnine. When the temperature is very high a cold sponge or cold pack may be resorted to to reduce the same, but antipyretics should not be employed. Having inaugurated the general treatment outlined above it is necessary to make a careful examination of the patient and to treat whatever local manifestations of the process are present.

On the other hand, attempts have also been made to attack the infection through the circulatory system by intravenous injections, vaccines, and sera. Among the antiseptics which have been used for intravenous injection the silver salts and bichloride of mercury have been most commonly employed. The use of silver nitrate in the proportion of one part to a thousand of sterile water was introduced by Hume of Baltimore and intravenous injections of collargol have likewise been employed, but subsequent reports show that this method is of slight value and a favorable action is perhaps due to promoting a phagocytosis. Ilkewitsch considered that the effect was due largely to the water and reports a series of 142 cases in which infusion of distilled water was employed in the proportion of 8 c.c. per kilo of body weight, and in sixty-two cases of pyemia and septicemia, forty-two patients were reported cured. Bichloride of mercury has also been employed and Barsony injects 0.005 gram of the drug and if the temperature keeps up repeats the injection the same day. If symptoms of intoxication result a smaller dose is used. In one instance twenty-eight injections were employed in the course of sixteen days and the patient recovered. An increase in the red cells resulted, and aside from the intravenous injections and potassium permanganate douches no other treatment was employed. Barrows' suggestion to employ formaldehyde in very dilute solution in cases of puerperal infection has not met with confirmation or success and has been practically abandoned. The serum treatment of puerperal infection for the purpose of producing immunity is applied in two ways. Direct or active immunity is attained by the injection of organisms or toxins in an attenuated form so that by repetition at suitable intervals a high degree of resistance to infection may be induced. The treatment of puerperal infection by vaccines is based on this method. Indirect or passive immunity is obtained by the direct introduction of a serum derived from a subject already immune, the resultant serum stimulating the resisting powers of the body against the further extension of infection. Serum treatment in septicemia has been experimentally investigated on animals by a number of observers and if administered early may check an infection, but after an interval of twenty-four hours the serum may fail entirely. In the later stages of the infection the administration of serum may lead to a rapid destruction of the organisms in the blood and thus liberate large quantities of the bacterial endotoxins which in themselves may lead to a rapidly fatal termination. Although extensive statistical evidence had been published, no conclusive statements of the value of the treatment are at hand. Antistreptococcic serum obtained from animals inoculated with these organisms derived from human infection is usually employed, but it is possible that the immune substances developed in the serum of the animal may fail to unite with the complement present in the human individual. A polyvalent serum is generally used. As puerperal infection varies greatly in intensity a reliable judgment as to the efficacy of any form of specific treatment is difficult and as the infection is very intense in some cases a bactericidal serum can hardly be expected to have an effect. Again we know that many severe cases run a short course which ends in recovery without treatment. The usual dose is from 20 to 40 c.c. subcutaneously of a polyvalent antistreptococcic serum and the dose repeated twice daily. If no improvement after four injections occurs the treatment should be abandoned. Serum has also been proposed as a prophylactic measure in cases where infection is liable to occur and has been tried out on a large scale by Pinard but other observers claim that the frequency of streptococcic infection is in no way influenced by this means. The unreliability of the methods for the production and testing of antistreptococcic sera makes their content of protective material doubtful in quantity and character. They may thus be inert, or contain bacterial poisons which if injected will do more harm than good by aggravating the already existing toxemia.

Prompted by the uncertain results of the serum treatment attempts have been made to secure artificial immunization by the injection of specific toxins for the purpose of stimulating the formation of protective material in the blood. The substances in the blood serum which favorably influence the ability of the leucocytes to ingest bacteria are known as opsonins. The relation between the opsonic power of the serum of the individual infected and that of a normal person to the same organism is the opsonic index. This should be determined in every case and according to Sir E. A. Wright, who has systematized our knowledge of the subject, a low opsonic index is the accompaniment of unsatisfactory clinical conditions, while a high index is usually associated with clinical improvement. Wright claims that suitably administered vaccines will bring about this change. A vaccine is prepared by growing a pure culture of the isolated organism in a solid medium. After determining the number of bacteria per cubic millimeter according to Wright's procedure, the emulsion of bacteria is sterilized by exposure to a temperature of 60° F. in a sealed tube in a water-bath. The initial dose is from five to ten millions of bacteria and is repeated if the symptoms improve. Inoculation is usually followed by the so-called negative phase in which the antibactericidal power of the blood is diminished. This is followed by a positive phase in which a marked resistance to infection appears. Inoculations should then be controlled by determinations of the opsonic index, for an excessive dose of vaccine, especially if administered during a negative phase may produce severe constitutional symptoms. Although a number of observers have published series of cases treated by vaccines they are insufficient for a final judgment but that there is a marked effect on the opsonic index has been confirmed and the inverse relation between the opsonic index and the degree of pyrexia has also been shown. As mixed infections are not uncommon it may be necessary to use the vaccine from more than one organism in an attempt to induce immunization. It has also been pointed out by Wright that autoinoculations may occur spontaneously and thus

render it difficult to estimate the precise influence of the vaccine itself.

The artificial production of suppuration by the injection of turpentine into the loose cellular tissue of the abdominal wall has been attempted as a check and curative treatment for puerperal sepsis. As the formation of pus is usually associated with leucocytosis this has been assumed to be the essential factor in bringing about a favorable effect. The turpentine is injected in doses of from 1 to 5 c.c. and repeated at intervals of twenty-four or forty-eight hours. If an abscess fails to develop the case is regarded as a serious one, and if a good reaction with the formation of pus is obtained considerable improvement has been observed. Another method, adapted by Fabre of Lyons, has been to inject 1 c.c. each of the essence of turpentine and alcohol mixed with six ounces of physiological salt solution twice daily. Aside from edema of the tissues no severe reaction is observed and the effect is more or less of a systemic one. Turpentine has also been advocated as a local application to the interior of the uterus in the form of a tampon saturated with the oil. Cramer has reported good results in a considerable number of cases.

Operative procedures include the removal of retained secundines from the uterus, the treatment of localized pus foci, the removal of the uterus and the ligature or excision of infected pelvic veins. In each instance the general measures already referred to must be followed and painstaking judgment exercised before resort to surgical interference. In general it may be stated that if the condition of the patient appears to be getting worse and a localized infective process can be determined, operation must be considered. If it is determined that the interior of the uterus should be cleaned of all fragments of tissue, this should be carried out as gently as possible, preferably with the finger, a dull curette or a placental forceps. Great care should be exercised not to invade the protective granulation layer or to perforate the friable uterine wall. Subsequent to this cleaning, the interior of the uterus may be swabbed out with alcohol, tincture of iodine, or other antiseptic and loosely packed with gauze for purposes of drainage. If a localized collection of pus is present in the form of an acute cellulitis an incision must be made to secure the best possible drainage, this being done either through the culdesac of Douglas, or along Poupart's ligament, or any other place where a rupture is imminent. The removal of an acute pyosalpinx or ovarian abscess during the course of the puerperium is attended by considerable risk. Operative interference should be limited to a drainage incision if possible. The treatment of general puerperal septic peritonitis by opening the abdominal cavity is practically hopeless. Ligation or excision of thrombosed veins in the treatment of puerperal pyemia has been extensively advocated although many writers consider it an unjustifiable procedure. It should only be undertaken by well-qualified operators in the presence of distinct indications. The prospects of cure are considered to be better in the chronic than in the acute forms and the transperitoneal approach to the thrombosed veins is usually considered to be superior to the extraperitoneal method. The subject is too extensive for discussion within the limits of this article and the reader is referred to the extended study on the same by J. Whitridge Williams (*American Journal of Obstetrics*, vol. lix., No. 5). Out of a series of fifty-six cases of thrombophlebitis studied by Dr. Williams, fifteen operations by the extraperitoneal method gave a mortality of eighty per cent., and forty-one by the transperitoneal method a mortality of 43.9 per cent., which is not an appreciable difference from that following expectant treatment. Excision of the thrombosed veins is unnecessary and they should be exposed to ligation only when the vessel appears likely to rupture or is surrounded by inflammation.

A complete excision of the puerperal uterus for an infectious process is of doubtful value. If done early, before extension has taken place, the later course may have rendered a radical removal unnecessary whereas if done at a period when other organs are involved, it will likewise prove unavailing. Cases of putrid or gangrenous endometritis and uterine abscesses seem to constitute the only definite indications for hysterectomy in puerperal sepsis. The patient's general condition, her environment and the operator's ability must be taken into consideration. The abdominal excision, with drainage through the culdesac and possibly anchoring the stump in the lower angle of the wound offers the best results.

A review of the results obtained with various therapeutic measures in the treatment of puerperal sepsis does not afford much encouragement for a successful solution of this important and far-reaching problem. Thorough prophylaxis is the keynote of a safe and successful outcome of labor, whether this takes the form of proper care during pregnancy or the immediate measures for the conduct of an aseptic delivery. If infection has already resulted it is of the utmost importance to check its extension by the procedures already referred to and the resisting power of the patient must be developed and not interfered with by unnecessary radical operative or other procedures. GEORGE W. KOSMAK.

Pulex.—A genus of insects which includes the human flea, *P. irritans*. It differs from other *Pulicidæ* in the absence of a rod-like thickening on the mesosternite from the insertion of the coxæ upward. See *Insects, parasitic.* A. S. P.

Pulicidæ.—A family of fleas in which neither the head nor pronotum has a ctenidium, and in which the labial palpi are asymmetrical. The two important species *Pulex irritans*, the human flea, and *Xenopsylla cheopis*, the rat or plague flea. See *Insects, parasitic.* A. S. P.

Pulsatilla.—N. F. *Pasque Flower.* The dried herb of *Anemone Pulsatilla* L. and *A. pratensis* L. (fam. *Ranunculaceæ*), collected soon after flowering, carefully preserved and kept not longer than one year. Both are low, hairy herbs and among the earliest and most beloved of spring flowers. For medicinal purposes the plant should be dried in the shade and stored in a cool and dry place. The drug is thus described: Silky-villous; leaves radical, long-petioled, the petioles usually purplish, the blades twice or thrice deeply three-parted or pinnately cleft, the lobes linear and acute; flowers long-peduncled, subtended by an involucre of three pinnately parted sessile leaves; calyx of (usually six) large, dull purple, hairy sepals; petals obsolete; stamens numerous; pistils several, becoming in fruit long, plumose-tailed akenes; inodorous and very acrid.

CONSTITUENTS.—Pulsatilla yields upon distillation with water a very pungent, volatile, oil-like principle, from which ether or chloroform extracts a peculiar camphor, which has been called *Anemone camphor* and which possesses the acridity of the oil to such a degree that it is capable of blistering the skin. This camphor is divisible into anemonin and iso-anemonic acid. The former is a colorless, crystalline, neutral substance, of but little taste when cold, but intensely pungent when melted. It is but slightly soluble in cold alcohol, ether, or water, more so in those liquids when hot, and is readily soluble in chloroform. *Iso-anemonic acid* is a white, amorphous, insoluble substance, without odor, taste, or medicinal property.

Action and Use.—The clinical investigation of pulsatilla has been greatly neglected by physicians, apparently with little better reason than that it is a favorite medicine with homeopaths and eclectics. That it possesses powerfully active properties is sufficiently proven by its action upon the skin and the mucous membrane. Its action is fairly well described in a general way by saying that it resembles that of aconite, but its special field of usefulness is well worthy of careful determination. It is a fairly active counterirritant, and is frequently so employed, Although capable of blistering, if applied with friction, such a use of it is not wise, since the blister is rather uncontrollable. Applied to the mucous membrane, it produces a burning and tingling followed by numbness, much as does aconite. In the stomach it acts as a stimulant, or in larger amount as an irritant emetic. Systemically, it reduces both the rate and the force of the heart and of the respiration. It is therefore an antiphlogistic, and is somewhat used as a respiratory sedative. Among the homeopaths and eclectics its sedative action is largely utilized in the treatment of inflammatory conditions of the genitals, although it is also a favorite emmenagogue.

The powdered drug may be given in doses of gr. i.–v. (0.06–0.3), or the fluid extract in an equal number of minims. The tincture is probably more used than all other of its preparations combined. It is commonly made of twenty per cent. strength, and the dose is ℥viij.–xv. (0.5–1.0). The extract is used in doses of one-half to two grains and anemonin in doses of one-fifth to one-half a grain.

Allied Drugs.—*Anemone nemorosa* L., the common wind-flower, and various other anemones, have a similar composition to that of pulsatilla, and are similarly used. Various species of *Ranunculus* or buttercup, and of *Clematis* or virgin's bower, also exhibit resemblances in the same direction, as does Hepatica or liver-leaf. All these pertain to the family *Ranunculaceæ*. Henry H. Rusby.

Pulse, The.—Introductory and Historical.—The pulse, literally a beating or throbbing, may be broadly defined as periodic movements caused by the rhythmic action of the heart. The term is commonly applied to the changes in size and tension of the blood-vessels which may be seen or felt at each heart beat. In the history of medicine the observation of the pulse, and also its employment in diagnosis, preceded by many centuries the discoveries which opened the way for its interpretation. Aristotle refers to the pulse, and states that it is simultaneous in all parts of the body; but he was not aware of its relation to the activity of the heart. Galen, equally ignorant of its origin, devoted much attention to it, but his lack of physiological knowledge led him to form many false conceptions, and he attached a significance to minor variations which later experience has not justified. He believed that the arteries expanded and contracted actively by some force which they possessed within themselves. Chinese physicians of the old school describe and even graphically depict the pulse in great detail. They imagine they find indications in it of the exact seat no less than the nature of nearly every disease.

A more reasonable claim, where the indications given are better supported by other symptoms, is ascribed by the poet Browning to Paracelsus, that erring Moses who in the sixteenth century began to lead the profession out of the Egypt of tradition.

> "When we would thoroughly know the sick man's state
> We feel awhile the fluttering pulse, press soft
> The hot brow, look upon the languid eyes
> And thence divine the rest."

The foundation for the scientific study of the pulse was laid by William Harvey, who discovered and described the circulation early in the seventeenth century. Among his conclusions we find that "the heart is the organ of propulsion for the blood" and that "the pulsation of the arteries is nothing else than the impulse of the blood within them." In 1707 Sir John Floyer states a little more definitely: "The pulse is that sensible motion which is given to the artery by the blood which the heart injects into it." Still fuller is the account given in Haller's "Elements of Physiology," published in 1760: "The arteries are, in a living person, always full of blood, since the jet or stream that starts from an artery is not interrupted by alternate stops, while the heart rests or relaxes itself, but it flows on in a continued thread. . . . Since, therefore, a new wave or column of blood is sent into the arteries already full, although it bears but a small proportion to the whole mass contained in the arterial system throughout the body, . . . yet by its immediate contact with the precedent wave or column, which moves slower as it gets farther from the heart, it consequently drives the same forward, lengthens the artery, and makes it assume a cylindrical form, augments its diameter, etc. This dilatation of the artery, whereby its light or capacity is changed from a less to a greater circle, is called the pulse." In 1767 Henri Fouquet described in detail the sensations imparted to his finger by the pulse and was the first in Europe (the Chinese were before him) to represent the pulse by drawings. In 1855 K. Vierordt described a rough means of recording the movements of the arteries automatically, thus laying the foundation of modern sphygmography. On this foundation a host of modern investigators, both laboratory and clinical, have raised a substantial structure of useful knowledge.

Arterial Pulse.—*Description and Explanation.*—The arterial pulse comprises a succession of waves initiated in and near the heart and propagated through the arteries. As the contents of the left ventricle are forced through the semilunar valves, room is made

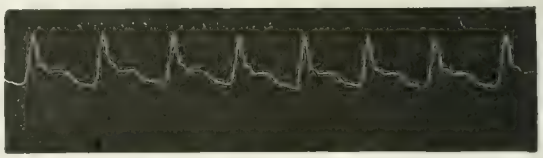


Fig. 4345.—Normal Pulse Tracing.

for the blood, partly by the distention of the aorta and partly by a pushing on of what is already there into the smaller arteries, causing the latter to be distended in turn. This distention slightly increases the caliber of the arteries; but what we recognize as the pulse, when we lay our finger on the wrist, is rather the increase of tension or pressure within the vessel which occurs at the same time. In some cases an artery may become more tortuous as the wave of increased tension is passing over it. With the finger on the pulse, it is sometimes possible to recognize more than one impact or wave. It is difficult, however, and often impossible to be sure of these so-called secondary waves by the sensation imparted to the finger, and we should know very little about them were it not for the assistance furnished by the sphygmograph. By means of this instrument it is possible to communicate the movements of the artery to a lever supplied with a writing point. This is brought to bear upon a piece of smoked paper moved by clockwork. The result is a graphic representation of the variations in pressure occurring within the artery. Some of the many forms of instrument and the method of employing them are described in the article on *Cardiography*. Fig. 4345 represents the tracing obtained by one of these instruments (Dudgeon's

sphygmograph) from the radial pulse of a healthy man.

If it be examined it will be seen that each pulse beat is represented by a sudden rise followed by a more gradual fall. The sudden rise is known as the *primary or percussion wave* and can be traced to the contraction of the ventricle. The descent is broken by two secondary waves, of which the second, known as the *dicrotic wave*, is in this case the largest and most distinct. This wave is very constant, being found in almost all pulse tracings. It is preceded by a depression known as the *dicrotic notch*. There has been much controversy as to the cause of the dicrotic wave, one view being that it is due to a rebound of the blood from the aortic valves at the moment when they close, and the other that it is a wave reflected back from the small peripheral vessels. While a very few still hold the latter view, it has been discarded by most physiologists as a result of overwhelming evidence that has been advanced in favor of the rebound theory. If the wave were due to a reflection of the percussion wave from the periphery, it would occur earlier in the peripheral than in the central vessels, which is not the case. Moreover, a number of physiologists, notably Karl Hürthle, have shown that the dicrotic notch which marks the beginning of this wave follows immediately the closure of the aortic valves. He has invented the so-called differential manometer to record the time of closure of the valves. This instrument records the relation of the pressure in any two cavities. If connected with the aorta and left ventricle through a Hürthle's heart catheter, it indicates the moment when the pressure in the ventricle falls below that in the aorta. This moment corresponds of necessity with the beginning of a back flow into the ventricle, and must be directly followed by closure of the valves. In Fig. 4346 from Hürthle's "Beiträge zur Hæmodynamik" *A* is the curve of pressure at the root of the aorta, that of the left ventricle, and *D* the curve of the differential manometer showing the relation between the pressure in the ventricle and that in the aorta. When the curve *D* rises above the base line the pressure is higher in the ventricle, and blood begins to flow into the arteries; when it falls below the line, there is a tendency for a back flow to take place and the semilunar valves close. The vertical lines 1, 2, 3, 4, 5 show corresponding points of time in the three tracings. The aortic valves close directly after the line 3, which marks the beginning of a backward flow into the ventricle. This corresponds in time very closely with vertical line 4, indicating the commencement of the dicrotic wave. The close agreement in time between these two events is strongly suggestive of a causal relation. The correspondence between the closure of the aortic valves and the dicrotic wave has also been successfully demonstrated by Martius, Karl Schmidt, Jr., and others by marking the time of the second sound of the heart as heard with a stethoscope upon the pulse curve.

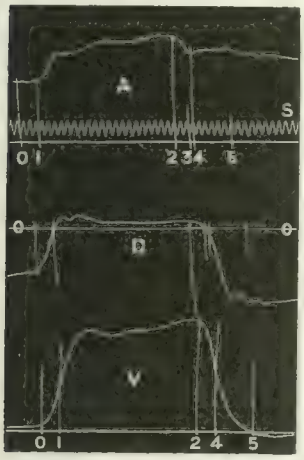


Fig. 4346.—Shows Relationship between the Pressure in the Ventricle and that in the Aorta. (From Hürthle.)

The rebound from the semilunar valves may be explained as follows: The blood is thrown out of the ventricle at a certain speed and with a certain momentum. When the ventricle has emptied itself the momentum of the blood in the aorta tends to carry it forward away from the ventricle. This cannot actually take place, or a vacuum would be left at the root of the aorta, but the tendency in that direction causes a low pressure and consequent suction action at the aortic orifice. This lower pressure or suction leads to a wave in a backward direction, completing the closure of the semilunar valves. This is reflected forward again as the dicrotic wave. The dicrotic wave is most pronounced when the smaller arteries are dilated and the peripheral resistance is low. In this case the column of blood, meeting with little opposition, is thrown out of the ventricle with greater speed and momentum, and the recoil against the semilunar valves consequently occurs with greater force. There is some difference of opinion between clinicians and physicists as to the proper definition of dicrotism of the arterial pulse. For clinical purposes we may define a dicrotic pulse as one in which a well-marked dicrotic wave may be felt by the finger or seen in a tracing.

Immediately preceding the dicrotic wave another, and in this case (Fig. 4345) smaller, wave may be seen which is known as the *predicrotic* or *tidal wave*. The cause of this is more doubtful than that of the dicrotic wave. It is found in the curve of intraventricular pressure, and may even be present under certain conditions in the tracing of the transverse diameter of the frog's ventricle (Marey), so that it is frequently ascribed to a peculiarity in the contraction of the ventricular walls, "the systole not being equally sustained" (Foster) or "the outflow remainder wave" (Roy and Adami). There are those who ascribe this wave entirely to inertia and recoil of the instrument used. The instrument may, and often does, exaggerate it, but there is little doubt of another factor being present. The most plausible explanation is perhaps something like this: both the percussion wave and the predicrotic originate within the ventricle during its systole; the reason of there being a depression or notch dividing them into two is that a slight fall of pressure occurs when the semilunar valves open and afford a passage for the blood into the aorta. If the pressure in the arteries is low, the ventricle nearly empties itself with one effort, and the predicrotic wave is scarcely seen; but if the pressure is high, only part of the blood is forced out at first, and after a slight fall in pressure at the opening of the semilunar valves, the continued contraction of the ventricle raises it again up to or beyond its original height, forming the predicrotic wave. It is certainly a practical rule that where the predicrotic wave is pronounced and reaches a high level the blood pressure is high relatively to the strength of the ventricle.

Other secondary waves are sometimes seen upon pulse tracings and are probably due to oscillations taking place within the vessels, or in some cases they may be instrumental in origin. A multiplicity of secondary waves points to high blood pressure and consequent tension of the arterial walls. Elevations or depressions occurring upon the descending limb of a tracing are called catacrotic, those more rarely seen upon the ascending limb are called anacrotic. A tracing with interruptions upon the ascent is called an anacrotic tracing, and we may also speak of an *anacrotic pulse*. Similarly, where there are interruptions on the descent we speak of a catacrotic tracing and *catacrotic pulse*. A pulse may be both anacrotic and catacrotic. The normal tracing in Fig. 4345 is catacrotic only. The tracing shown in Fig. 4347 taken from a case of aortic stenosis, could be classed as both anacrotic and catacrotic. The predicrotic wave forms the summit of the tracing and indicates resistance to the outflow of blood from the ventricle; the primary or percussion wave forms an anacrotic crest or angle on the ascent, and the dicrotic wave is seen as an elevation on the descent (catacrotic).

Factors Contributing to the Character of the Pulse.—The exact character of the pulse depends on three principal factors: the force of the ventricular contraction, the degree of elasticity of the arteries, and the resistance offered to the outflow of blood from the arteries into the capillaries and veins. The quantity of blood in the body naturally occurs to one as a modifying factor, but its influence is difficult to trace, and in any case it probably acts chiefly by modifying the ventricular contraction. An additional factor that does, without doubt, however, exert a modifying influence in special cases is the condition of the aortic and to a much less extent of the mitral valves. Of the three principal factors mentioned *the ventricular contraction* determines the rate and combines with the other two factors to give the pulse its other qualities. *The elasticity of the arteries* modifies the pulse in the direction of less abruptness. The more elastic the larger arteries are, the less sudden is the increase of tension in the smaller ones. The diminished elasticity of age tends to make the rise of the pulse wave steeper. In cases of low blood pressure the same effect is noted, because the elasticity of the arteries is not fully brought into play. *The peripheral resistance* depends largely upon the degree of activity of the muscular coats of the arterioles. When these are relaxed the blood pressure falls, the ventricle empties itself easily, and the pulse is large and soft. When the arterioles are contracted the blood pressure rises, the work of the ventricle is increased, and this is indicated in the pulse by hardness and a prominent predicrotic wave. Advancing age tends to raise the peripheral resistance by the withering of many of the capillaries and consequent narrowing of the channel by which the blood

Fig. 4347.—Anacrotic Pulse (aortic stenosis).

must flow from the arteries into the veins. Age also affects the force of the ventricles and the elasticity of the arteries so that the pulse in old people varies according to the part of their vascular system where degenerative changes have been most active. As the thoughtful observer notes in the pulse the modifications brought about by ventricular activity and peripheral resistance, he will find there suggestions of many possible influences acting through the cardiac and vasomotor nerves.

Rate of Propagation.—It takes a certain measurable time for the effect of the ventricular contraction to make itself felt in increased tension of the peripheral arteries. In other words, the pulse waves travel at a certain rate. This "rate of propagation" varies somewhat, but is usually given as between three and ten meters a second. It is considerably influenced by variations in blood pressure and by the degree of rigidity or elasticity of the arteries; the more rigid the vessels the more rapid the propagation of the pulse.

Further information on some of the subjects treated of above will be found in the article on *Blood, Circulation of the.*

The Examination of the Pulse and What it Shows.—One should not make any direct examination of the radial pulse until he has obtained what information he can by inspection of the visible parts of the body. A glance is often sufficient. In the face one can find indications of the condition of the capillary circulation in the glow of health or in pallor or lividity. In the neck there may be violent throbbing of the arteries or distention and pulsation of the veins. In the fingers one may find lividity and clubbing or a capillary pulse. The pulsation of the temporal and radial arteries may be visible.

It is important to choose for the examination of the pulse a time when the patient is as little excited as possible. It is well to distract his attention by conversation. To obtain the best results the patient should lie or sit in a comfortable position. The observer should be in front of the patient or to his right side. The patient's right arm should be supported with the elbow flexed and the forearm half pronated. Two or three fingers of the observer's right hand should be laid upon the radial artery where it passes over the lower end of the radius between the styloid process and the flexor tendons. The fingers are to be moved up and down the artery and across it, flatten out the vessel so as to bring out *the condition of the arterial wall.* If the artery can be felt and rolled beneath the fingers when flattened out it indicates the thickening of arteriosclerosis or the rigidity of atheromatous or calcareous degeneration. If the latter change has taken place to a marked degree, one can often feel the arterial wall to be uneven and ribbed. If the artery can be felt to be tortuous, one is justified in inferring that the patient has been the subject of relatively high blood pressure extending over a long period. In examining the wall, as described above, an impression will often be received of *the caliber or fulness of the artery.* One is very apt to be misled on this point, according to Leonard Hill, by the fact that the venæ comites accompany the artery and contribute to the sensation of size given to the finger.

The arterial pressure may be roughly estimated by the amount of pressure which must be exerted by the finger to obliterate the pulse in the portion below. The artery should be pressed directly backward against the radial bone, and it is well to compress it below as well as above the examining finger so as to exclude any "anastomotic pulse" from a communicating vessel. Even under the most favorable circumstances the estimation of blood pressure by digital examination is only approximate. One is very liable to confuse the sensation given by high arterial pressure with that of a thickened or calcareous artery. For an accurate estimation it is necessary to employ one of the various instruments which will be described shortly.

The pulse proper should be examined with reference to its rate, regularity, size, and quickness. The so-called *hardness or softness of the pulse* is practically identical with the arterial pressure which has just been discussed. *The rate of the pulse,* whether frequent or infrequent, is to be determined by counting the pulse beats by a watch for not less than half a minute. It is well to note the number of beats in each period of five seconds so as to determine whether or not the rate is variable.

When the pulse is too frequent to be successfully counted in the ordinary way it is sometimes possible to calculate its rate by counting every second beat and doubling the result. When some or all of the beats are too feeble to be distinguished, the rate can be obtained by auscultation of the heart. A record of the variations in the pulse rate from day to day is often valuable. Before drawing conclusions from the rate of the pulse, due weight must be given to the fact that it may be modified by very slight influences such as the position of the patient or slight mental excitement. If the rate be abnormally high it should be counted again when any excitement has had time to subside. The rate of the pulse varies much within the limits of health. *Age* has a very great influence. The average rate is something over 130 in the first year of life, about 90 in the tenth year, 70 in adult life, and 75 or 80 in those who have passed the allotted span. *Sex* has little influence, the average in females being only a few beats per minute more than in males

of the same age. What little difference there is in the two sexes may with reason be attributed to *size*, for, as a rule, the greater the height the less frequent the pulse. Tables showing in more detail the effects of age, sex, and size on the rate are given in the article on *Blood, circulation of*. *The time of day* has a slight influence on the pulse rate, which is usually five or ten beats higher in the afternoon and evening than in the morning. *Meals*, especially if hot, may increase the rate for one or two hours. *Change of position* from lying to sitting raises the rate from two to five beats per minute. On standing a further increase of four to eight beats may result. *Exercise* has a still greater influence, very slight exertion sending the pulse up twenty or thirty beats, and violent exercise may more than double the rate. An increased frequency out of all proportion to the effort made is commonly seen in the debilitated and the diseased.

Pathological frequency of the pulse may be conveniently divided into three groups (Mackenzie). First, those in which the heart responds to an extra call upon it by an excessive increase of rate; second, those in which the pulse rate is continuously increased; third, those in which periods of increased rapidity takes place in irregular paroxysmal attacks.

To the first group of *abnormal excitability* belong all cases in which the reserve power of the heart is impaired. This may be the result of some general disease or of valvular or other heart affection. When no other sufficient cause can be found, one may suspect a neurotic temperament or the abuse of some stimulant or narcotic (alcohol, tea, or tobacco).

In the second group of *continued frequency* we may place (*a*) most febrile diseases. In fever the pulse usually bears some relation to the temperature. It is commonly increased about ten beats per minute for each degree Fahrenheit of pyrexia. Marked exceptions to this rule are found in typhoid fever where the increase in the pulse rate is usually small for the amount of pyrexia, and in meningitis where the rate is very variable, but may be lower than normal in spite of considerable fever. (*b*) Diseases of the heart. Increased frequency of the pulse is a common but by no means an invariable symptom of valvular disease. In disease of the aortic valves, especially aortic stenosis, the pulse rate is less likely to be increased than in mitral disease. In degeneration of the heart muscle the pulse rate is very variable, and may be either higher or lower than normal. The rate is usually increased in pericarditis and in overstrain from excessive work. (*c*) Exophthalmic goiter. (*d*) Numerous other conditions such as incipient tuberculosis, exhausting diseases, neuroses, pregnancy, hemorrhage, alcoholism, great anxiety, severe pain.

The third group of *paroxysmal attacks* embraces palpitation and paroxysmal tachycardia. In *palpitation* we have a sudden onset of rapid, violent heart action accompanied by throbbing of the larger arteries. This excessive throbbing does not extend to the smaller arteries, "the radial pulse, for instance, being rapid but having no excess of force" (Balfour). True palpitation occurs in weakly anemic individuals, and is induced by psychical and gastric reflexes of various origins, "never by exercise." The patient is usually painfully conscious of the violent action of his heart.

In *paroxysmal tachycardia* the subjective symptoms are less pronounced. The heart may be beating even more frequently than in palpitation, and yet the patient be unconscious of the fact. The attacks are variable in duration, but may last several days. During the attack the heart frequently dilates as a result of incomplete emptying by the rapid feeble beats (see *Arrhythmia, cardiac*).

Diminished frequency of the pulse must always be carefully distinguished from those cases of missed beat in which only every second pulse is strong enough to be felt at the wrist. It is a safe rule to count the heart sounds before diagnosing an abnormally slow pulse. An infrequent pulse is sometimes present in individuals who show no other signs of disease. It is said that the pulse of Napoleon Bonaparte was never over forty. An infrequent pulse is most common in the latter half of life. It may sometimes be a symptom of degeneration of the myocardium. It is often seen in diseases accompanied by high blood pressure, such as chronic nephritis, and as a result of poisons produced within the body, as in jaundice, or introduced from without, as digitalis. The most marked instances of infrequent pulse, or *bradycardia*, as it is called, are those following injury to the spinal accessory nerve. This nerve arises from the spinal cord as far down as the fifth or sixth cervical vertebra, and may be implicated in fracture of the spine or inflammatory compression of the cord in this region. In such cases the pulse may fall to thirty, twenty, or even lower. A pulse rate of eight per minute has been recorded. In such cases syncopal attacks and epileptiform seizures are common (see *Arrhythmia, cardiac*).

Regularity of the Pulse.—In healthy people who are not suffering from any disturbing influences, the pulse beats are usually regular in rhythm and volume. This may be recognized by the examining finger. In some cases, however, we find variation in the intervals between the beats or in their volume or both. Such departures from the normal present themselves in a great variety of types which will be found described in the article on *Arrhythmia, cardiac*.

Size or Excursion of the Pulse.—Pulsus magnus or parvus, large or small pulse. These terms are used to describe the sensation that the finger has of being lifted as the pulse wave passes. When the sensation is very considerable we speak of a large pulse, when it is slight of a small pulse. One naturally explains this sensation by supposing that the artery expands as the result of increased tension. Many writers, however, among whom Sir William Broadbent is prominent, minimize the effect of arterial expansion or deny its occurrence. According to them the finger pressing upon the wrist pushes in or flattens the artery between the beats, but feels a tendency of the vessel to resume its cylindrical shape under the increased tension of the pulse wave. This latter view seems very reasonable, but some slight expansion must certainly take place.

A large pulse means that a large quantity of blood is being forced into the arterial system at each heart beat and points to a powerfully acting ventricle and unobstructed vessels.

A small pulse may be present in a variety of conditions. It may be from the presence of some disease of the valves of the heart putting the ventricle at a disadvantage. It may be from some obstruction between the ventricle and the wrist, such as aortic stenosis, aneurysm, or tumor. Or the artery being examined may be abnormally small on account of some other artery like the ulnar being larger than usual. The most obvious cause of all is a heart beating feebly.

If we get a small pulse in a contracted artery we call it a wiry pulse, if the arterial tension is still considerable; if the tension is low and the pulse very small, we speak of a thready pulse, which is seen in cases of severe shock or where a patient is in extremis. A small pulse in a relaxed vessel is sometimes spoken of as a trembling or a running pulse.

Quickness of the Pulse.—Pulsus celer or tardus, quick or slow pulse. These terms are properly applied not to the rate of the pulse, but to the suddenness with which the expansion of the vessel takes place. In the quick pulse the sensation imparted to the finger is that of a sudden tap. In the slow pulse there is a sensation of more gradual lifting or heaving, and the feeling of pressure lasts for an appreciable time. A quick pulse is seen when the ventricle empties itself

easily. It is usually present when the blood pressure is low, but not in aortic stenosis, for then there is obstruction to the work of the ventricle. The most characteristic form of quick pulse is the Corrigan's or water-hammer pulse of aortic regurgitation. The character of a slow pulse differs according to the position where the obstruction to the outflow of blood from the ventricle may be. If the obstruction is at the aortic valves the pulse is slow and of low tension, as in aortic stenosis. If the obstruction be in contracted peripheral vessels, then the pulse is slow and of high tension, as in chronic nephritis.

Symmetry of the Pulse.—An examination of the pulse is not complete without comparing the corresponding arteries on the two sides of the body. When there is a difference on the two sides, it is necessary to trace up the course of the vessel on the side where the pulse is weakest. Somewhere in its course from the heart to the wrist one may find a tumor or aneurysm or dilatation interfering with the normal propagation of the pulse waves on one side, usually the left. Dr. Allison, of Edinburgh, made the claim in a clinical lecture some seventy years ago that he had observed in a severe case of fever that the pulse has a fuller character on the side on which the patient was lying. He ascribed this to the influence of gravity acting on weakened relaxed vessels much as it would do after death.

Failure of the Radial Pulse When the Arms are Elevated.—Sewall has drawn attention to the fact that in certain cases elevation of the hands above the head while in the upright position leads to failure of the pulse in one or both radials. This is seen in certain cases of exhaustion, during convalescence from fevers and in well-compensated valvular disease. It does not usually occur during the acute stage of fevers, in valvular disease with marked failure of compensation or in general arteriosclerosis. In some cases the failure of the pulse only occurs during one or other phase of respiration. He ascribes the phenomenon to an exaggerated vasomotor reflex in which contraction of the radial arteries helps to maintain the blood supply to more vital tissues by diverting the stream from less sensitive organs.

Field of Response.—This is a term suggested by Mackenzie for the ability of the heart to rise to occasions. We may also speak figuratively of the heart's "bank account." This may be investigated by noting the effect upon the pulse of various degrees of exertion. Sometimes a pulse which seems good when the patient is resting changes its rate and character to such an extent on slight exertion as to indicate serious weakness. The breathing should be noted and may furnish confirmation of the opinion formed from the pulse. This is a method of considerable value in estimating the seriousness of an irregular pulse. The less dangerous forms of irregularity tend to disappear on slight exertion, whereas cases due to a failing heart may be expected to show increase of irregularity and breathlessness (limitation of the field of response).

Instrumental Aids in the Examination of the Pulse.—*The caliber of the vessel* may be approximately measured by Oliver's arteriometer. The principle is that a pointer on the graduated dial marks the distance which the central foot has to be pushed down from the time it begins to press on the artery till it quite obliterates it. The readings of this instrument may not be absolutely reliable, but it is sufficiently accurate for comparing the size of the same artery under different circumstances. In this way it has been used by the inventor for working out the effect of various influences on the vasomotor tone and the distribution of the blood in the body.

Arterial Pressure and the Sphygmomanometer.—Of all instruments used in the examination of the peripheral circulation those most in vogue at the present time are without doubt the various forms of sphygmomanometers for the estimation of arterial pressure.

Definitions.—Blood pressure is the pressure exerted upon the inner wall of the vessels by the contained blood. It is usually expressed in millimeters of mercury. When the term blood pressure is used without any qualification arterial pressure is usually understood. *Systolic or maximal pressure* is that exerted during the primary or systolic wave of the pulse, when the contraction of the ventricle is raising the arterial pressure to its highest point.

Diastolic or minimal pressure is that exerted at the end of diastole, when the arteries have partially emptied themselves into the capillaries and veins.

Pulse pressure is the increase in pressure which results from the passage of the pulse waves and equals the difference between the systolic and diastolic.

Sphygmomanometers.—While the instruments on the market for the estimation of blood pressure are many, the principles involved in most of them are very similar. The essentials are an air cushion with which a limb and its blood-vessels may be compressed, a pump by means of which the pressure exerted by the cushion may be raised to any desired height, a manometer to indicate the pressure exerted on the vessels at any moment and the necessary tubing to connect these parts with one another.

The usual form of air cushion now used is a cloth armlet containing a distensible rubber bag. For accurate results the armlet should be not less than twelve centimeters wide and may be reinforced on the outside with leather. The pump may be a rubber bulb with necessary valves or a small modification of a bicycle pump. The manometer may be either of the mercurial or the aneroid dial type. Both forms are more or less liable to become inaccurate with age. The mercurial may suffer from chemical changes in the mercury and the aneroid may become changed by overstretching of certain parts of the internal mechanism. These defects are probably somewhat exaggerated by competing dealers and as a matter of fact very reliable instruments of both types may be obtained. The aneroid form is the most portable and convenient and is sufficiently accurate if occasionally tested with a recently standardized instrument. For the past couple of years the writer has been using one of Dr. Rogers' Tycos instruments and during that time it has not deteriorated appreciably. Several other makes are probably equally good.

Methods.—A proper examination of the arterial pressure involves the estimation of both systolic and diastolic pressure and for each of these there is a choice of methods.

Systolic Pressure.—Palpatory Method.—The armlet is adjusted around the upper arm, the pressure is raised with the pump until the radial pulse can no longer be felt, the pressure is allowed to fall gradually by manipulation of the valve until the radial pulse just begins to be perceptible; at this point the manometer reading gives the systolic pressure.

Auscultatory Method.—Instead of palpating the radial artery one may listen for the return of the pulse with a stethescope applied over the brachial at the bend of the elbow. For this purpose it is convenient to use a bracelet stethescope as sold for the purpose. The pressure in the armlet is raised and gradually lowered as in the case of the palpitory method. At the moment when sounds begin to be heard the systolic pressure is indicated on the manometer.

Diastolic Pressure.—Maximum Oscillation Method.—This method can only be carried out with an aneroid manometer or with an instrument supplied with special recording apparatus. Raise the pressure in the armlet up to or above the systolic level and then allow it to fall very gradually. As the pressure falls note the oscillations of the manometer needle or

recording lever. At the moment when the oscillation is greatest the manometer is thought by some to register the diastolic pressure.

Auscultatory Method.—Better and more accurate results are obtained by this method. As in the case of the systolic pressure one listens over the brachial artery with a stethescope. As the pressure falls below systolic various changes in the sounds occur but when they suddenly become faint the manometer reading may be taken as the diastolic pressure. In some cases the sounds cease entirely almost immediately after the sudden diminution in intensity. In aortic regurgitation and in some other cases sounds may still be heard when the pressure is further lowered or entirely removed. It is pretty generally agreed that in such cases the sudden diminution in intensity rather than the total disappearance of all sound marks the diastolic pressure.

Pulse pressure is obtained by subtracting the diastolic reading from the systolic.

Criticism of Methods.—Both methods described for taking the systolic pressure are in most cases sufficiently accurate for clinical purposes and even approach absolute accuracy. The principal criticism is that of Russell who claims that a fallacy is introduced by the varying resistance of the arterial wall to compression. The resistance of the arterial wall, moreover, may be made up of two factors, hypertrophy or arteriosclerosis and contraction or hypertonus. In such cases the resistance overcome by the indicated pressure is blood pressure plus vessel wall and he claims that the latter may amount to a considerable proportion of the total. These objections are not taken very seriously by most other writers. For instance Leonard Hill and also McWilliams and Kesson after many experiments concluded that it is at most only in exceptional cases that any great fallacy is introduced by the resistance of the arterial wall.

A more important consideration is the fact that a rigid or hypertonic arterial wall favors a better conduction of the systolic pulse wave, and actually determines a higher systolic pressure in the arteries affected (Hill). This is accountable for the anomalous results which have been described in cases of arterial disease and aortic regurgitation. In these cases the degeneration may be more advanced in some vessels than in others and the systolic pressure taken in different arteries at the same level may differ by fifty or one hundred millimeters.

Of the methods of taking the diastolic pressure it may as well be admitted that the maximum oscillation method is quite unreliable. To begin with it is often very difficult to determine the exact level at which the maximum oscillations occur. A more important objection is that while Marey and a number of others have taught that the maximum oscillation corresponds to the diastolic pressure, others among whom are Hill and Barnard and C. J. Martin claim that it corresponds to mean pressure. To complete the confusion MacWilliam and Melvin have proved to their own satisfaction that the point of maximum oscillation does not bear any constant relation to either diastolic or mean pressure. In view of these conflicting results the method is obsolescent and is being superseded by the auscultatory method which is meeting with general acceptance. While the auscultatory has only recently come into general use it has so far stood the test of experiment well and is without doubt the best method at our disposal (MacWilliam and Melvin).

Normal Standards of Blood Pressure.—Most of the statistics of normal blood pressure heretofore published have been obtained by the older methods. With the use of the more exact auscultatory method, the systolic pressure will probably be found a few millimeters higher and the diastolic pressure a little lower than the figures given below. In the practical physiology class at McGill a few years ago the following results were obtained.

Systolic Pressure.—32 subjects—Maximum 140, minimum 90, average 115.

Diastolic Pressure.—21 subjects—Maximum 90, minimum 60, average 75.

Nicholson gives the following results as obtained by different observers.

Age.	Systolic.	Diastolic.
Erlanger—nineteen to twenty-five years	120	65 mm. Hg
Hirschfelder—All ages	115–120	75–85
Janeway—Before mid. life	100–130	25–40 mm. lower than systolic
After mid. life	130–135	25–40
Before second year	75–90	
After second year	90–110	
Normal—		
Cook—Before thirty years		120–130
Thirty years on		125–140
Abnormal—		
Before mid. life pressure above		145 mm. Hg
After mid. life pressure above		160 mm. Hg
Low Limit—		
Janeway—Male		100 mm. Hg
Female		90 mm. Hg

Children—"L. Gordon"—Systolic.

	Millimeters.
Under one year	71.0
One year	73.0
Two years	79.3
Three years	81.0
Four years	83.0
Five years	86.5
Six years	88.5
Seven years	85.0
Eight years	93.0
Nine years	100.0
Ten years	95.0
Eleven years	104.0
Twelve years	105.0

Faught gives the following rules for calculating the average normal systolic pressure at different ages. Consider the normal average systolic blood pressure for a male aged twenty to be 120 millimeters and add 1 millimeter for every additional two years of life. The average normal for females at the same age is approximately 10 millimeters less than for males. Faught would allow a variation of 17 millimeters above or below the average as within the limits of health.

The pulse pressure varies inversely with the rate of the heart. With a moderate heart rate and a normal diastolic pressure it averages in the neighborhood of 40 millimeters. As the diastolic pressure rises, indicating increased peripheral resistance, there is need of a higher pulse pressure to maintain an efficient circulation. Instead of stating a fixed standard of pulse pressure therefore it is more correct to say that it should bear a proportion to the diastolic pressure of about one-half. Thus if the diastolic pressure is 80 we should expect a pulse pressure of about 40. If the diastolic pressure is 100 we may expect a pulse pressure of 50.

Abnormal Variations in Blood Pressure.—Hypertension.—The systolic blood pressure is above normal in a great variety of conditions. A high systolic pressure tells us that there is something wrong, but what that something is must be determined by other means. Hypertension is a symptom not a disease. Among the conditions suggested by it are nephritis, arteriosclerosis, heart failure, amenorrhea, over-eating or drinking, physical or nervous strain.

The cardinal principle in the management of hypertension is to treat the patient and not the symptom. All one's knowledge of medicine is not too much to apply to the diagnosis and treatment of a case. It is important to remember that in many cases

the hypertension is protective and may be the last line of defense between the patient and circulatory failure. The indiscriminate prescribing of vasodilators in cases of hypertension is much to be deprecated. As a means of giving temporary relief they probably have a place, but their prolonged administration is more likely to do harm than good and is happily becoming less common. There is no panacea for hypertension. One must take the time and trouble to trace it to its cause and treat that as far as may be possible. If one cannot find out the cause of the hypertension he had better leave the blood pressure alone.

Hypotension.—The systolic tension is below normal in hemorrhage, shock, wasting diseases, and the later stages of infectious fevers. The same principles of seeking the underlying cause apply here as in hypertension. The treatment required is usually of the nature of rest, food, and tonics.

Our knowledge of diastolic and pulse pressure is so recent and incomplete that we cannot dogmatize as to the meaning of their variations. All we can do is to consider a few of the general principles which may be applied to a case.

The diastolic pressure is suggestive of the state of the peripheral vessels. If these are normal and relaxed the diastolic pressure is low. If they are sclerosed or contracted it is high.

The pulse pressure is rather an indication of the functional activity of the heart. A large pulse pressure suggests a strongly acting ventricle with a large output. A small pulse pressure suggests a weakly acting ventricle and small output. Other things being equal the more easily and quickly the ventricle empties itself the higher the pulse pressure.

Heart disease outside of affections of the aortic valve has surprisingly little effect on blood pressure. Both systolic and diastolic pressures are more often high than low in cases of organic heart disease. The pulse pressure is less altered than one would expect, except toward the end when the heart becomes unable to empty itself and pulse pressure falls.

The exceptions referred to above in the case of disease of the aortic valves are as follows: Regurgitation favors a large pulse pressure by allowing the blood to flow back into the ventricle during diastole, while stenosis favors a small pulse pressure by slowing the outflow from the heart.

The pulse pressure is also dependent to some extent on the condition of the walls of the aorta and larger arteries. When young and elastic they are easily distended to make room for the blood sent out by the heart and the pulse pressure is moderate. As the arteries lose their elasticity with age they resist distention more and more and we find a higher pulse pressure in proportion to the output of the ventricle. Almost any part of the body may have a share in modifying the blood pressure. The brain in the presence of worry, brain tumor, or deficient blood flow may raise the pressure through the action of the vasomotor nerves. In some cases there may also be a direct action on the heart through the cardiac nerves. Nephritis raises the pressure in a way not fully understood, possibly by the action of retained waste matters on the peripheral vessels. Innumerable toxic and nutritional disorders may influence blood pressure in one way or another.

After meditating long and carefully on all the considerations which have been referred to we will often still be uncertain as to the cause of an abnormal blood pressure and also as to the indications it offers of the state of efficiency of the circulation.

The writer believes that too much relative importance is attached to blood pressure estimations as a means of diagnosis. Its semblance of scientific exactness has won for it more respect than is its due. A much more valuable albeit simpler method of testing the efficiency of the circulation is to find out what effort the patient is capable of without respiratory or circulatory distress (Field of Response).

The pulse waves may be made to record themselves automatically by one of the various forms of *sphygmographs*. These instruments, as already said, are contrivances by which movements of a blood-vessel are transmitted to a lever, which records them on smoked paper. For the various forms of instrument and the method of using them the reader is referred to the article on *Cardiography*. The product is a tracing, of which a normal example has already been given in Fig. 4345.

Criticism and Appreciation of the Sphygmograph.—It was thought for a time that the sphygmograph would indicate, so that he who ran might read, the pressure, size, and quickness of the pulse, as well as the peculiarities incident to various diseases; these hopes have proved vain, and we now know that the sphygmograph is inferior to the finger in most of these points. One great difficulty in the interpretation of the sphygmogram is that a great variety of tracings may be btained from the same pulse by simply varying the pressure of the instrument or by employing different makes. Fig. 4348 shows three pulse tracings taken within a few seconds of each other from the radial artery of the writer. The differences are due to the pad being pressed down upon the artery with varying force. Fig. 4349 shows tracings taken, the upper from the carotid, and the lower from the radial of the same subject, within a few minutes

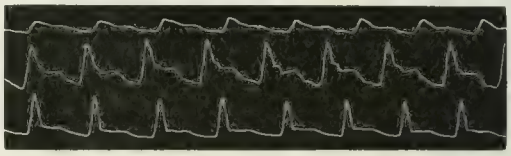


Fig. 4348.—Pulse Tracings Which show Effect of Varying Pressure.

of one another. In this case the carotid was recorded by air transmission and the radial by transmission through a spring. Features are sometimes found in pulse tracings which do not represent anything in the pulse at all, but are dependent on inertia or rebound of the instrument.

In spite of all these pitfalls that beset us, however, it is possible to take sphygmograms that will afford us much information about the pulse and the conditions which determine its character. In tracings we can see the principal events of the pulse in their proper time relations. They show us what to feel for, and corroborate or controvert the opinions we have formed of the pulse from our tactile examination. The sphygmograph is very useful as a guide to those who are learning to feel the pulse and in whose finger tips the tactile sense is not fully educated. There are points about the pulse, too, that even the most highly trained "thumb and finger fail to plumb" which are shown with ease by this instrument. The dicrotic wave and the predicrotic wave usually belong to this category. Of recent years the simple arterial sphygmograph has been largely replaced by the polygraph, an instrument with which tracings of the arterial pulse can be taken simultaneously with the venous pulse, the heart beat or the respiration. By means of the polygraph great additions have been made in recent years to our knowledge of the circulatory organs and their diseases. This is especially true of the various forms of arrhythmia and although the polygraph is now being supplemented and to some extent supplanted by the galvanometer it is still a most valuable if not an indispensable instrument for the diagnosis of many heart conditions.

Normal Sphygmograms.—High and Low Pressure.—The four tracings shown in Fig. 4350, are all taken

from people in good health without any circulatory or general disease.

So far as tracings can do so, the first of these four sphygmograms indicates rather high blood pressure and the last one low pressure, while the two between represent intermediate conditions. While a sphygmogram is very inferior to a sphygmomanometer reading and even to the finger as a means of estimating the arterial pressure it is well to be acquainted with the indications that it does give in this regard.

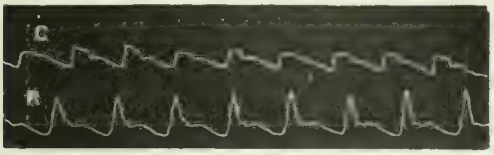


Fig. 4349.—Pulse Tracings Taken from the Carotid (*C*) and the Radial (*R*).

In the first place the tracing must be taken by a person of experience. A poorly taken tracing is very misleading. Where the blood pressure is high the rise and fall of the waves are more gradual, in low blood pressure quick or steep. In high blood pressure the dicrotic wave is usually small and high up on the descent. As the blood pressure becomes lower this wave becomes more distinct and approaches nearer to the base line, and may appear as a wave rivalling the primary wave in size and separated

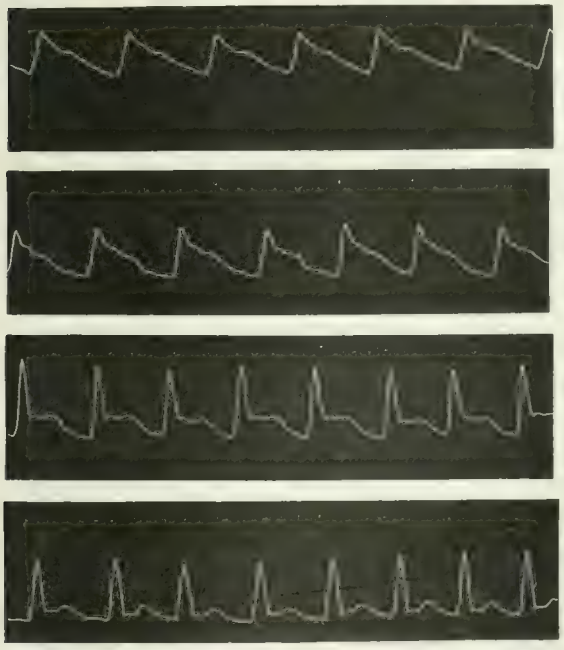


Fig. 4350.—Normal Pulse Tracings, Indicating Different Arterial Pressures.

from it by a distinct interval. If the blood pressure becomes very low indeed, as in cardiac failure, then the dicrotic wave becomes smaller again and may quite disappear. A well-marked dicrotic wave is a sign of relaxed peripheral vessels and not of a weakly beating heart. It is seen best developed at the beginning of fevers when the skin is hot and the blood distributed to the surface, but the heart still beating strongly.

The predicrotic wave is most pronounced in cases in which there is most resistance to the outflow from the ventricle, and therefore usually indicates high blood pressure. It is also seen, however, in aortic stenosis (see Fig. 4347). A practical rule for judging of the predicrotic wave is given by Gibson: "Draw a line from the top of the primary wave to the lowest point of the dicrotic notch." If the predicrotic wave fails to reach this line the pulse is of low or medium pressure. If the predicrotic wave rises higher and crosses this line the pulse is of high pressure (better, the resistance to outflow of blood from the ventricle is great). Another peculiarity often seen in high-pressure pulse tracings is the presence of several oscillation waves on the descent such as those seen in parts of Fig. 4351.

When interpreting tracings it is well to bear in mind that the part from the beginning of the primary wave to the bottom of the dicrotic notch corresponds to the time when the blood is being driven out of the ventricle into the arterial system. This almost corresponds with the ventricular systole, and may con-

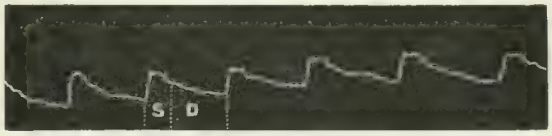


Fig. 4351.—High-tension Pulse. (Hutchison and Rainey.)

veniently be called *the systolic portion* of the tracing. From the bottom of the dicrotic notch to the beginning of the next primary wave the aortic valves are closed and no blood is leaving the ventricle. This may be called the *disastolic portion* of the tracing.

Any peculiarities in the systolic portion may usually be traced to the ventricle; but the diastolic portion cannot depend directly upon the ventricle, as during this time the aortic valves shut off the arteries from the heart. Variation in the rate of the pulse is brought about principally by shortening or lengthening of the diastolic portion. Thus in an infrequent pulse like that in Fig. 4351 the diastolic portion which I have marked *D* is about twice as long as the systolic portion *S*, whereas in Fig. 4352 where the pulse was 130 as the result of a fever, the two portions are of about equal duration.

In some tracings the bottom of the dicrotic notch forms the lowest part. These tracings are called

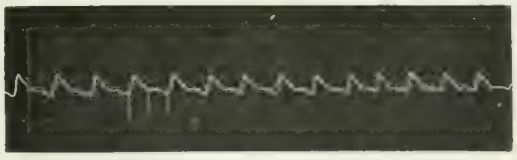


Fig. 4352.—Frequent Pulse.

hyperdicrotic. An example is shown in Fig. 4353 in which *S* is the percussion and *D* the dicrotic wave. It will be noticed that the dicrotic notch *N* is the lowest part of the tracing. This may usually be explained by the fact that diastole has become shortened to such an extent that the descending limb of the dicrotic wave has not time to reach a low level before the next percussion wave interrupts it. Gibson has published a few examples of hyperdicrotic tracings in which this explanation did not seem possible. In such cases one would have to consider the possibility of the phenomenon being dependent on a hypersensitive instrument.

The Pulse in Various Pathological Conditions. —*Affections of the Aortic Valve.*—The pulse of aortic regurgitation is one of the most typical, and is known as *Corrigan's pulse*, from Sir Dominic Corrigan, who was one of the first to describe it, or as the *water-hammer* pulse from a toy of that name that gives a

sudden shock to the fingers. Corrigan's pulse may be described as large and quick, usually infrequentl and regular. It is sometimes described as collapsing because the vessel seems to become empty between the pulse beats. The impression given to the finger is that of a momentary tap.

The peculiarities of Corrigan's pulse are best made out by raising the patient's arm high above his head while feeling his radial.

The statement made by Henderson, Balfour, and others that the rate of propagation is slower in aortic regurgitation than where the heart and vessels are normal has been shown by François Frank, Keyt, and Mackenzie to be without foundation. A prominent feature of aortic regurgitation is the violent throbbing of the vessels of the neck. A capillary pulse may also usually be seen. In some cases the pulse wave passes right through the capillaries into the veins and may be observed in the veins of the

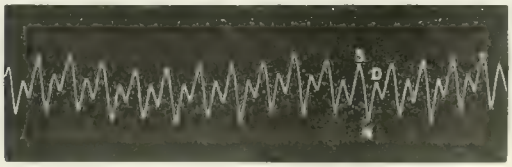


Fig. 4353.—Hyperdicrotic Pulse. (Mackenzie.)

back of the hand, and, sometimes, a tracing may be obtained of this rare form of venous pulse. Such a tracing is figured in Gibson's book on the heart.

Tracings from the radial in aortic regurgitation are characterized by a steep rise and fall of the percussion wave and by the fact that the predicrotic wave is usually more pronounced than the dicrotic. The tracing shown in Fig. 4354 is from a case of moderate severity and illustrates these points. In a more pronounced case the dicrotic wave would be still less marked or even absent altogether, and the percussion wave might be even steeper in its rise and fall. The presence of a fairly pronounced dicrotic wave does not, be it noted, exclude a moderate degree of aortic regurgitation.

The pulse of *aortic stenosis* is not so characteristic as that of regurgitation. It usually feels slow and sustained to the examining finger, is of normal or diminished frequency, and, like that of aortic regurgita-

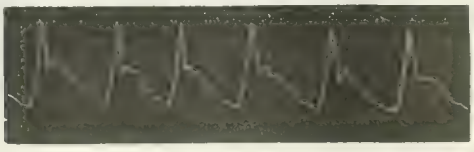


Fig. 4354.—Aortic Regurgitation.

tion, regular in rhythm and volume. The tracing is usually anacrotic (see Fig. 4347). The predicrotic wave rises higher than the primary, indicating the difficulty the ventricle has in emptying itself. The details vary in different cases. Sometimes the primary and predicrotic waves form two well-marked crests separated by a distinct depression, forming the so-called *pulsus bisferiens*. In other cases instead of the tracing being anacrotic we may simply have a primary wave with a gradual rise and a rounded crest, followed by a poorly marked dicrotic wave.

In *mitral regurgitation* and *mitral stenosis* the pulse may be quite indistinguishable from the normal. As one or other of these diseases progresses, however, dilatation of the ventricle, and especially of the auricle, takes place; then the pulse tends to become weak, rapid, and markedly irregular in both rhythm and volume, constituting what was formerly called the *mitral pulse*. This irregular pulse of mitral disease is now known to be dependent upon concomitant changes in the heart muscle and indicates fibrillation of the auricles (see Arrhythmia, cardiac).

Affections of the Heart Muscle.—There is nothing uniform or typical about the pulse in these conditions. It may be abnormally slow or fast or irregular. The cardiac field of response is diminished. Any departure of the pulse from the normal rate or rhythm should lead one among other things to consider the probability of the heart muscle being diseased, but other considerations besides the pulse will have to be depended on for the solution of the question.

The presence of the pulsus paradoxus in certain cases of *adhesive pericarditis* has already been referred to.

In *arteriosclerosis* and especially in old age as pointed out by Léon Fredericq there is commonly a systolic plateau. Some of his tracings resemble quite closely Fig. 4351.

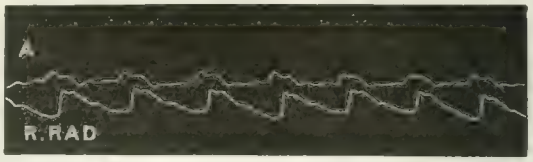


Fig. 4355.—Simultaneous Tracings from a Thoracic Aneurysm and from the Right Radial Artery.

In *aneurysm* of the transverse part of the aorta the left radial pulse is often smaller and slower than the right. It sometimes feels delayed too, but this is questioned by some writers. The exact character of the radial pulse varies greatly in cases of aneurysm according to the situation of the disease, the degree of degeneration of the vessels generally, and the condition of the aortic valves. Fig. 4355 shows simultaneous tracings from the aneurysm and the right radial in a case in which a large pulsating aneurysm extended from the chest up the right side of the neck. The exaggeration of the predicrotic wave seen in this tracing seems to be very common in aneurysm, as it is in both forms of aortic valvular disease.

In some cases of aortic aneurysm it is possible as Draper has shown to obtain tracings from the pulsating area resembling aortic (root) pressure curves. These tracings show two small waves preceding the

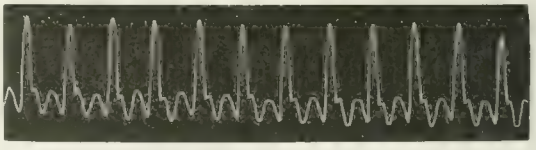


Fig. 4356.—Pulse in Sthenic Fever. (Mackenzie.)

main systolic plateau. There is some difference of opinion as to the causation of these smaller waves. It is more than possible that the first is dependent on the auricular systole and the second on the first part of the ventricular systole before the semilunar valves open (presphygmic period).

In fever we have to distinguish between the effect of the pyrexia as such upon the pulse and the effect of the disease causing the pyrexia. Moderate pyrexia tends to modify the pulse through both the heart and the peripheral resistance. The heart is made to beat more rapidly, partly by a direct action of the increased temperature on the heart tissue itself, and partly indirectly through the cardiac centers in the medulla. The superficial arteries are dilated and an increased amount of blood is carried to the skin. The effect of these changes is to cause a pulse of increased frequency and diminished pressure with exaggeration of the dicrotic wave. To the finger such a pulse feels frequent, large, and soft. It is often

referred to as bounding. A tracing would more or less approach the type shown in Fig. 4356.

If the pyrexia runs high or lasts long the heart suffers and becomes feeble and often irregular. In such cases the pulse is very frequent and is small, soft, and compresssible. Tracings taken at intervals, when the heart is failing, show gradual disappearance of the dicrotic wave, the absence of which in a case of fever is usually a very bad sign. Irregularity of the pulse in the early stages of a fever or increase of rate in an adult beyond 140 per minute are symptoms which usually indicate great danger. During convalescence slight irregularity is common and of little significance. The character of the pulse in fever may be much modified by other influences, such as specific poisons or mechanical interference.

Summary of the Diagnostic Value of the Pulse.—The pulse furnishes the best single indication of the state of efficiency of the circulation. In it we find indications both of the condition of the vessel walls and of the strength of the heart beat.

Very important information may be obtained by observing the changes in the pulse during bodily activity.

The discovery of high tension may direct our attention to the presence of nephritis or lithemia.

In aortic valvular disease a quick collapsing pulse or a slow, small pulse will indicate the predominance of regurgitation of stenosis.

In pericarditis with effusion, where the heart sounds are faint, the pulse is of especial value in indicating the degree of caridac failure.

In fever the rate, the tension, and the presence or absence of irregularity are of great prognostic value. A sudden change in the pulse may be the first indication of a crisis or a fresh complication. In many diseases the pulse is of value in furnishing indications for treatment (stimulants) and in exhibiting the effect of the remedies used.

In the search for all these indications the finger is the best means to employ. In special cases some of the more elaborate instruments may furnish additional or confirmatory information.

The Venous Pulse.—*Introductory.*—The term "venous pulse" is applied to changes in volume occurring in the veins as the result of the action of the heart. The distention and collapse of the veins incident to the alternate phases of respiration are not included. Being essentially a volume pulse, rather than a change of tension like the arterial, it is best observed by a visual examination of the neck. With the patient in the recumbent position it is usually possible to see rhythmic movements of the external jugulars and of the tissues overlying the internal jugulars. In normal individuals one usually sees a drawing in of the neck or negative pulsation synchronous with the arterial pulse. Other movements may be recognized in some cases but are best studied by graphic methods.

Historical.—The first description of the venous pulse in medical literature is claimed for Homberg who reported his observations before the French Academy in 1704. Lancisi in 1740 and Morgagni in 1762 developed the subject further. Morgagni recognized the two main types and pointed out how the pathological or ventricular form could be distinguished from the normal by noting the time relations between the movements of the jugular vein and the pulsation of the carotid artery.

The venous pulse in animals was described by Hunter in 1794 and by Barry in 1826. Wedemeyer in 1828 inserted a catheter into the jugular vein of a horse and connected it with a glass tube containing colored fluid. He was able to observe fluctuations in the height of the fluid with each heart beat. Bamberger in 1857 drew attention to the positive venous pulse as seen in cases of tricuspid regurgitation and a few years later published tracings of it. In 1863 Marey published the first tracings of the venous pulse in animals. Friedrick in 1865 emphasized the presence of the venous pulse in cases other than tricuspid insufficiency and described it as being made up of two waves one referable to the contraction of the auricle and the other to the shock of the aorta against the superior vena cava. Potain in 1881 took simultaneous tracings from the jugular vein and either the carotid artery or the apex beat so as to establish the time relations of the waves. He recognized the presence of the venous pulse in normal individuals and described the waves very much as we do to-day. Riegel in 1882 showed how the normal and pathological forms could be distinguished from one another by comparison of simultaneous tracings.

Later researches on the venous pulse have been numbered by the hundreds and it would be quite impossible to mention them all. The most important event in the recent history of heart medicine was the publication by Sir James Mackenzie of a book on "The Study of the Pulse" in 1902. In this work he drew the attention of the whole medical world to the fact that the venous pulse was of the greatest use in the diagnosis of many heart affections, especially those accompanied by some form of arrhythmia. His description of the various waves of the venous pulse and their mode of origin have not proved universally acceptable, but his personality has pervaded all recent work on the subject to such an extent that it is impossible to read and understand the modern literature of the heart without a knowledge of his conception of the venous pulse and of his terminology.

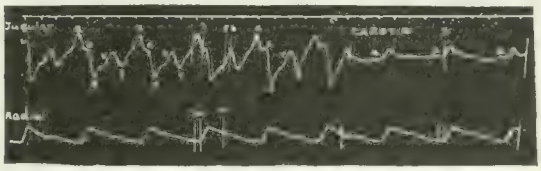


Fig. 4357.—Simultaneous Tracings of the Jugular and Radial Pulses and of the Carotid and Radial. (Diseases of the Heart, Sir James Mackenzie.)

Fig. 4357 shows a tracing taken from Sir James Mackenzie's "Diseases of the Heart." The methods of taking such a tracing are described in the article on Cardiography.

In this tracing Mackenzie describes the following waves:

The Auricular Wave (*a*) corresponds with the first rise in a tracing of intraauricular pressure and like it is due to the systole of the auricle.

The Carotid Wave (*c*) he ascribes to the fact that the subclavian and carotid arteries lie in such close proximity to the jugular vein that the receiving funnel covers a portion of these arteries, and the impact of the arterial pulse produces the wave (*c*) which he calls the "carotid wave."

The Ventricular Wave (*v*), he tells us, is due to the storing (or stasis) of blood in the auricle and vein during the ventricular systole. "While the beginning of this rise is very variable its termination is one of the most certain periods in the cardiac cycle, indicating the time of the opening of the tricuspid valve. The variableness in its beginning is due to the fact that it owes its origin to the quantity of blood stored in the auricle during ventricular systole, and this varies in individual cases, and also in the same individual, with exertion and respiration. The blood comes mainly from the periphery pouring into the auricles through the veins. When the auricle becomes filled, the surplus distends the superior vena cava and jugular, and hence appears in the tracing as a wave.

Another source is sometimes regurgitation through the tricuspid orifice. It is necessary to bear this in mind, as the failure to recognize how tricuspid regurgitation would be manifested in the venous tracing has led to a total misconception of the meaning and nature of the ventricular form of the venous pulse."

He calls this wave (*v*) the ventricular wave, because of its association with the systole of the right ventricle. "Thus the termination of the wave is due to the relaxation of the right ventricle and opening of the tricuspid valves; it is often made up of blood sent back through the incompetent tricuspid orifice by the systole of the right ventricle; though this wave may be small and of brief duration in the auricular form of the venous pulse, it becomes increased in size and the main or only wave in the ventricular form of the venous pulse."

The fall x which occurs during ventricular systole is due, he says, to three factors.

1. The relaxation of the auricle after its systole.
2. The dragging down of the auriculo-ventricular septum by the ventricular muscle and consequent enlargement of the auricular cavity.
3. The diminished intrathoracic pressure in consequence of the expulsion from the chest of the contents of the left ventricle.

When there is a delay in the contraction of the ventricle the fall due to the last two factors may be separated by a considerable interval from that due to the first.

The fall y, he tells us, is due to the blood that has been stored in the auricle during ventricular systole flowing into the ventricle after the opening of the tricuspid valves. Then, as the ventricle becomes filled, stasis in the auricles and veins takes place, causing the rise between *y* and *a* till the auricle again contracts.

Criticism and Discussion of Sir James Mackenzie's Account of the Venous Pulse.—As already indicated a number of writers have been unable to entirely accept Mackenzie's description as outlined above.

His account of the (*a*) wave has met with practically universal acceptance and does not call for special comment. Some writers have dignified the descending limb of the (*a*) wave with a separate description and designation. There is considerable difference of opinion as to its mechanism but its importance is scarcely sufficient to justify a discussion of it in a brief account like the present.

Over the second (*c*) wave a most heated controversy has been waged. Mackenzie ascribes it to an impact of the carotid wave against the vein or the receiving tambour and names it the "carotid wave." Many authors, including the writer, regard it as a wave transmitted into the veins from the auricle and originating in a sudden impact of the ventricular contents against the tricuspid valve at the beginning of systole. We prefer to call it the *systolic* (*s*) wave.

The arguments in favor of a carotid origin put forward by Mackenzie and his followers are as follows (Piersol).

(1) Its time falls within the time of active ventricular systole, synchronous with the carotid pulse.

(2) The size of this wave varies significantly according to the nearness of the pressure joint of the receiving cup to the carotid artery, and according to the depth at which it is placed in the neck tissue.

(3) The wave (*c*) is absent in the "liver pulse."

(4) During irregular heart action when the venous pulse continues and the arterial pulse is absent, in tracings of the jugular pulse taken at this time the carotid wave is not seen.

(5) When there is a distended jugular bulb the (*c*) wave is not apparent in the venous tracing.

(6) When the carotid wave is very prominent in a jugular tracing its shape often is almost identical with that of a tracing of the carotid pulse.

Some of the above statements are equally compatible with either theory of the "carotid" wave and others are of doubtful accuracy.

Those who dispute the essentially carotid origin of this wave, and ascribe it to the impact of the ventricular contents through the auriculo-ventricular valves, base their opinion on the following facts.

(1) It is present in pressure curves taken from within the auricle, from the superior vena cava and from the external jugular vein as well as in those from the internal jugular.

(2) Its size relative to the other waves is just as large in one case as in the other (see Fig. 4358).

(3) It usually or frequently precedes the carotid pulse by an appreciable interval (Bard).

(4) It persists in the internal jugular tracing after the carotid artery has been tightly clamped at its point of origin from the aorta.

That, moreover, it is not caused by the impact of the aorta against the superior vena cava is proven by the fact that it still persists in the vena cava tracing when the aorta is held away with retractors. In view of these considerations we feel justified in regarding this wave as dependent on the upward push

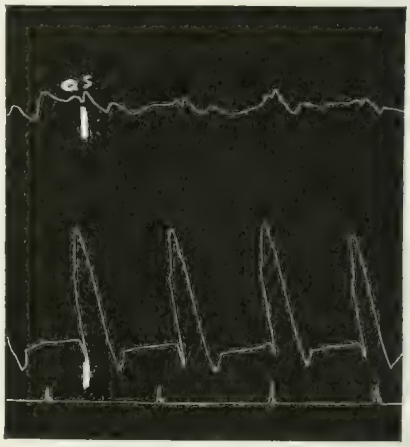


Fig. 4358.—Curves of Pressure from the Auricle (above) and Ventricle (below) of a Dog. *a*, Auricular wave due to the systole of the ventricle; *s*, systolic wave occurring at the time of ventricular systole and corresponding with the wave in the venous pulse which Sir James Mackenzie ascribes to the impact of the carotid artery.

of the tricuspid valves rather than on the impact of the arteries. This does not exclude the possibility that a receiving cup may be so applied to the neck that this wave may be reinforced by the impact of the carotid pulse, but this reinforcement is not a constant or essential feature of the wave. The writer with many others believes that it would be better to call this the *systolic* (*s*) wave which would not be emphasizing a causation which, to say the least, is open to grave doubt.

In the case of Mackenzie's "Ventricular Wave" the difference of opinion is less as to the mode of production and more as to the propriety of the name which he has given it.

If the reader will refer back to Mackenzie's excellent description he will find that this wave is mainly due to the distention of the veins by the onflow of blood from the periphery, which takes place more rapidly than the auricle can find room for it. For this reason the writer has suggested that it be called the *first onflow wave* (o_1) a name which has met with some favor. The name ventricular seems to imply an element of regurgitation from the ventricle. While tricuspid regurgitation is comparatively common and is a frequent cause of reinforcement of this

wave it can scarcely be regarded as a factor under perfectly normal conditions.

The fall in the venous tracing which occurs during the early part of systole has been arbitrarily named (*x*) by Mackenzie. In the opinion of the writer it would be better to give it a more descriptive name, such as *systolic fall* (f_1) from its time relations, or *auricular collapse* from the fact that the diastole of the auricle plays a large part in its production. The first is probably the best name as other factors besides auricular diastole contribute to its causation. Similarly the fall (*f*) of Mackenzie is better identified if called the *diastolic fall* (f_2).

Following the diastolic fall there is in cases of slowly beating hearts a gradual rise due to the blood flowing into the veins toward the heart faster than this organ can accommodate it. For this the writer has proposed the name *second onflow wave* (o_2) as the mechanism of its production is quite similar to that of the first onflow wave. It is absent when the heart rate is frequent, but when the diastole is prolonged it forms quite a prominent feature of the venous tracing and fills up the space betweeen the end of the diastolic fall and the beginning of the next auricular wave.

The venous pulse as obtained by the writer from a healthy dog is illustrated in Fig. 4359.

The waves of the venous pulse as understood and named by Sir James Mackenzie and the writer respectively may be summarized in the following table:

	Sir James Mackenzie		Alternative	
	Name	Cause	Name	Cause
1	Auricular wave	Auricular contraction	Auricular wave	Auricular contraction
2	Carotid wave	Impact of carotid artery	Systolic wave	Impact through tricuspid valves
3	*x* Fall	Relaxation of auricle, descent of auriculo-ventricular junction, change in intrathoracic pressure	Systolic fall	Same as Mackenzie
4	Ventricular wave	Stasis of blood during ventricular systole; sometimes tricuspid regurgitation	First onflow wave	Onflow of blood from periphery, in excess of what auricle can receive during ventricular dystole
5	*y* Fall	Emptying of veins and auricles into ventricles after opening of tricuspid valves	Diastolic fall	Same as Mackenzie
6	No special name	Stasis	Second onflow wave	Onflow of blood from periphery distending veins when auricles and ventricles are full

The waves above described are the most constant, and may be regarded as the cardinal or primary waves of the venous pulse. A number of other waves have been described which may be regarded as interposed between or superimposed upon the primary waves. In cases where the auriculo-ventricular interval is prolonged Bard describes a small wave which is interposed between the auricular wave and the systolic. He calls it the *intersystolic wave* and ascribes it to a recoil from the ventricle after auricular systole. Its occurrence has been confirmed by Ewing and others. With normal auriculo-ventricular interval it is fused with and loses its identity in the systolic wave. There is frequently seen a secondary wave (*d*, Fig. 4360) superimposed upon the rise of the first onflow wave. Riegel drew attention to this wave in 1882 and ascribed it to an impact through the ventricle at the time of closure of the semilunar valves. Ewing claims that this assumption is untenable as simultaneous tracings from auricle and ventricle show that the wave precedes slightly the closure of the semilunar valves. Ewing ascribes the wave to the upward movement of the base of the ventricle at the beginning of diastole and suggests that it be called the *diastolic wave.* Hirschfelder and Gibson have independently described a small wave which occurs early in diastole and corresponds in time with the third sound of the heart. It is ascribed to the sudden flapping together of the tricuspid valves by currents of blood during the filling of the ventricle. Hirschfelder calls it the "*h*" wave and Gibson the "*b*" wave. As usually seen it occurs as a small knee or crest on the ascent of the second onflow wave (*h*, Fig. 4360).

A second small crest (*w*, Fig. 4361) is sometimes superimposed on the second onflow wave near its termination and has been ascribed by Hirschfelder to the contraction of embryonic muscular tissue around the terminations of the great veins.

Pathological Variations in the Form of the Venous Pulse.—A great deal of obscurity has been introduced into the literature of the pathological venous pulse by the attempt to include under one head several forms which have little or nothing in common.

The most important variations are seen in:

1. Tricuspid regurgitation.
2. Auricular fibrillation.
3. Simultaneous contraction of auricles and ventricles.

1. In *Tricuspid Regurgitation* the back flow of blood from the ventricle may have different effects on the venous pulse according to the amount of the regurgitation, the part of the cardiac cycle in which it occurs and the degree of stasis in the veins.

It may cause chiefly reinforcement of the systolic wave as seen in Fig. 4361. In this case the regurgitation was probably very moderate in amount and occurred chiefly in early systole.

The regurgitation may affect chiefly the first onflow wave as seen in Fig. 4362.

In many cases we notice shallowing or obliteration of the systolic fall. This may be seen to some extent in Fig. 4362 and may be ascribed to the fact that when the auricle goes into diastole it is partly filled by blood flowing back from the ventricle which leaves less to be drawn from the veins. In cases where the regurgitation is more pronounced we may find the systolic fall entirely absent with a consequent fusion of the systolic and onflow waves into a more or less complete systolic plateau as seen in Fig. 4363. The venous tracing in this case was taken from the external jugular so as to exclude any suspicion that the form of the waves might be due to impact from the carotid artery.

When the auricle is much overdistended its power of contraction may become impaired and the size of the auricular wave approaches the vanishing point as in Fig. 4364.

The writer likes to describe each tracing as it presents itself rather than to force a great variety of

tracings into the narrow bounds of one general description. It does not seem possible, for instance, to describe the large combined wave, seen in tricuspid regurgitation and refer to it by the name of any single

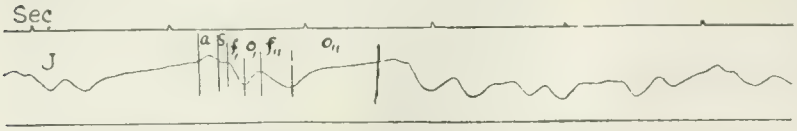


Fig. 4359.—Tracing from Internal Jugular Vein of Dog. Respiratory variations in pulse rate may be observed. Time in seconds. *a*, Auricular wave; *s*, systolic wave; f_1, systolic fall; o_1, first onflow wave; f_{11}, diastolic fall; o_{11}, second onflow wave.

wave of the normal tracing. It is not exactly the same as either the systolic or the onflow wave, although it includes both. *Systolic Plateau* is suggested as a fairly appropriate designation.

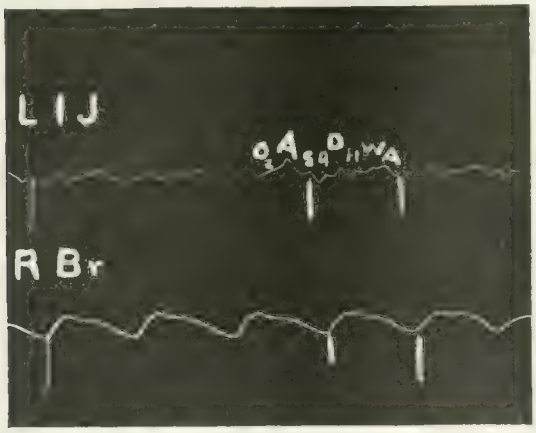


Fig. 4360.—Simultaneous Tracings from the Left Internal Jugular Vein and the Right Brachial Artery. O_2, Second onflow wave; *A*, auricular wave; *S*, systolic wave; O_1, first onflow wave; *D*, diastolic wave; *H*, Hirschfelder's *h* wave; *W*, Hirschfelder's *w* wave. It will be noticed that the waves *h* and *w* occupy the place of and are really superimposed upon the second onflow wave.

2. *Auricular Fibrillation* will be found described in the article on *Arrhythmia* from which the tracings shown in Figs. 4365 and 4366 are taken. The lettering has been changed to correspond with that recommended above.

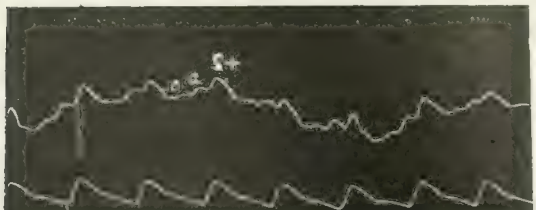


Fig. 4361.—Simultaneous Tracings from the Internal Jugular Vein and Brachial Artery. *O*, Onflow wave; *a*, auricular wave; *s*+, systolic wave reinforced by regurgitation through the tricuspid valves. The patient was in Dr. Grant Stewart's ward in the Western Hospital. He had a history of rheumatism, a dilated heart, systolic murmurs in the mitral and tricuspid areas, and a well-marked venous pulse. Note the unusual prominence and duration of the systolic wave *s*+.

These tracings show absence of the auricular wave and of the systolic fall, fusion more or less complete of the systolic and first onflow waves to form a systolic plateau, presence of the second onflow wave where the pulse intervals are sufficiently long. The irregularity in the length of the pulse intervals is a characteristic feature. In many cases tracings from cases of tricuspid regurgitation and auricular fibrillation resemble one another, but where both take so many different forms it is better to describe each tracing as it presents itself rather than to try to generalize too much.

3. *Simultaneous contraction of auricles and ventricles* is seen in ventricular and auriculo-ventricular extra-systoles whether these be occasional or are constant features of a paroxysmal tachycardia. The two chambers also contract together at intervals in complete heart block. In all these cases the auricular and systolic waves are fused into one large (a + s) wave. The combined wave may be much higher than the arithmetical sum of its constituents. This is explained by the fact that the onflow of blood from

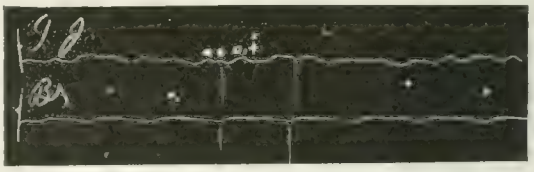


Fig. 4362.—Simultaneous Tracings from Internal Jugular Vein and Brachial Artery. Patient was a young man with a history of rheumatic fever, with shortness of breath on exertion and a systolic murmur of maximum intensity to the left of the sternum at about the level of the fourth cartilage. The large first onflow wave was ascribed by the writer to reinforcement of the first onflow wave by tricuspid regurgitation.

the auricle is impeded by the ventricular systole and the force of the auricular systole expands itself backward into the veins.

The auricular wave may also be fused with the first onflow wave in cases of heart block or in auricular extrasystoles. Examples of all these phenomena will be found illustrated in the article on arrhythmia.

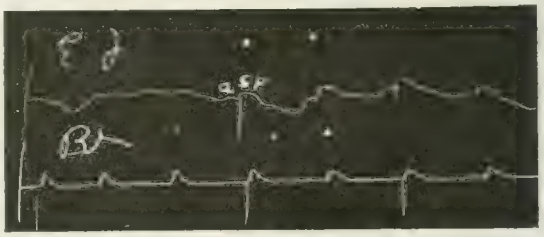


Fig. 4363.—Simultaneous Tracings from External Jugular Vein and Brachial Artery. The patient was a man of seventy-four with chronic diarrhea which turned out to be due to abdominal carcinoma. His heart was enlarged outward about an inch and there was a soft systolic murmur to be heard all over the pericardium. *a*. Auricular wave; *S.P.*, systolic plateau due to fusion of the systolic and first onflow waves with obliteration of the systolic fall by regurgitation through the tricuspid valves.

Confusion is sometimes caused by one or other of the waves of the venous pulse being of relatively abnormal size. In Fig. 4367 is shown a tracing where the auricular wave is much higher than usual. In this case there was a positive pulsation in the veins of the neck, suggesting tricuspid regurgitation, but actually due to the large auricular wave as shown by the tracing.

Sir James Mackenzie has drawn attention to the

occurrence of similar large auricular waves in cases of tricuspid stenosis but such a diagnosis could not be established in this case.

An unusually large systolic wave is frequently found in cases of exophthalmic goiter. The writer regards this as possibly due to transmission of the arterial pulse wave through the dilated arteries of the gland into the veins.

Many writers group together the various forms of venous pulse seen in tricuspid regurgitation, auricular

Fig. 4364.—Jugular and Brachial Tracings from a Woman Recently Operated On for Uterine Fibroid. Her heart was slightly dilated. Before operation a systolic murmur could be heard at the apex but at the time the tracing was taken one could only describe the first sound as muffled. Three months later the venous tracing was approximately normal except for some exaggeration of the first onflow wave. *a*–, Small auricular wave scarcely distinguishable in some cases; *S.P.*, systolic plateau due to fusion of systolic and onflow waves by back flow through incompetent tricuspid valves.

fibrillation and certain other conditions under the common names, of "*pathological*," "*positive*," or "*ventricular*" venous pulse. It is necessary to know this custom in order to understand references in the literature but the practice does not commend itself to the writer. The term pathological was applied before we knew how many different variations from the normal might be met with and is not a sufficiently exact term to have any real significance.

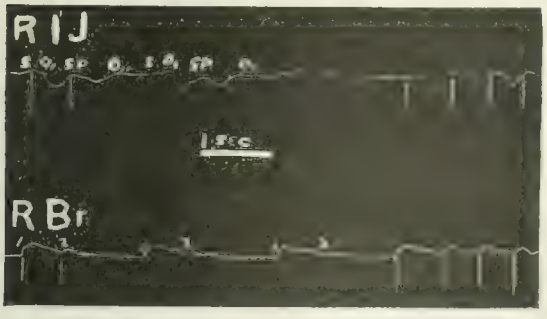


Fig. 4365.—Young Man with Rheumatic Valvular Disease and Auricular Fibrillation. Periods of pulsus bigeminus ascribed to action of digitalis. *s*, Systolic wave; o_1, first onflow wave; *S.P.*, systolic plateau due to fusion of systolic and first onflow wave; o_{11}, second onflow wave. The shallowing of the systolic fall with frequent fusion of the systolic and first onflow wave is partly explained by the absence of typical auricular diastole with drawing in of blood from the veins. An element of tricuspid regurgitation cannot be excluded as the heart was greatly dilated in all directions.

The term positive venous pulse is an excellent one to apply to the results of inspection of the veins of the neck when we find the usual systolic collapse replaced by systolic expansion, but this term is not to be regarded as sufficiently indicating the nature of the expansion. When we think we see marked positive pulsation in the veins we may find on further investigation any one of the following: tricuspid regurgitation; auricular fibrillation; exaggerated auricular wave; simultaneous contraction of auricle and ventricle from any cause; a venous pulse of normal type obscured by the violent arterial pulsation of aortic regurgitation, exophthalmic goiter or ordinary palpitation. To determine between these different conditions a tracing is usually necessary.

The term ventricular venous pulse may appropriately be applied to the form of pulse seen in auricular

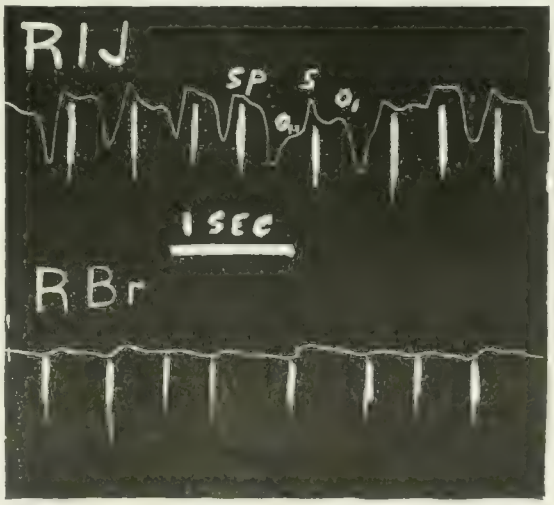


Fig. 4366.—Tracings from a Case of Auricular Fibrillation. *s*, Systolic wave; o_1, onflow wave only partially fused; *S.P.*, systolic plateau due to more or less complete fusion of systolic and first onflow waves; o_{11}, second onflow wave.

fibrillation when there is no indication of auricular activity, but it gives more definite information to say that the venous pulse shows the form characteristic of auricular fibrillation, and it is still better to describe it as suggested above. There is some difficulty about using the term ventricular venous pulse to describe the tracing from a case of tricuspid regurgitation as we get all possible gradations between the normal form of venous pulse and one closely resemb-

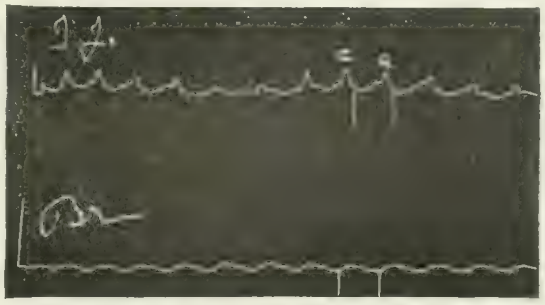


Fig. 4367.—Jugular and Brachial Curves. Patient was an old woman with an enlarged retroverted uterus. Heart moderately enlarged. Pulmonary 2nd accentuated. No murmurs. Note the large auricular wave (*a*). There was marked positive pulsation in the veins of the neck which could be seen and felt. Until the tracing was taken it looked like the positive pulse of tricuspid regurgitation.

ling that seen in auricular fibrillation. Here again it seems far better to describe the main waves as seen, adding perhaps that the form of venous pulse seems to point to tricuspid regurgitation of slight or pronounced degree as the case may be.

There are so many controversial points in connection with the venous pulse that it would be a good idea for some influential medical association, pre-

ferably international, to appoint a committee to consider the various diverging veins and recommend a uniform nomenclature.

The Liver Pulse.—A pulsation can be felt and recorded in the liver in certain cases in which the right side of the heart and the views are much distended. In some cases the tracing has the form corresponding to the auricular venous pulse. In these cases, according to Sir James Mackenzie, there are usually tricuspid stenosis and auricular hypertrophy,

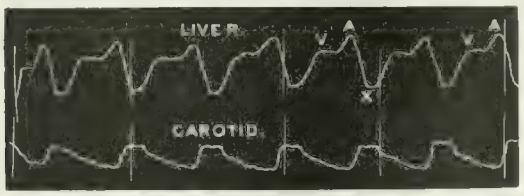


Fig. 4368.—Auricular Liver Pulse.

as the normally weak auricular waves have not force enough to make themselves felt in the liver.

In other cases the liver pulse has the characters of the ventricular venous pulse, and then we may be reasonably certain of the existence of tricuspid regurgitation. Tracings of these two forms of liver pulse taken from Mackenzie's book are shown in Fig. 4368 and Fig. 4369.

Capillary Pulse.—This consists in alternate reddening and paling of an area of the skin with each

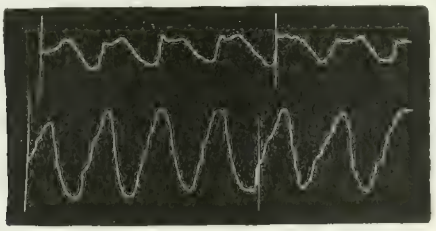


Fig. 4369.—Ventricular Liver Pulse. (Carotid above; liver below.)

heart beat. It is most frequently looked for in the bed of the finger nails, and may be brought out most distinctly by raising the arm. Quincke, who first described the capillary pulse, recommends rubbing gently a spot upon the forehead and looking for it there. The capillary pulse is chiefly seen in cases of aortic regurgitation with a strongly acting ventricle (hypertrophied). William S. Morrow.

Pulveres.—(Plural of *pulvis*, a powder).—Medicines are often prescribed to be dispensed, and also to be administered, in the condition of powder. Furthermore, the United States Pharmacopœia establishes certain powders of special composition as official preparations. Medicines fit for administration in the condition of powder are ordinarily such as are neither oily on the one hand nor deliquescent on the other, and are neither corrosive, bad-tasting, nor bulky in dose. So far as bad taste is concerned, however, this feature can be neutralized more or less completely by mixing the dose with molasses, honey, or syrup, or by enclosing it in a pulp of apple scraping, or, better yet, for such patients as are old enough to swallow whole a bolus, by encasing the powder in a so-called *capsule or wafer*. The *capsules* designed for such purpose are commonly made of jujube paste or some similar material, and consist of a cylindrical chamber, made in two pieces, each open at one end, of which pieces one closely fits into the other, telescope fashion. These capsules are made of several sizes, of capacities to hold from two to four or five grains of a light vegetable powder, dry, or—if moistened so as to pack closer—ten grains. *Wafers* are of two forms. One style consists of two watch-glass shaped bodies, whose edges, upon moistening, will cohere, leaving a central space for enclosure of the powder. The charged wafer is dipped for an instant into water, whereby its surface becomes soft and slippery, when it is to be swallowed immediately whole with a sip of water. The other style consists of a single large, thin, circular sheet of wafer material. Such sheet, dipped into water, becomes flexible, and in such condition is used as a literal *wrap* for the dose of powder.

There are nine powders official in the United States Pharmacopœia.

	Composition	Dose
Pulvis Acetanilidi Compositus (compound acetanilide powder).	Acetanilide, 70 gm.; caffeine, 10 gm.; sodium bicarbonate, 20 gm.	7½ gr. (0.50).
Pulvis Aromaticus (aromatic powder).	Saigon cinnamon, 35 gm.; ginger, 35 gm.; cardamom, 15 gm.; myristica, 15 gm.	15 gr. (1.00),
Pulvis Cretæ Compositus (compound chalk powder).	Prepared chalk, 30 gm.; acacia, 20 gm.; sugar, 50 gm.	30 gr. (2.00).
Pulvis Effervescens Compositus (compound effervescing powder).	Sodium bicarbonate, 31 gm.; potassium and sodium tartrate, 93 gm.; tartaric acid, 27 gm.	1 set of two powders.
Pulvis Glycyrrhizæ Compositus (compound powder of glycyrrhiza).	Senna, 180 gm.; glycyrrhiza, 236 gm.; washed sulphur, 80 gm.; oil of fennel, 4 gm.; sugar, 500 gm.	60 gr. (4.00).
Pulvis Ipecacuanhæ et Opii (powder of ipecac and opium).	Ipecac, 10 gm.; powdered opium, 10 gm.; sugar of milk, 80 gm.	7½ gr. (0.50).
Pulvis Jalapæ Compositus (compound powder of jalap).	Jalap, 35 gm.; potassium bitartrate, 65 gm.	30 gr. (2.00).
Pulvis Morphinæ Compositus (compound powder of morphine).	Morphine sulphate, 1.5 gm.; camphor, 32.0 gm.; glycyrrhiza, 33.0 gm.; precipitated calcium carbonate, 33.5 gm., alcohol, q.s.	7½ gr. (0.50).
Pulvis Rhei Compositus (compound powder of rhubarb).	Rhubarb, 25 gm.; magnesium oxide, 65 gm.; ginger, 10 gm.	30 gr. (2.00).

R. J. E. Scott.

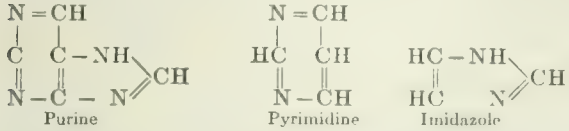
Pumpkin Seed.—See *Pepo*.

Punkies.—Sand-flies. Popular names usually applied to little flies of the genus Culicoides, but in some localities used for flies belonging to the genera *Simulium* or *Phlebotomus*. The larvæ are found in ponds or puddles. Many of the flies bite man and animals. A. S. P.

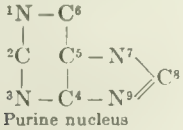
Pupipara.—Dipterous insects with leathery integument, abdominal segments often indistinct, wings often absent, parasitic. These flies are known as sheep-ticks, horse-ticks, etc., and may attack man. A. S. P.

Purgatin.—Purgatol, anthrapurpurin diacetate is an odorless, tasteless, yellowish-brown powder recommended by von Hösslin as an agreeable laxative. It acts slowly, requiring thirteen to twenty-four hours, and produces a copious, non-liquid stool. The urine is colored red. Dose, 0.5 to 2 gram (gr. viij.–xxx.). W. A. Bastedo.
R. J. E. Scott.

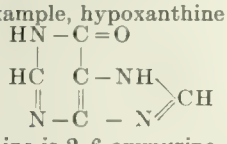
Purines.—The *nuclein* bases or *alloxuric* bases are cleavage products of nucleic acids, hence of nucleoproteins, and they belong to the larger group of *purines*, of which uric acid is also a member. The purines may be considered as derivatives of the synthetically prepared substance purine which may be regarded as a combination of a pyrimidine ring with an imidazole ring. Thus,



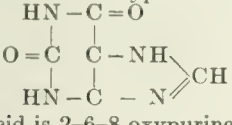
From the substance purine may be derived the different purine bodies by substitution of the hydrogen atoms of hydroxyl, amine, or alkyl groups. To signify the different positions of substitution use has been made of Fischer's plan to number the different members of the purine nucleus as follows:



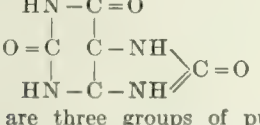
For example, hypoxanthine is 6 oxypurine or



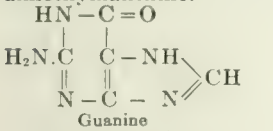
Xanthine is 2–6 oxypurine.

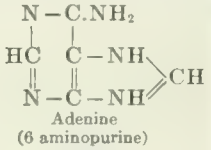


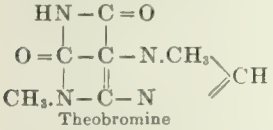
Uric acid is 2–6–8 oxypurine

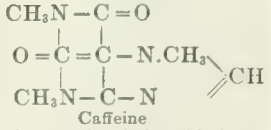


There are three groups of purines, namely, the *oxypurines*, hypoxanthine, xanthine, and uric acid; the *aminopurines*, comprising adenine or 6 aminopurine and quanine 2 amino 6 oxypurine or amino hypoxanthine, and the *methyl purines*, comprising caffeine or trimethylxanthine, and theobromine or dimethylxanthine.









Some of the purines as xanthine, hypoxanthine, and uric acid are constant constituents of the urine, and the first two named together with adenine and guanine are also found in small amounts in the feces. Purines ingested are excreted as such in the urine. A portion of the urinary purines comes therefore from food intake and has been termed the *exogenous* origin. This portion is quite variable and varies directly with the *character* of the protein food eaten—foods rich in nucleoproteins causing a large output. On the other hand, there is a small constant output of purines, which comes from the disintegration of the nucleoproteins of the body cells and this fraction has been termed the fraction of *endogenous* origin.

The intermediate stages in purine metabolism may be regarded as taking place in the following order. In the alimentary canal nucleoprotein may be split to the stage of nuclein or nucleic acid. Nuclein existing in the tissues whether from food or as a result of tissue disintegration is acted upon by an enzyme, nuclease, which is capable of splitting nuclein into some of the purines. Nuclease has been shown to be present in various tissues as in the liver, spleen, lungs, and kidneys. It is assumed that when nuclease acts upon nuclein, adenine and guanine are formed. Through the influence of an enzyme, adenase, also contained in certain tissues, adenine becomes transformed to hypoxanthine, as follows,

$$\underset{\text{Adenine}}{C_5H_5N_5} + H_2O = \underset{\text{Hypoxanthine}}{C_5H_4N_4O} + NH_3$$

Guanine, in turn is changed to xanthine by a second enzyme, guanase, thus,

$$C_5H_5N_5O + H_2O = \underset{\text{Xanthine}}{C_5H_4N_4O_2} + NH_3$$

These two enzymes are also called deamidizing enzymes because of their ability to split off from adenine and guanine the group (NH_2), amino group. Their action is quite specific.

Hypoxanthine and xanthine, in turn, are acted upon by an oxidase to which the specific name of xanthine oxidase has been applied. Hypoxanthine is oxidized to xanthine, thus,

$$\underset{\text{Hypoxanthine}}{C_5H_4N_4O} + O = \underset{\text{Xanthine}}{C_5H_4N_4O_2}$$

Xanthine by the same enzyme becomes changed to uric acid.

$$\underset{\text{Xanthine}}{C_5H_4N_4O_2} + O = \underset{\text{Uric acid}}{C_5H_4N_4O_3}$$

Uric acid may be eliminated as such or in part at least be subjected to the action of a uricolytic enzyme whose property is to decompose uric acid into urea. In man about one-half the uric acid *formed* in the body is transformed to urea in this manner. In some of the higher animals uric acid destruction by this process goes on to a much more limited extent.

FRANK P. UNDERHILL.

Purkinje, Johannes Evangelista.—Born at Libochowitz, Bohemia, Dec. 17, 1787. At the age of twenty-one he began the study of medicine at the University of Prague. In 1819 he received the degree of Doctor of Medicine from that institution, and at the same time he was made an Assistant in Anatomy and Physiology, under Professors Rottenberger and Ilg. His graduating thesis ("Beiträge zur Kenntniss des Sehens in subjectiver Hinsicht") attracted a great deal of attention, and brought him the friendship and protection of Goethe. In 1823 he was called to Breslau, Prussia, to fill the Chair of Physiology and Pathology in the University of that city. He held this position for twenty-six years, during which period he made many original investigations, and was also successful in founding, in connection with the university the Physiological Institute. In 1849 he accepted a call to occupy the Chair of Physiology in the University of Prague—a position which he held up to the time of his death, on July 28, 1869.

Purkinje's researches and discoveries in every field of physiology and microscopic anatomy were of great importance. This is particularly true of the work which he did in physiological optics and in embryology. For example, Purkinje was the discoverer of the germinal vesicle in the bird's egg, and it was he also who first observed and described what is known as "ciliary movement;" his pupil, Valentin, being associated with him in the making of this discovery. His researches in physiological optics are reported

in the treatise entitled: "Beobachtungen und Versuche zur Physiologie der Sinne," Berlin, 1823–1826, 2 volumes. A complete list of all his published writings, up to the year 1859, is to be found in the *Prager Vierteljahrsschrift* for 1859. A. H. B.

Purpura.—*Synonyms:* Hæmorrhœa petechialis; Ger., *Blutflecken.* Purpura is a disease characterized by the extravasation of blood into the skin. In many instances, however, it is not limited to this organ and may be encountered in almost any structure of the body. The parts coming most readily under visual inspection are naturally the skin and mucous membranes, although in severe and fatal cases the autopsy shows that the internal viscera are likewise involved. It may be asked whether purpura is not rather a symptom-complex than a well-defined affection *per se.* It occurs under so many apparently varied conditions that one is at a loss to ascribe to it definite limitations. In this con-

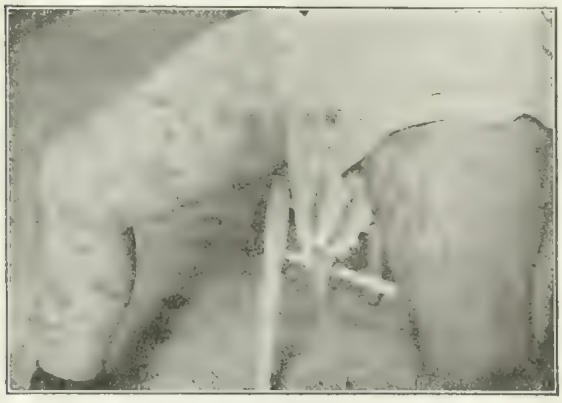


FIG. 4370.—Purpura Simplex. (Case of Dr. William T. Corlett.)

nection, however, it will be considered from a dermatological standpoint, the skin being the organ most extensively involved. The clinical manifestations of purpura vary; hence several varieties have been described, although the essential feature is the occurrence of hemorrhage into the structures surrounding the blood-vessels. In severity purpura likewise varies greatly, being in some instances an exceedingly mild affection with extravasation only in dependent parts, as the legs; or it may be an extremely severe and rapidly fatal disease. Between these extremes numerous grades, both in appearance and in severity, occur. Usually purpura is accompanied by constitutional symptoms which to a great extent depend upon the amount of cutaneous hemorrhage.

For convenience of description the various lesions have received distinct names. Thus we speak of *vibices* when the extravasation of blood into the skin assumes a streaked or elongated form. *Ecchymoses* are irregular extravasations of blood involving considerable areas, and giving the appearance of bruises. *Ecchymomata* or *hæmatomata* are terms used to designate tumors formed by the extravasation of blood, usually occurring when a large vessel wall has given way. The term *purpura papulosa* is employed to designate pinhead-sized extravasations which are usually situated in the upper part of the derma. *Hemorrhagic bullæ* are extravasations underneath or between the layers of the epidermis, while *hæmatidrosis* is a rare condition in which the sweat glands give forth a bloody exudate. *Petechiæ* are cutaneous areas of extravasation of various shapes and sizes.

The cutaneous lesions of purpura are characteristic in that they are symmetrically arranged, are of a dark bluish color, and do not disappear on pressure. At first they may be of a bright red or claret color, although at an early stage they take on a purplish hue; as absorption goes on the color undergoes various changes from a brown to a greenish-yellow tint, such as may be observed in an ordinary bruise. The cutaneous manifestations occur in successive crops; hence various shades of color may be seen at the same time. Most cases of cutaneous hemorrhage may be grouped under three heads, which will be treated as varieties of the disease.

Purpura Simplex represents the mildest form of the disease. This is commonly observed in the skin, and is frequently limited to this structure. As a rule, it is unaccompanied by constitutional symptoms. It usually makes its appearance suddenly, and is first seen on the dependent parts, as the legs (see Fig. 4370), although in children the arms, neck, and other parts of the body may be involved. The most usual sites are the inner aspect of the legs, the dorsum of the feet, and the posterior surface of the forearms. In this form the mucous membranes may be involved to a slight extent, that most frequently implicated being the mucous membrane of the mouth, although we have reason to believe that the hemorrhagic process is not limited to these structures, but that, on account of the mildness of the symptoms, it escapes notice when occurring in parts not easily inspected. In this variety the lesions consist of variously sized and shaped petechiæ which are at first roundish or oval, and which sometimes extend at the periphery; at other times they remain stationary until absorption takes place. A more infrequent form, in which the lesions are punctate (*lichen lividus* of Willan) and surround the exit of a hair shaft, is also encountered. The lesions in purpura usually continue to appear for several days or weeks, although the disease is self-limited and as a rule terminates in recovery within one or two months. The cutaneous lesions soon undergo resorption and the deposition of hematin which leaves an indelible stain in the tissues finally disappears.

Purpura rheumatica, Peliosis rheumatica, toxic purpura (*Purpura exanthématique* of the French) is a more severe form of the disease, so called because of its association with vague pains which are usually referred to the joints or muscles, and are supposed by some to be closely related to acute articular rheumatism. In this variety constitutional symptoms are more marked. In some cases distinct swellings occur about the joints, there is a slight elevation of temperature, the tongue is frequently coated, and usually there is anorexia, sometimes with nausea and vomiting. Extravasation of serum alone may likewise take place, giving rise to urticarial lesions in the skin (*purpura urticaria*). In very rare instances the serous exudate occurs in the epidermis, giving rise to bullæ and edematous plaques. Stelwagon[1] has observed swelling of the lips and throat which he describes as a *febrile, purpuric edema.* Sometimes the eruption becomes associated with symptoms of a multiform erythema, the lesions varying in appearance, although always associated with cutaneous hemorrhage. From the foregoing it may be seen that this form of purpura is closely allied to the exudative erythemata.

This toxic form of purpura is sometimes associated with complications of a grave nature. Thus endocarditis and pericarditis, together with necrosis and sloughing of the mucous membrane of the mouth, have been observed by Osler.[13] It is sometimes recurrent and may appear annually throughout a period of several years. Henoch[2] has called attention to gastrointestinal symptoms occasioned by hemorrhages into the intestinal mucosa; this has been accompanied by vomiting and diarrhea, the stools not infrequently being tinged with blood. Hemorrhage may likewsie take place to a slight extent into the bladder. This has been most frequently observed in children. In severe cases the kidneys are affected,

giving rise to the symptoms of acute hemorrhagic nephritis. In these cases albumin is usually present in the urine. The spleen is sometimes easily palpable.

Purpura hemorrhagica, sometimes known as morbus maculosus Werlhofii and also as land scurvy. This is a more grave affection than the two preceding varieties. The severity of the disease, however, largely depends upon the cause as well as on the extent of the cutaneous hemorrhage. The onset of this variety varies; it may be insidious, appearing as a mild attack with few or no constitutional symptoms; soon gradual impairment of the health becomes manifest, and the patient becomes weak from loss of blood. The appetite disappears, assimilation is interfered with on account of intestinal hemorrhage, and diarrhea with bloody stools finally occurs. The gums bleed easily, and there is not infrequently hematuria, epistaxis, or hemoptysis. The lesions usually assume the form of large ecchymoses or ecchymomata, and the mucous membranes are apparently involved to an equal, if not greater, extent than the skin. In the latter the disease may appear on the more dependent parts, although the whole body soon becomes involved. In severe cases symptoms of collapse occur, and the disease may soon terminate in death (*purpura fulminans*). At other times the disease pursues an uninterrupted course for several months, when finally resolution takes place and the patient recovers. At other times extravasation of blood takes place into the brain or spinal cord, giving rise to symptoms referable to a tumor in these parts. There is usually but slight elevation of temperature in this form, although the disease is sometimes noted to be ushered in with a slight fever, the temperature rising one or two degrees.

Cutaneous hemorrhage may also occur as a symptom of other well-recognized diseases, such as variola, the plague, and cerebrospinal fever, and in cases of poisoning from the bite of poisonous reptiles.

Etiology.—The disease occurs in both sexes, and is met with at all ages. It is a fairly common disease in my experience, and has been most frequently encountered between the ages of sixteen and forty-five. The general health of the cases that have come under my observation, previous to the advent of the cutaneous hemorrhages, has been good, although, as has been stated, there is sometimes a tendency for the disease to recur from time to time during a period of several years. In a series of cases which I had the opportunity of observing a number of years ago, bad hygienic conditions with a defective food supply were undoubtedly the chief etiological factors in the disease. Of these the chief rôle must be given to the withdrawal of green vegetables from the dietary, most notably potatoes, cabbage, and greens; at any rate, on supplying these articles in moderation the disease disappeared from various families in which it had been observed to occur for a long time. Further, in my experience the disease has been met with more frequently in women than in men, the nationality most frequently affected being the Bohemian. It has occurred usually in people in the lower walks of life. Various drugs have been known to produce cutaneous hemorrhage, notably potassium iodide, chloral, belladonna, ergot, phosphorus, iodine, quinine, copaiba. These drugs do not produce the same effect in all people, there being in some individuals an idiosyncrasy by which the ingestion of certain substances, innocuous to others, gives rise to toxic effects. Again, toxic substances or their ptomaines, by acting on the nerve centers, are thought to be potent factors in the causation of purpura, notably in the erythematous or toxic form.

As malaria undermines the general health, it is thought by some to contribute to this condition. Other diseases contribute in like manner to purpura, most notably those which tend to profound anemia, such as scorbutus, hemophilia, pyemia, sarcoma, nephritis, scarlatina, typhus fever, cerebrospinal fever, variola, and rubeola, as well as various diseases of the nerve centers, such as locomotor ataxia and hysteria. The venom of serpents must likewise be mentioned in this connection. In new-born infants, the sudden change to which the circulation is subjected may give rise to cutaneous hemorrhage, which should be looked upon as purely mechanical. Various microorganisms have likewise been described as associated with purpura. Martin de Gimard,[3] Letzerich,[4] and Kolb[5] have succeeded in producing the disease in animals by inoculating with pure cultures of a bacillus which they describe, and doubtless this accounts for some cases, especially among the severe forms. Weil and McMeans[9] report a case of purpura in a man aged forty-two in whom bacteria of the mucosus group, bacillus lactis aerogenes, were obtained during life from the blood, urine, and prostatic secretion, which they believe gave rise to the disease. According to Duke[10] any agent capable of reducing the platelet count below from 40,000 to 75,000 may, apparently, give rise to purpura. From the foregoing it will appear that the cause of purpura apparently varies in different cases, and no one condition can be assigned as invariably producing the disease.

Stelwagon, in summarizing the various causes of purpura, believes that the etiological factors may be divided into classes, most conspicuous of which are the vasomotor, toxic, and infectious; and that some of the latter arise from autointoxications, which have their origin in the intestinal tract. This latter seems especially true in those cases which are marked by a multiform erythema and urticarial lesions. It is evident, therefore, that we have in purpura a condition of variable appearance and widespread distribution, affecting almost every organ and structure of the body and producing symptoms which vary according to the part attacked. What we know, therefore, is this: purpura is a symptom, in the broad sense of the term, of many conditions, many of which at the present time are wholly unknown.

Pathology.—The most constant findings in purpura are circumscribed areas of blood extravasation, which are usualy found in the papillary layer of the derma. Less frequently the epidermis may be invaded, the latter occurring only when the blood extravasation has been excessive, as from rupture of an arteriole, or when the disease assumes a toxic form (*peliosis rheumatica*). When the disease is not limited to the skin, the deeper part of the derma or even the subcutaneous structures (purpura hemorrhagica) may be involved. Again, there may be only a few red blood cells surrounding the vessel (diapedesis), in which case the lesions are usually limited to the superficial stratum of the derma. If the disease has existed for some days the characteristic retrogressive changes are found, namely, the presence of coloring matter from the blood giving rise to a rust-like stain, which gradually fades away, leaving only a slight pigmentation. Frequently these are the only changes found. At other times the vessels in the area involved are markedly dilated (*purpura ectasique* of the French), and red blood cells are found outside the vessel wall. This Leredde regards as due to paralysis of the vasomotor filaments distributed to the vessel. This form is supposed to be of toxic origin involving primarily the nerve centers. Aside from these changes there have been noted dilatation of the vessels with proliferation of the endothelium, together with an accumulation of blood cells, fibrinous thrombi, and microbic emboli. Furthermore, amyloid degeneration of the vessels has been noted, together with proliferation of the connective-tissue cells and necrosis of the vessel wall. The study of the blood has attracted close attention, and Lenoble[6] holds that true purpura (*P. myéloïde*) or the toxic form is

invariably due to alterations in the blood. The following, according to this observer, are always present and may be regarded as characteristic:

1. Absence of contraction of the clot and consequent expression of the serum. This is constant, and it is only after recovery that the expression of serum becomes normal. In light cases one can see a certain degree of contraction of the clot, although occurring a little later than usual.

2. The appearance of bone-marrow cells which are always present, sometimes abundant, and are characterized (*a*) by the apparition of nucleated red blood cells, few in the chronic, but more abundant in the acute form; in the latter case, however, they are not permanent. These red cells are in the group of Ehrlich's normoblasts, more rarely megaloblasts or even microblasts (one case); (*b*) by the appearance in the circulation of myelocytes which are usually neutrophilic, more rarely eosinophilic. This reaction is always slight or feeble, and varies from a fraction of one per cent. in the chronic type to six or seven per cent. in the acute form.

3. Marked changes in the blood platelets, which are diminished in number and increased in volume, but whose chief alteration is in the more or less complete loss of their characteristic grouping. This loss of the power of clumping explains the lack of contraction of the clot, the special anemia, and the profuse hemorrhages which are characteristic of the disease.

These changes, which are constant, may persist indefinitely in the chronic form. In the subacute form the duration is variable, and normoblasts may be found long after recovery is apparently complete.

The following are given as accessory and inconstant blood changes:

1. Leucocytosis with increase of the polynuclear eosinophiles and especially of the lymphocytes. These last are always increased, and were omitted from the primary changes mentioned because they are found in all forms of purpura. Their presence is as important as is that of the myelocytes, whose office it is to repair the constant loss of the large mononuclears which undoubtedly act as macrophages. According to the Dominici these cells also give rise to parent cells of the elements which are destroyed by the circulating toxins.

2. Frequent but inconstant is the appearance in the pure blood of a reticulum either with a coarse or with a fine network.

3. Contrast between the number of red corpuscles, which may be much increased, and the amount of hemoglobin per cell, which may remain small.

This disease is thus controlled by a double cause, viz., an infection and an anemia. The intensity of the symptoms varies with the intensity of the infection. The blood shows few changes in chronic, subacute, and transient types, but in the acute form the blood appears disorganized and shows the presence of bone-marrow cells, while the red blood cells have become very vulnerable. This is shown by the large number of pseudoparasites whose importance has been dwelt on by Hayem.[7] Recently Ledingham and Bedson[8] were able to produce purpura in rabbits and guinea-pigs by injecting into the veins antiplate serum, and observed that the diminution in the number of platelets occurred simultaneously with the outburst of skin purpura.

Diagnosis.—Little difficulty need be experienced in recognizing a well-marked case of purpura. In purpura simplex the lesions sometimes resemble flea-bites or the bites produced by other insects (*purpura pulicosa*). In the latter, however, there may be seen a characteristic inflammatory halo surrounding a deep red punctate center, which is never present in purpura. Erythema nodosum might, late in its course, be mistaken for purpura, especially when the dark-red inflammatory nodules of the erythema have receded, leaving bruise-like areas. The location and history of the affection should enable one to differentiate between them. It should be borne in mind that erythema is an acute affection of two or three weeks' duration, with large, elevated, slightly inflamed and painful nodules, usually limited to the anterior surface of the legs and to the forearms; while the lesions of purpura appear in successive crops lasting from four to twelve weeks, are of a dark color, usually not elevated except in the form of bullæ and are not inflammatory or painful. In erythema the redness disappears on pressure, while this does not take place in purpura. Pain has been experienced on pressure in erythema, but pressure does not cause pain in purpura. From trauma purpura may be distinguished by the multiform character and distribution of the lesions, and by the absence of any history of injury.

The late manifestations of syphilis likewise give rise to pigmentation, but they are also preceded by inflammation, and are always chronic, which offers a sharp contrast to the lesions of purpura. Even in the necrotic form of purpura the lesions are smaller, are multiform, and are of comparatively shorter duration than those of syphilis. From the various drug eruptions, noticeably that of cubebs and copaiba, the erythema is of a brighter red and disappears on pressure. In the acute infectious exanthemata cutaneous hemorrhages are not uncommon, notably in variola and rubeola; but in the former we have a grave affection which, as a rule, rapidly advances to a fatal termination, and in measles the coryza and characteristic features of the rash would enable one to exclude purpura which has a slower evolution and less often terminates fatally.[8]

Prognosis.—This depends on the extent of the cutaneous hemorrhage, the cause of the disease, and the complications present. In simple purpura the prognosis may be considered favorable, whereas in toxic cases, or in those accompanied by marked involvement of the viscera, the prognosis must be guarded. In purpura simplex the majority of patients recover in from four to twelve weeks. In purpura rheumatica the disease is liable to return, although it is seldom from the primary affection that a fatal issue ensues. In severe forms the disease is always grave, if not fatal.

Treatment.—The first consideration is rest in a horizontal position. Except in very mild cases this should be maintained very strictly throughout the whole course of the disease. Many cases are reported in which fresh crops of eruption have appeared after the patient assumed the erect posture. When the lower extremities are mainly involved, it is well to elevate the feet above the horizontal plane by means of pillows. When the extremities are the chief seats of predilection, flannel bandages may be applied so as to give support by gentle pressure. The room should be well ventilated and an abundance of direct sunlight admitted. The diet should be simple, nutritious, and easy to digest. In toxic cases diffusible stimulants may be indicated. The drugs which have given the best results are: turpentine, in doses of five drops three times a day, or by inhalation; ergot, or the subcutaneous injection of ergotin, which is highly spoken of by Crocker; silver nitrate, 0.008 (gr. $\frac{1}{8}$ to gr. $\frac{1}{6}$) in pill form; aromatic sulphuric acid; and chloride of lime in doses of from one to two grams (fifteen to thirty grains) three times a day. The latter remedy should not be given for a longer period than two or three days, as it acts directly on the coagulation of the blood. Astringents in the form of iron or a four-per-cent. solution of hydrochlorate of cocaine have been resorted to in severe cases. Ice in the mouth, or elsewhere, may be indicated as a local application. Boulloche[9] recommends the injection of artificial serum, and relates a case of fulminating purpura in which death

seemed imminent, but which, under this treatment, made a complete recovery. In this case 120 c.c. were given. Absolute cleanliness should be insisted upon, and some mild astringent and antiseptic gargle may be applied to the mouth and fauces. Further than this the treatment depends largely on the cause of the disease and the complications which are encountered. WILLIAM THOMAS CORLETT.

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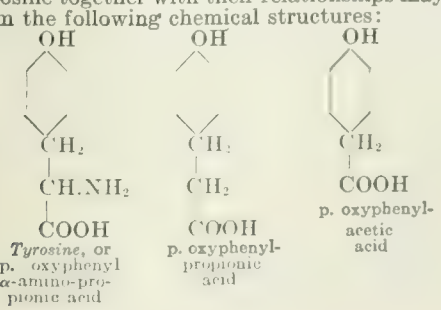
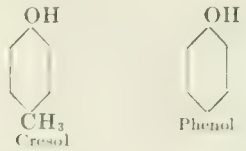
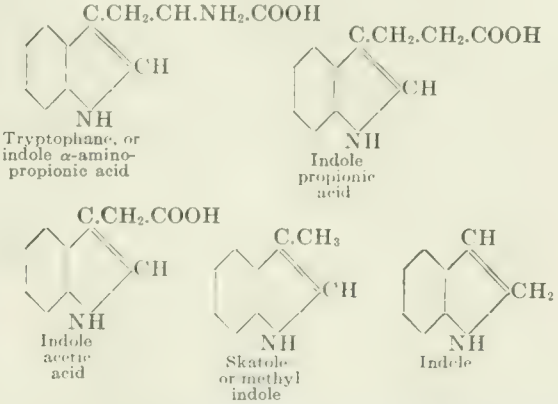
Putrefaction is the term applied to the action of microorganisms upon proteins. In the alimentary tract putrefaction occurs, as a rule, only in the large intestine. This action of microorganisms is similar to the influence of digestive enzymes, trypsin, for example, upon protein since some of the same products are formed such as proteoses, peptones, and amino-acids, but differs from pancreatic digestion of protein in causing the formation of a series of substances not characteristic of trypsin action, and the process is also more profound. The substances characteristic of putrefaction are indole, skatole, paracresol phenol, phenylpropionic acid, phenylacetic acid, paraoxyphenylacetic acid, volatile fatty acids, carbon dioxide, hydrogen, marsh-gas, hydrogen sulphide, and methylmercaptan. The volatile fatty acids formed are caproic, valerianic, butyric, and succinic acids. The remaining putrefactive products which are peculiar may be divisible into three groups, the phenol group, to which belong tyrosine, the aromatic oxyacids, phenol and cresol; the phenyl group, including phenylacetic acid and phenylpropionic acid, and, finally, the indole group, to which belong indole, skatole, indole propionic acid, and indole acetic acid.

The substances which are peculiar to putrefaction may be traced back to two distinct types of groups existing in the protein molecule, namely, tyrosine and tryptophane. The compounds that may be formed from tyrosine together with their relationships may be seen from the following chemical structures:

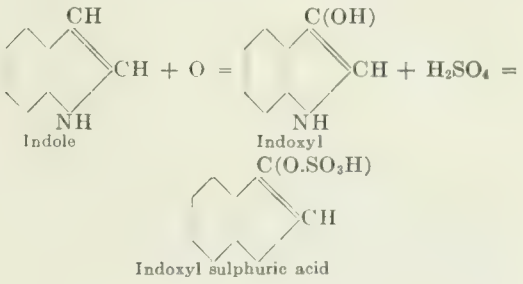




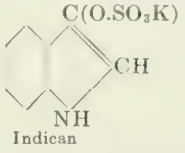
From tryptophane may be formed the following compounds.



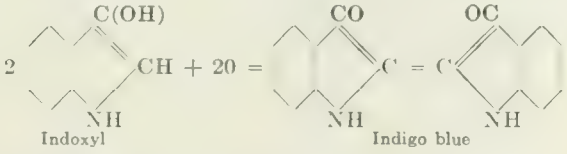
In the body phenol is combined with sulphuric acid and eliminated by the kidneys. This combination is called an ethereal sulphate. Indole is carried to the liver, oxidized to indoxyl, combined with sulphuric acid and eliminated in the urine as the potassium salt, or indican, which may thus, after extraction as indigo blue, be regarded as an index of the extent of intestinal putrefaction. The transformations which occur in the body whereby indole is changed to indican follow:



which in the presence of potassium salts is changed to

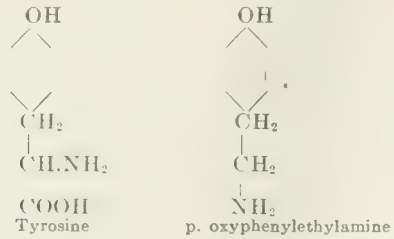


Indican on treatment with hydrochloric acid and ferric chloride is transformed into indoxyl again. An oxidation of indoxyl indigo blue is formed and may be extracted from urine with chloroform.



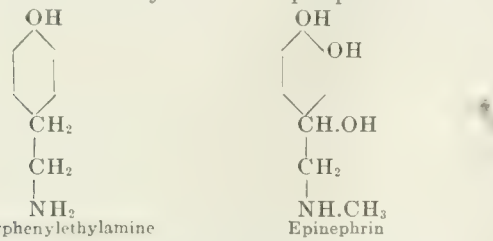
Very recently knowledge of the products of putrefaction has been much enlarged by the discovery of the presence of amines in putrefaction mixtures. From various putrefying mixtures a body known as p. oxyphenylethylamine or *tyramine* has been isolated and it has also been formed by the action of microorgan-

isms upon tyrosine. There is no doubt that tyrosine is the mother substance of this base and its mode of formation follows:



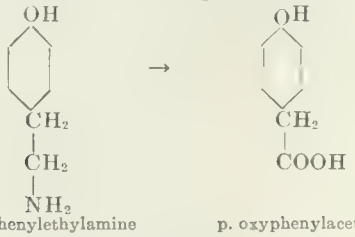
Tyrosine — p. oxyphenylethylamine

This amine is closely related to epinephrin.



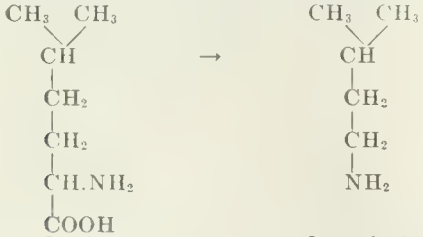
p. oxyphenylethylamine — Epinephrin

Like epinephrin, tyramine reproduces both the motor and inhibitory effects of the true sympathetic system. Its action, however, is somewhat weaker and slower in onset, and it is less strictly though mainly peripheral. It is especially interesting to note that tyramine is one of the substances which give to ergot its characteristic action on the uterus. Tyramine is eliminated from the body as p. oxyphenylacetic acid.



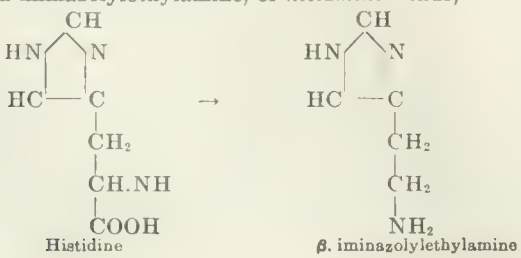
p. oxyphenylethylamine — p. oxyphenylacetic acid

From leucine another characteristic amino acid, arising from the hydrolysis of protein whether induced by digestion or putrefaction processes a second amine may arise—namely, isoamylamine.



Leucine — Isoamylamine

When histidine is subjected to the action of putrefactive bacteria a third amine is formed, namely, beta-iminazolylethylamine, or *histamine*—thus,



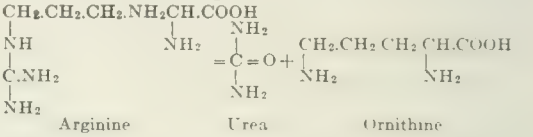
Histidine — β. iminazolylethylamine

Like tyramine histamine is found in ergot extracts and both substances exert similar influences on the uterus muscle. Histamine is also capable of producing symptoms practically identical with those induced by injections of peptone solutions, or by serum or other protein in the sensitized guinea-pig, that is, producing anaphylactic shock. It also has a mild, stimulant effect on the activity of the salivary glands and the pancreas. This secretory action, being paralyzed by atropine, may be regarded as a weak action of the pilocarpine type; the association has some interest in that pilocarpine also contains an iminazole ring.

Some of these amines have been isolated from the intestine, and it is probable that they may place a more or less important rôle in metabolic activities in health and disease. That these substances may be introduced as food also is evident when it is noted that they may be formed in the ripening of certain types of cheese

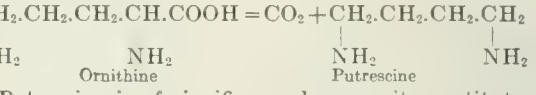
FRANK P. UNDERHILL.

Putrescine is a so-called diamine which may be derived from arginine one of the amino acids formed from protein on hydrolysis. By enzyme action arginine may be split up into ornithine and urea.



Arginine — Urea — Ornithine

By the action of bacteria ornithine is transformed to putrescine.



Ornithine — Putrescine

Putrescine is of significance because it constitutes one of the ptomaines and also is characteristic in that condition known as diaminuria which may accompany cystinuria.

See also *Cadaverine, Ptomaines.*

FRANK P. UNDERHILL.

Pycnosis (also spelled *Pyknosis*) is the term applied to that condition of the nucleus in which, in the early stages of necrosis or just preceding necrosis, it stains more intensely with nuclear stains. At the same time there is usually a contraction of the nucleus; but the nucleus may remain of normal size or even swell. A pycnotic condition of the nucleus also occurs as a postmortal change due to inspissation. *Caryorrhexis* may follow pycnosis, or there may occur a gradual *caryolysis* without a disintegration of the chromatin elements. In sections stained with hematoxylin the pycnotic nuclei may appear almost black. This phenomenon is usually explained as due to a condensation of the chromatin. Pycnosis may be observed in necrosing cells of all organs and tissues; it is seen particularly in necrosing syncytial cells, bone-marrow giant cells, muscle cells, sarcoma cells, etc. The nuclei of tissues in a state of mummification are usually pycnotic. Pycnotic cells are sometimes mistaken for newly formed cells; and in some cases the differential diagnosis is difficult. This is particularly the case in striped muscle. Undoubtedly many of the cells regarded as evidences of muscle regeneration have been cells in a condition of pycnosis.

ALDRED SCOTT WARTHIN.

Pyelitis, Pyelonephritis, and Pyonephrosis.—These lesions of the kidney are so intimately correlated that they may well be considered together; for with suppurative pyelitis as the initial lesion, a

secondary invasion of the parenchyma may take place giving rise to pyelonephritis, and progressive dilatation of the affected pelvis and destruction of the parenchyma, together with interference with urinary outflow, lead to pyonephrosis as the end result. On the other hand, an initial septic nephritis may involve the pelvis secondarily, so that we again have pyelonephritis with ultimate pyonephrosis in prospect. Pyelitis may be primary or secondary; acute or chronic; and ascending and descending types have usually been described. Pyelonephritis may be acute or chronic. Pyonephrosis is always a secondary and, except for the initial stage of infection of a hydronephrosis, is always a chronic process. Any of these lesions may be unilateral or bilateral.

Etiology.—While certain factors may be especially concerned in the causation of any one of these three pathological conditions of the kidney, most of the etiological factors are common to all.

Predisposing causes comprise all conditions tending to lower the normal resistance of the kidney to infection. Among these should be especially mentioned: (1) *intrinsic causes*, renal calculi; renal tuberculosis; renal tumors; renal congestion; excessive mobility of the kidney; and congenital or acquired lesions in, or pressure upon, any part of the lower urinary tract interfering with the normal outflow of urine from the renal pelvis; (2) *extrinsic causes*, acute infectious diseases, especially typhoid fever, septic endocarditis, diphtheria, and certain of the exanthemata; septicemia, pyemia, and septic processes in any part of the body; the ingestion or inhalation of certain drugs, such as cantharides, turpentine, bichloride of mercury, chloroform and ether; exposure to cold; and traumatism. Pyonephrosis is a terminal process and occurs as a sequel to pyelitis or pyelonephritis, or when a hydronephrosis becomes infected.

The *exciting cause* may be any of the pathogenic organisms but in the majority of instances is the colon bacillus. Indeed, Furniss,[1] speaking of infections of the urinary tract in women, states that fully ninety per cent. of the cases he sees show the colon bacillus in pure culture. Irrespective of sex, other authors have found this bacillus present in seventy-five per cent. or more of the infections of the renal pelvis, either alone or in combination with other pathogenic bacteria. When the pelvic involvement is secondary to hematogenous infection of the kidney by the staphylococcus or other organisms not of the colon bacillus group, infection by the colon bacillus often occurs later and may supplant all other organisms or at least be the one that ultimately predominates. Tuberculous infections of the kidney and pelvis have been discussed elsewhere (see vol. v., page 751).

Mode of Infection in Pyelitis.—Five routes by which infection might reach the pelvis of the kidney have been described: (1) by direct infection through wounds penetrating the pelvis; (2) by contiguity; (3) through the lymphatics; (4) by direct extension upward through the lumen of the ureter; and (5) through the blood stream. Interest has centered principally upon the last two of these possible routes. Practically all admit that the proportion of cases arising through infection by the first two routes is so small as to be practically negligible, but there are many who hold that lymphatic transmission is responsible for a very considerable percentage of cases. Formerly it was generally believed that the lymphatics held a position second only to that of the lumen of the ureter in the transmission of infection from the lower to the upper portion of the urinary tract; hence pyelitis apparently following infection of the bladder was described as "ascending," while the extension of the process to the parenchyma of the kidney was signalized by the term "ascending pyelonephritis," or "surgical kidney." When we come to the discussion of the last two routes (through the lumen of the ureter or through the blood) we reach a question which has long been hotly debated and upon which unanimity of opinion is apparently still far distant. Rovsing,[2] in a paper presented at the International Congress of Surgeons in London in 1913, called attention to the fact that since 1889 he had unceasingly insisted upon the frequency of hematogenous infections of the kidney, and that in 1897 he published an article entitled "Clinical and experimental studies upon the infectious diseases of the urinary passages" in which he gave clinical as well as experimental proofs that colon bacillus infection is almost always of hematogenous origin; and he naively remarks that it is only from this period that the correct conception began to prevail among surgeons and urologists. At all events, most surgeons now agree with Rovsing that the greater part of the infections of the renal pelvis are of hematogenous origin, and that whatever influence is exerted upon the development of pelvic infection by pre-existing pathological conditions in any part of the lower urinary tract lies principally in the obstruction to urinary outflow through constriction or pressure at some point, thereby resulting in some degree of pelvic distention or at least in lowered resistance of the kidney to infection brought in the blood. On the other hand, Oppenheimer,[3] on the basis of his experience and the review of 100 cases of pyelitis occurring in his practice and in the Frankfurt Gynecological Clinic, believes the ascending type of infection to be much the more frequent and that the infecting organisms reach the pelvis through the lumen of the ureter and not through the lymphatics; but that to allow this, two conditions are necessary: relaxation of the normal valve-like action of the ureteral orifices, and decreased force of the urinary flow—a relative stasis. In recent years Furniss and others have called attention to the fact that postoperative renal infection is not at all infrequent, particularly after operations upon the intestinal tract, and that mild renal infections account for many of the instances of previously unexplained rise of temperature occurring some days after convalescence has become uneventful and without apparent cause as far as the operative field or general condition of the patient is concerned. It has been suggested in such cases, where there has never been any infectious process in the lower urinary tract, and where those organs have not been disturbed in the course of operation, that infection reaches the kidney through the lymphatics. Furniss advances the theory that infection comes through the blood stream from infected thrombi at the seat of operation. This is very ingenious and plausible but one wonders, however, why it is necessary to limit the point of origination for the colon bacillus in hematogenous cases to infected thrombi, when the traumatism and consequent lowering of resistance of the tissues of the mesentery and intestine itself incident to operation are sufficient to furnish a wide open portal of entry for that omnipresent germ. In infants and children pyelitis is found much more frequently in girls than in boys. The advocates of the ascending theory seize upon and make much of this fact on the ground that as the urethra is shorter and of larger caliber than in the male, the colon bacilli gain entrance to the bladder through the urethra more easily in the female, and from the bladder travel up the ureter (some say within its lumen, others say in the periureteral lymphatics) and infect the pelvis of the kidney. In the adult, however, pyelitis is far more common in the male than in the female; yet the anatomical differences as to the urethra still exist, except that the length of the male urethra has disproportionately increased, making it still harder for infecting organisms to enter the bladder through the urethra, while the opportunities for their entering the female urethra are increased from the fact that the parts are bathed in secretions at each menstrual flow and during the puerperium.

It is certainly true, however, that in the adult, obstruction to urinary outflow from stricture of the urethra and other causes is in general more frequent in the male than in the female, yet this fact alone is not sufficient to account for the greater incidence of pyelitis in the adult male; for in reviewing the cases of pyelitis seen at the Mayo Clinic during a period of five years, Braasch[4] found that there were 164 cases where there was no mechanical obstruction in the urinary tract or other evident predisposing factor, and that 112 of these, or 68 per cent., occurred in the male. The evidence in favor of the hematogenous origin of the infection in practically all cases of pyelitis not due to the extension of a septic process in the parenchyma of the kidney seems fairly conclusive.

Mode of Infection in Pyelonephritis.—While it has long been known that even large numbers of bacteria may pass through the normal kidney without leaving appreciable traces of their passage, it is quite another matter when the kidney has suffered from traumatism —either artificial, as in animal experimentation, or by the presence of a calculus—or if its resistance has been lowered by any of the previously mentioned predisposing causes. Under such conditions there may be an arrest of the progress of the bacteria or small emboli composed of infected material in any part of the arterial supply of the parenchyma of the kidney, most frequently in the cortex. A few small foci may result in minute abscesses which may ultimately heal; but if the dissemination of the infectious material is at all extensive, or the organisms especially virulent, acute septic nephritis is instituted from which the pelvis is almost invariably infected secondarily, producing pyelonephritis. Aside from infections secondary to pyelitis, this is the usual route by which infection reaches the parenchyma of the kidney, though it cannot be questioned that occasionally the kidney is involved by direct extension from neighboring structures. The possibility of direct infection of the parenchyma through the lymphatics has received very little serious consideration.

Pathology.—Catarrhal pyelitis is found particularly in the course of acute infectious diseases and as a result of elimination through the kidney of toxic material by which the entire parenchyma is more or less affected, and in the early stages of calculus formation or pelvic urinary retention due to mechanical interference with the urinary flow from any cause. In these cases the mucosa is swollen and congested and may show ecchymotic patches. The swelling decreases the size of the ureteropelvic orifice, emptying of the pelvis is interfered with, and there is consequently more or less dilatation and possible distortion of the pelvic cavity. Later, if there is no mechanical obstruction to urinary outflow or calculus formation, the process tends to resolution and *restitutio ad integrum* may occur with the cessation of action of the exciting factor. In the more serious purulent cases the inflammation affects the subepithelial layers, which are infiltrated, and connective-tissue changes result leading to thickening and marked loss of elasticity of the pelvic wall, irregular dilatation of the calices and pelvic cavity and flattening of the papillæ. Extension of the infection to the parenchyma of the kidney may then take place through the tubules or the intertubular structures.

In pyelonephritis of embolic type the kidney is swollen, edematous, and studded both in the medulla and cortex with yellowish-white punctiform abscesses surrounded by hyperemic zones. With continuation of the process contiguous abscesses coalesce to a certain extent and there is marked hyperplasia of the connective tissue forming their wall. An indurated, atrophic kidney may result but usually much if not all of the parenchyma is destroyed, the pelvis is involved, and the fusion of abscesses progresses until finally the kidney may be converted into hardly more than a pus sac—pyonephrosis. When pyelonephritis is secondary to pyelitis there is at first a diffuse infiltration which may be followed by abscess formation and further evolution as in the embolic type described above.

In both pyelitis and pyelonephritis there is practically always some inflammatory reaction in the ureter. When pyelitis clears up quickly the ureteritis also subsides and leaves little if any traces of the process; but when renal infection is long continued, initial tumefaction is followed by dilatation and thickening and stricture often results. Cystitis usually also develops to some degree sooner or later.

Symptoms.—In the milder forms of *acute pyelitis* there may be no appreciable symptoms, or merely frequent urination; or there may be moderate pain or feeling of discomfort and tenderness on pressure in the kidney region, together with clear or a slightly turbid urine, frequent urination, and other evidences of mild cystitis. In the severe cases there may be considerable pain and tenderness in the loin, chills, fever, malaise and gastrointestinal disturbances, while the bladder irritation may be marked and often leads to an erroneous clinical diagnosis of cystitis although, as pointed out by Hunner,[5] cystitis *per se* is rarely if ever the cause of marked temperature elevation. The urine in these cases may be increased or decreased in amount, contain a small amount of albumin, a few red blood cells, moderate to considerable numbers of pus cells and many bacteria. In cases with distinct pyuria this may be continuous or intermittent. When there is mechanical obstruction there may be attacks of severe pain in the kidney region or referred down the course of the ureter.

In the *chronic* form the symptoms vary greatly. In some there is little if any pain and in spite of the continued passage of purulent urine there is little or no discomfort referred to the bladder. In this type, however, there may be occasional periods in which there is moderate to severe pain in the kidney region, sometimes with evanescent sharp pain due to the passage of purulent masses down the ureter, while symptoms of cystitis reappear or are intensified. In other cases patients appear septic and bladder symptoms are a constant annoyance. Apparent exacerbations of chronic pyelitis may mean extension of the suppurative process into the parenchyma of the kidney. With bilateral pyelitis these acute exacerbations may be of grave import, for with the curtailing of urinary output that usually accompanies them uremic manifestations are not at all infrequent and anuria may supervene. Many patients go along for years with a marked pyuria and without more than occasional discomfort at any point in the urinary tract. They may also appear to be in perfect health, though they are apt to complain of headaches and occasional mild digestive disturbances. There is no type of fever that is typical of pyelitis. Often, even when the urine is markedly purulent, the temperature remains at or near normal. In other cases it is of the intermittent or remittent type, or there may be continuous elevation of temperature, though in this latter contingency gradually progressive invasion of parenchyma is to be suspected.

In *pyelonephritis* the symptoms depend upon the mode of infection of the parenchyma. If the process is an extension from a pyelitis, an exacerbation of the symptoms of the original condition is noted, while the fever becomes high and irregular and usually associated with chills, pain, and fairly well marked tenderness in the kidney region. Casts, composed of pus, blood and epithelia, may or may not appear in the urine. The severity of the symptoms gradually lessens and the patient settles down into nearly or quite the same state as previously, or the symptoms become still more severe, the patient appears profoundly septic and ultimately dies, usually in coma.

In the hematogenous type of pyelonephritis there may be a sudden and very acute onset with high fever, chills, pain in the region of the kidney, rapid pulse and overwhelming toxemia, with a marked diminution or total absence of secretion of urine from the affected kidney or from both kidneys—the so-called fulminating cases which are rapidly fatal; or the toxemia may not be excessive, the initial fever, while high at the start, begins to fall within forty-eight hours, the pulse rate and quality are good, prostration not particularly marked, and the urgent symptoms gradually subside as the kidney begins to functionate more normally and the condition merges gradually into that found with chronic pyelonephritis. During the acute stage there are usually vomiting and other gastrointestinal disturbances, and pain may be referred to various parts of the abdomen, so that errors in diagnosis are not infrequent and the appendix or gall-bladder have at first been thought responsible for the patient's condition. In the very acute cases the prognosis is very bad, though many reach the chronic stage. In occasional cases, where dissemination of the infection is not extensive or the infecting organism is not very virulent the symptoms are much milder and almost of the chronic type from the start. In the chronic cases when the process is extensive there is fever of the remittent or septic type, with occasional chills, anorexia, gastrointestinal derangements, gradual loss of flesh and strength, together with constant or intermittent dull pain and urinary changes. The intoxication may gradually increase and the patient finally die in coma, or the abscesses may empty into the pelvis and the condition finally become one of pyonephrosis.

In *pyonephrosis* there have usually been the clinical symptoms of pyelitis or pyelonephritis and cystitis, sometimes of hydronephrosis; but occasionally the condition may develop insidiously and the first symptoms noted may be those belonging to a decided pyonephrosis. These symptoms are: pyuria, pain and tumor in the kidney region, and fever. Pyuria may be constant or intermittent and the pus may be in very large or moderate quantities. The intermittence is due to the occasional blocking of the ureter by cheesy or putty-like masses, or its temporary occlusion by pressure of related organs or inflammatory swelling. While the ureter is occluded by any of these methods the urine is clear if the other kidney is not also affected by a septic process and if there is little or no cystitis; while with reëstablished patency of the ureter there is a sudden copious flow of purulent urine. Pain is generally dull in character but may be increased when temporary occlusion of the ureter takes place and diminish or disappear entirely upon reëstablishment of drainage through the ureter. In some cases there is no pain for long periods of time. Tumor is always present though until it attains considerable size it may be impossible to determine its existence by palpation, especially in patients of large build and with thick or tense abdominal walls. In many cases there is intermittent swelling to be noted in the loin, coincident with the intermittent ureteral occlusion and comparatively pus free urine. When a mass is felt it may be rounded or irregular in shape. Fever may be of the septic type, or there may be long periods when the kidney is draining satisfactorily when there is not enough rise in temperature to attract attention. With sudden blocking of the ureter there is usually a marked rise in temperature, associated with chills and other septic manifestations. There is always hyperleucocytosis and the polymorphonuclear percentage is usually very high. In most of these cases there is cystitis, often marked in degree, and that may be the only symptom of which the patient complains. In many cases the general health of the patient may remain apparently good for months or even years, but more frequently there is a gradual undermining of the constitution until finally the health fails rapidly unless operative relief from the constant septic absorption is obtained.

Diagnosis.—It must have become impressed upon the reader that there is a marked correlation not only in the etiology and nature of the pathological processes of the three types of renal lesion under consideration in this section, but also in the symptoms; and that the symptoms—both subjective and objective—that have been described, overlap in rather bewildering fashion. For this reason positive clinical diagnosis of the exact nature and extent of septic processes in the kidney was next to impossible until the introduction of cystoscopy, ureteral catheterization and radiography and until sufficient experience in the single and combined use of these resources led to reasonably accurate interpretation of the findings. As a good example of the difficulties in the way of accurate diagnosis before the advent of these diagnostic aids, Chetwood[6] calls attention to the fact that in the Vienna General Hospital, before present methods of diagnosis were in vogue, in more than two-thirds of 750 cases of pyelitis, upon which autopsies were performed, a diagnosis had not been made. It is safe to assume that in the Vienna series attempts at correct clinical diagnosis were made with at least ordinary care and probably in most cases with great care; and that the failure to properly appreciate the condition during the life of the patient was due to the inherent difficulties in making the correct diagnosis and not to incompetence or carelessness. It must therefore be apparent that in only a minority of the cases can the correct diagnosis be made by a consideration of the mode of onset, clinical course as shown by analysis of the subjective and objective symptoms, and the study of the voided urine; and that except under unusual circumstances the attempt to make a diagnosis in these dangerous and destructive lesions of the kidney by antiquated methods alone is absolutely indefensible. The diagnosis rests upon the consideration of all that could be brought out by the old methods plus evidence discovered by means of cystoscopy, ureteral catheterization, radiography, pyelography and, in many cases, estimation of the functional value of the kidneys by means of the phenolsulphonephthalein, indigo-carmine, or some other test. Furthermore, it is hardly justifiable to compel the patient afflicted with serious septic involvement of the kidney to undergo the sometimes severe mental as well as physical strain incident to the employment of some of these measures unless the operator is reasonably competent to interpret the findings. It is in these cases especially that the expert cystoscopist and röntgenologist should be called in coöperative consultation whenever possible; for in many cases differential diagnosis of the type and extent of renal involvement is none too easy even at the hands of the most expert. By the use of the cystoscope one may note the condition of the bladder mucosa, the ureteral orifices, the presence or absence of urinary flow from the ureter of the affected side, whether or not the urine comes with the usual swirl, and whether both urines are clear or one or both cloudy. By ureteral catheter the presence of residual urine in the pelvis can be determined, its capacity measured, individual urines collected for chemical, microscopical, and bacteriological examination, functional tests made, and upon filling with collargol a pyelogram will show the outlines of the ureter, pelvis, and calices, also usually renal stone, if present.

The differences encountered in the size and conformation of even what may be considered normal pelves and calices are so manifold that it is manifestly impracticable to attempt to point out here slight shades of difference upon the appreciation of which diagnosis may be based in cases of pyelitis and pyelonephritis. In general it may be said that in the *acute* cases of pyelitis, where bladder irritation may be the most

prominent symptom, cystoscopic examination shows no evidence of an inflammatory process in the bladder or not enough to account for the degree of vesical irritation experienced. The mouth of the ureter may be congested and edematous and upon ureteral catheterization the pelvis of one or both kidneys may be found to be dilated and contain a variable amount of residual urine, which shows the characteristics of an inflammatory process and which usually gives a pure culture of the colon bacillus. In *chronic* pyelitis some diffuse inflammation of the bladder may or may not be noted but usually there is at least some inflammatory change at the base and around the ureteral orifice. Sometimes, however, the bladder appears practically normal even after long-continued suppuration in the kidney. Ureteral catheterization and pyelography show some degree of dilatation of the pelvis and possibly of the upper part of the ureter, while, except in cases accompanied by mechanical obstruction, the dilatation of the pelvis and calices is characterized by general irregularity in outline. In *pyelonephritis* the degree of inflammatory dilatation is usually considerable when infection of the pelvis predominates, and relatively slight when infection begins and predominates in the parenchyma. In *pyonephrosis* thick pus may often be seen exuding from the ureter; the bladder may be more or less inflamed, though it is remarkable how often, even with long-standing pyonephrosis, the bladder remains practically normal except perhaps in the immediate vicinity of the ureter. In the lesser degrees of pyonephrosis the capacity and outline of the sac may be determined. In closed pyonephrosis no secretion is seen coming from the affected kidney, but evidences of old inflammation at the ureteral orifice, in connection with the history of a previous purulent urine and the *x*-ray examination, usually make the condition clear. For further details the reader is referred to any of the larger works on cystoscopy, such as that by Pilcher,[7] and that on pyelography by Braasch.[8]

Treatment.—For the acute cases of pyelitis, Brewer's laconic statement of the treatment for the mild cases of septic infarction of the kidney, "Rest, water, urotropin," is very *a propos*. In addition it is essential to determine the source of the renal infection and remove it if possible. It is generally best in the early stages of acute pyelitis to trust to medicinal and hygienic measures, though some believe in introducing the ureteral catheter to the renal pelvis, lavage with a mild antiseptic solution, and leaving the catheter in place for a number of hours (usually four to six) during which time the pelvis is occasionally irrigated with the antiseptic solution. An autogenous vaccine may also be employed. In the subacute and chronic cases Brewer's triad are also indicated. In my opinion many more cases of pyelitis would be nipped in the bud rather than progress to the chronic stage if hexamethylenamine were used in larger doses than customary. In the chronic cases I have run the dose up to approximately two drams per day for several days in succession, often with marked benefit as far as the suppurative process is concerned, and rarely with any ill effects. In those who appear to be particularly susceptible to the occasional irritative effects of the drug, this is noticed and the dose reduced before any actual harm has been done. If these measures are found to be inadequate, autogenous vaccines and lavage of the pelvis with an antiseptic solution are indicated. The usual antiseptic solution used is that of silver nitrate in strength of 1:1,000, up to one per cent. Solutions of certain of the proprietary silver salts have also been used and are highly recommended by some, also a two per cent. solution of aluminum acetate, as recommended by Koll.[9] Drainage by indwelling ureteral catheter for several days or even as long as two weeks at a time (Oppenheimer) is sometimes practised. Any condition leading to interference with pelvic drainage, such as movable kidney, stricture or pressure upon the ureter, etc., must of course receive appropriate treatment or the pyelitis may never clear up.

Outside of the surgery which may be indicated in removing the extrinsic or intrinsic predisposing causes of renal infection, or of its continuance once it has been inaugurated (such as renal calculus, pressure of uterine fibroid on ureter, etc.), operative measures in ordinary cases of pyelitis are rarely indicated. Nephrotomy, nephrostomy, or nephrectomy is, however, occasionally necessary. Braasch summarizes the conditions which render pyelitis surgical as follows: "(1) Persistent unilateral pyelitis causing recurring attacks of fever and weakness; (2) unilateral hemorrhagic pyelitis; (3) extensive inflammatory distention of the pelvis and destruction of renal tissue on one side, as may be seen in advanced pyelitis; (4) ureteral obstruction as the result of peripelvic and periureteral changes causing intermittent colic." When any of these conditions is present he believes nephrectomy is indicated, even though a moderate degree of infection is found to exist in the other kidney. Some of the conditions which he mentions closely border upon or suggest pyelonephritis or pyonephrosis.

In acute embolic pyelonephritis of the fulminating type, if unilateral, early nephrectomy is indicated. In the milder cases the patient may be treated medically in the manner indicated for cases of acute pyelitis, at least until symptoms of acute intoxication are over, if he is responding nicely to the treatment; otherwise the kidney should be explored and decapsulation, nephrotomy or nephrectomy performed as the judgment of the operator dictates. In chronic cases, especially those secondary to infections of the pelvis, medical cures are hardly to be expected and operation will usually be necessary sooner or later. If the other kidney is sound and the patient is showing signs of impairment of health or is greatly troubled by cystitis, the kidney if badly infected should be removed. If the other kidney is below par nephrotomy will be necessary, taking care to open into and drain all abscesses. Urinary fistula results, which is sometimes very long in closing and causes the patient a great deal of discomfort. In some such cases improvement in function of the remaining kidney is so great after the removal of the septic focus that secondary nephrectomy may be performed without much risk later. Sometimes with infection of both kidneys bilateral nephrotomy is required.

Pyonephrosis is rarely amenable to palliative measures except possibly in the cases where it develops as an acute infection of a small hydronephrosis. In these cases drainage through the ureter catheter with or without irrigation, as in the treatment of pyelitis, has sometimes been practised. The only other conditions under which palliative treatment has any place is where operation is positively refused or when the patient is in such poor condition that operation, even under local anesthesia, cannot be done. Otherwise nephrotomy is performed when there is a question as to the functional value of the other kidney or when the patient is in no condition to stand nephrectomy. When the other kidney is in good condition and fully able to take care of the urinary secretion, nephrectomy is the operation of choice; though it must be said that in pyonephrosis of moderate degree, as well as in hydronephrosis, it is remarkable how much recuperation of the parenchyma takes place after some drainage operations that have been done in cases of urgence, and one is sometimes at a loss as to whether nephrotomy or nephrectomy should be done in the individual case, especially when the pyonephrosis follows calculous disease. Unless the impediment to ureteral drainage can be removed or is relieved with the cessation of inflammation following drainage, nephrectomy will ultimately be

required. When the pyonephrosis is tuberculous and the other kidney is healthy there is no question but that nephrectomy, together with the removal of the ureter, is indicated. WESLEY GROVE VINCENT.

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Pyemia and Septicemia.—*Definition.*—The terms Sapremia, Toxemia, Septicemia, and Pyemia have been used to describe certain clinical conditions dependent on the growth of bacteria. One or more of them may arise in the course of practically any infection. The terms originated before the days when bacteria were appreciated and the newer studies lead us now to consider these conditions rather as *stages of infections.* They may slowly and gradually overcome the bodily defenses or begin with a sudden overwhelming of the body resistance. In the latter case the infection starts as a constitutional disease; in the first class it starts as a local infection and passes into a constitutional one; we call both classes *septicemia*, sepsis, or blood poisoning. The sapremias and toxemias are earlier stages—the pyemia a late stage. The older idea of ascribing all cases of septic fever to one special germ has given way to the appreciation that any bacteria capable of local growth and infection may, theoretically at least, invade the entire body and be the cause of this sepsis. If it is the bacteria themselves that spread throughout the body we have a *bacteriemia.* If it is their products, we have a *toxemia* and we usually do have both at the same time. If the toxins are produced and excreted by the living bacteria—the ectotoxins—and absorbed by our bodies, there develops a toxemia such as we find in diphtheria or tetanus. If the bacteria produce changes in the tissues in which they exist on the surface of the body causing putrefaction, and those putrefactive products are absorbed, we have a toxemia that in some of the cases especially the puerperal ones we call *sapremia.* In other cases with absorption from the intestinal surface of food products usually decomposed before ingestion; we call the condition *ptomaine poisoning.*

The great majority of the bacterial poisons, however, are the decomposition products of the bodies of the dead bacteria themselves that have been killed by the body defenses. We see the condition in surgical conditions in a phlegmon of the finger or in erysipelas; also in the medical conditions such as typhoid and pneumonia. The toxic products and the antibodies are found in the blood and sometimes are looked for as an aid in diagnosis. If the bacteria also are in the blood stream—a bacteriemia—we have the condition called *sepsis.* Typhoid fever and pneumonia are in the pathological sense as truly septicemias as any other bacteriemia, the bacteria being recoverable from the blood before the Widal is positive. But since the majority of the cases recover after running a typical course we do not group them with the cases of clinical sepsis with which we associate the lowered bodily resistance that so frequently does not lead to recovery. Other bacteriemias caused by a more active strain of bacilli in the same coli group and cocci in the pneumococci group, we still leave in the clinical class of septicemias. But the clinical picture of a bacteriemia going on to recovery can be seen in any characteristic typhoid fever when we appreciate that the symptoms of the bacteriemia are added to those of the local intestinal symptoms of a *bacillus coli* infection.

If the bacteria carried by the blood get a foothold in distant parts of the body and there multiply, forming metastatic foci, we have the condition clinically pictured as *pyemia.* When the bacteria are carried by the blood stream in clumps or embedded in a fragment of blood clot broken, perhaps, from an infected thrombus, naturally the mass of bacteria are more apt to gain a distant new foothold than when the bacteria lodge singly as they grow in the blood stream. Each new pyemic abscess now becomes a center for multiplication of bacteria and origin of toxins and the multiple foci of infection make the condition of the patient worse, other things being equal, than the simple bacteriemia. On the other hand, the formation of the new abscess means new concentration of leucocytes and bodily defenses at that point, which tends to control not only that local spot of infection but also to increase the entire body resistance.

When an infection starts, the body is called on to fight for its life and on its ability to cope with the invaders depends the clinical picture and the final outcome. If the body is able to resist the invasion all is well. Often, however, the resisting powers are not sufficient: we may group the cases clinically as either resistant or subresistant yet the course of the battle may change at any moment. As a rule, certain types of bacteria evoke in the body certain types of resistance, but just as there are people with differing degrees of resistance, so there are different strains of bacteria in each morphologically identical class which vary as much in their virulence as the human body varies in its resistance.

Of the cases where the body is adequately resistant there are some bacterial invasions that are practically always promptly met and walled off by the body, giving a circumscribed infection as in an aurococcus infection of the subcutaneous tissues in the ordinary boil. Other bacteria almost always spread throughout the system before being overcome and in place of giving an abscess produce a systemic infection with bacteria in the blood, but of such attenuation that inside of a limited number of days the body generally overcomes the invasion giving a clinical picture such as is found in typhoid fever.

Another group of bacteria producing systemic infection, are slower in their growth and induction of reaction. They give a clinical group of very slow infections which may take months or years to develop antibodies sufficient to overcome the invasion. There is practically a drawn battle and the patient wears out and succumbs to some secondary infection. In this group we see the most of the cases of tuberculosis. The infection may lie dormant for long periods giving no symptoms and then light up again for an irregular period or eventually fade out, but the heart, arteries, and other organs of the body probably always will carry the lesions of the prolonged struggle. One recognizes a similar picture in the cases of chronic arthritis. We scarcely group the cases as clinical sepsis and yet from the pathological definition of a bacteriemia they belong in that group.

It is the more intense infections in which the battle goes distinctly in favor of the bacteria, at least at the start, that we class clinically as the cases of sepsis. In some of them the body is suddenly overwhelmed by an intense invasion. In other cases the invasion is less severe, but the resistance of the patient fails to overcome the bacteria as soon as we expect and after one, two, three, four or more weeks of watchful waiting we still are not sure what the outcome is going to be. The acutely fulminating cases are very likely to be due to a pyococcus infection. The less

intense may also be due to the pyococcus, but perhaps nearly as often we find either the aurococcus, the gonococcus or the *Bacillus coli.*

Etiology.—The infection of practically any part of the body with any bacteria may lead to septicemia, providing that the invasion is by a virulent enough strain in a large enough quantity and the patient not resistant enough to overcome the infection quickly. Even the slow-growing tubercle bacillus in some conditions sets up an acute miliary tuberculosis, which is merely one type of sepsis and at times clinically indistinguishable from the cases produced by other germs. We had the care of one extremely interesting case in point. A young forester who had been having a slight discharge from his ear off and on since an attack of scarlet fever in childhood, and whom I had seen for a mild but persistent synovitis of the knee some months before, called me on account of an attack of headache and fever. On the second or third day we made a tentative diagnosis of typhoid fever on account of the rising temperature, a few suspicious spots on the trunk, the coated tongue clean on its edges, a fine tremor of tongue and fingers, and increasing apathy. However, the Widal was negative and the leucocyte count over 11,000. For ten days his temperature ranged between 100° and 100.6°, his pulse between sixty and eighty, his respirations eighteen to twenty; but his headache persisted, his bowels were constipated so that cathartics were very inefficient, although enemata were always effectual. He vomited once a day, usually after medicine, during the first week. At the end of ten days the Widal was still negative and the leucocyte count had risen to 23,000. Examination failed to show any focus that would account for the white blood count. His apathy increased and his memory grew very indistinct even for that day's events. His respirations at times were down to fourteen. The increasing cerebral symptoms led to a diagnosis of brain abscess subsequent on the otitis media. There were twitchings on the right side of the body, the same side as the running ear, but guided by the discharging ear rather than the symptoms we opened the right mastoid, finding most extensive caries. As there was no evident opening into the cranial cavity we trephined over the temporosphenoidal lobe, but repeated punctures failed to locate any pus in the brain. The lateral sinus also failed to show any involvement. The next day there was a deepening coma, a partial paralysis of the right side, and as a last hope we opened the left side of the skull. Again we failed to find any pus. During the night the man developed edema of the lungs and died. The autopsy showed a miliary tuberculosis, but in the brain, where we expected much, we found just four solitary tubercles, the largest three-eighths of an inch in diameter, a little bloody fluid in the ventricles, and a softening of the fornix, the septum lucidum, and the corpus callosum. The man had died nineteen days after the first symptoms suggesting a constitutional infection. The course of the disease was such as is seen in many cases of sepsis, and yet the primary cause was the tubercle bacillus.

The infection of operative *wounds* is a cause of sepsis in a steadily decreasing percentage of cases. Even the ordinary wounds of civil life much less frequently lead to sepsis because of the early antiseptic treatment that is being more and more appreciated and applied by the layman as well as by the medical practitioner. Still we not infrequently see the cases of intense bacteriemia coming from a splinter or a pin scratch. The extensive lacerated wounds of war, especially those due to hand grenades and shrapnel, lead to many cases of sepsis and at the present day are affording a vast field for study of this condition. Infection of the large serous surfaces, such as the peritoneum and the knee-joint, are especially prone to sepsis.

Second to the skin wounds as a source of infection we would put the *genito-urinary tract.* The tears of the cervix and perineum at labor and the wide mouths of the uterine sinuses at the placental site both after labor and after miscarriage, while still being the site of all too many septic invasions, do not now give anywhere near as many instances as they did fifty or even twenty-five years ago. The cases of sepsis following even criminal abortion are less frequent than they were though there are still many of them. The infection of the *genito-urinary tract* by the gonococcus whether in the male or the female leads to many cases of systemic infection, but usually of such a low grade that the cases do not often become classed as septic. In the woman the pus tubes and the pelvic peritonitis are apt to be the limit of the infection, while in the man the infection is most often limited to the urethra and the mucous membranes opening directly thereon. But the low-grade infections of the joints and serous surfaces throughout the body commonly enough show that the gonococcus has entered the blood stream so as to make a bacteriemia, in the pathological sense if not the clinical one. Another very common group of sepsis cases is that arising from prostatic obstruction with infection of the prostate, bladder, ureters, and kidneys, and from these spreading throughout the body before the source of infection is located and removed.

Another large group of septic cases come from infections that start in the *alimentary canal.* Many of them are primary infections in the tooth socket, the tonsils, and the nasopharyngeal pockets or the associated ear conditions. Many more come from the intestines primary in either the appendix, the cecum, the colonic diverticuli or even from the lumen of the intestines whence absorption is so rapid and extensive. Grouped with these alimentary tract infections we must always count those arising from the gall-bladder.

There remains another group of septic cases in which in spite of careful examination we can find no primary focus. Perhaps the primary focus has healed before we start to look for it. Perhaps it is obscured behind the ribs. We acknowledge our inability to find the primary source by calling the cases *cryptogenic* infections. But it is not justifiable to put in this group any case until we have made repeated systematic examinations of the patient from the tips of his toes to the top of his head—what some of the hospital internes call a "tip-top" examination. I recall one very instructive case of a man some fifty odd years of age admitted to the wards in a classical septic condition. Our repeated examinations of mouth, throat, nose, ears, genito-urinary tract, chest, abdomen failed to locate any focus of infection that might be called the source of the trouble. Of course he was on the surgical service, but we could find no excuse for an operation. He was on the ward for over a week when one day a nurse called somebody's attention to the soiling of the bed sheets by a discharge from the man's big toe. The man had a Charcot joint that, being perfectly painless, gave no sensation at the time of infection or thereafter. He did not know there was anything the matter with his toe. It would be impossible to enumerate all the possible sources of the septic infections; we would merely suggest that in the cases of sepsis of an obscure origin that a careful history be taken and a "tip-top" examination be made before we class them as cryptogenic.

Pathological Physiology.—The normal defenses of the body against invasion by infectious agents are seen primarily in the surface coverings of the physiological exterior of the body, for the bacteria cannot get into the interior of the body until they have passed through skin or mucous membrane. These act not merely by their presence as physical barriers, but also by their secretions help to wash away and

obstruct the entrance of the bacteria. The stomach, into which great numbers of bacteria are carried, is especially protected by the chemical action of the hydrochloric acid in its secretion, so that the duodenal contents becomes nearly sterile. So also the normal acid vaginal secretion is full of bacteria, but the upper end of the cervical canal and the uterine canal in healthy conditions are sterile. When these barriers are weakened infection is more likely to take place.

When the bacteria have passed the surface barrier they are antagonized by the lymphoid tissues in the immediately adjacent tissue, the leucocytes, the lymph vessels and the lymph nodes. The body fluids, especially the blood, are all bactericidal and it is by these in many cases that the bacteria are carried to the nearest lymph node, there to be filtered out. It seems that while a normal lymph node may allow a certain number of bacteria to pass, an inflamed node becomes a much better filter and stops so many of the bacteria that it bears the brunt of the infection and so is liable to be the first tissue to break down in the fight. Adami and McCrae in their "Text-book on Pathology" give a very graphic description of the bodily defenses as they are exerted against the pathogenic bacteria that affect the body through their endotoxins, the group that includes the majority of pathogenic bacteria. We quote from them: "If an aurococcus culture be put into the subcutaneous tissues by an hypodermic injection and the animal killed in twelve to twenty-four hours it shows an infected area with singularly slight local reaction. The cocci are growing freely and cause very little irritation. A few hours later we see an active attraction of leucocytes caused by the disturbed metabolism and excreted products of the tissue cells of that part, the nutrition being damaged by the mechanical pressure of the bacteria filling up the lymph spaces or breaking down and liberating of the split products of certain cocci whose death has been brought about by the multiplication of the bacteria cutting off the nutrition of some of their own number. Whatever the cause, once the leucocytes are attracted to the area they ingest some of the cocci and split up the proteins of the latter liberating the soluble and diffusible endotoxins. These diffusing cause dilatation of the surrounding capillaries and migration from them of more and more leucocytes with more and more phagocytosis. Many of the polymorphonuclear leucocytes are killed, forming pus. The endotoxins diffusing out gain entrance into the blood and lymph, and set up distant disturbances: fever, malaise, and headache. At first the cocci are attacked by non-specific lysins, the common proteolytic enzyme of the leucocytes and to these, the *lysins of the first order*, is due the liberation of the highly toxic endotoxins. Later the leucocytes and other tissue cells which have absorbed the poisonous split products of the bacteria develop specific enzymes, *lysins of the second order*, which break these down into harmless substances. It is with the production of these specific lysins in excess that the body overcomes the bacteria, the febrile process comes to an end, and healing ensues. At times this reaction does not occur until after the cocci, proliferating, have been carried into the blood stream. . . . . "and then we have a bacteriemia. Our bodies develop the specific immune bodies in only small numbers for certain bacteria, especially the pyococci, hence they appear often in the cases of bacteriemia; and again since the pyococci are saprophytic and may remain for long periods in the tonsils or in the mucosa of the nose we have recurrent attacks and also frequent pyococcal complications of other infections. We follow Adami and McCrae in speaking of the *Streptococcus pyogenes* as pyococcus, and the *Staphylococcus aureus* as aurococcus.

Pathology.—Since the stage of infection that we class as septicemia includes infections by all kinds of bacteria and each group of bacteria have certain tissues that they affect by choice more than other tissues, it follows that the changes produced in the body will vary with the group of bacteria causing the infection, as well as with the site of the primary infection. Hence the pathological changes described as those of bacteriemia must be added to those of the primary infection and will be modified by the selective action of the particular invaders.

The criterion of a bacteriemia is of course the presence of bacteria in the blood though the finding of the bacteria there is not essential for a clinical diagnosis. Whether they be demonstrated or not will depend to a certain extent on the care that is taken to isolate the organisms but also on the nature of the bacteria. The tubercle bacilli for instance are much more difficult to grow than the pyococci. Among the true bacteriemias are the cases of typhoid fever, acute miliary tuberculosis, acute articular rheumatism, acute endocarditis, anthrax, bubonic plague and many others. But excluding these that we think of as specific clinical entities and may group as medical septicemias there are left the many cases which we consider as surgical or obstetrical septicemias or bacteriemias. Among these the blood cultures far most frequently show the streptococci. These pyococci occur in nearly as many cases as all the other bacteria put together or in still greater proportions if we include the pneumococci among the streptococci. Next we find the bacillus coli group, the gonococcus, and the aurococcus. A certain number are due to anaerobic bacteria.

Along with the bacteria we find in the blood the antibodies and the toxins which also may be demonstrated in some cases by the agglutination tests, and serum reactions. The blood also shows an anemia that persists and increases week by week associated with a decrease in the red blood cells and in the hemoglobin. The number of white blood cells varies, usually increased but not infrequently decreased. The blood clotting is usually slowed.

The heart muscle shows a cloudy swelling that goes on to an interstitial myocarditis or a fatty degeneration. The blood-vessels show endothelial degenerations that allow the passage of transudates usually blood stained into any of the cavities of the body and into the intercellular spaces giving edema in the subcutaneous tissues. The injured vessel walls also account for the frequency of the petechial spots on all the surfaces of the body whether skin, mucosa, or serosa, as seen in the hemorrhagic septicemias. The lymphatic system becomes hypertrophied and shows congestion and edema especially in the lymph nodes and spleen. The Malpighian bodies in the spleen may be greatly enlarged.

The intestines show a similar swelling and congestion and not infrequently there develops a toxic ulceration in the duodenum or the pyloric end of the stomach. The liver cells are often greatly injured showing the same degeneration as the kidneys. The injury to the liver cells causes bile staining of all the tissues and body fluids. The kidneys undergo cloudy swelling, then fatty degeneration of either interstitial or parenchymatous type depending on the character of the infection, and its intensity. The lungs are frequently congested. There are at times irregular areas of pneumonic consolidation, bronchitis, and not infrequently edema. They are frequently the site of pyemic metastatic abscesses. The central nervous system almost always shows a diffuse granular degeneration. In general we expect the intense toxins to produce a cell degeneration or necrosis with exudation from the blood-vessels. The weaker toxins to give phagocytosis and proliferation of cells.

Symptoms.—Following the symptoms of the local infection or coming on without any recognizable primary local infection we notice the development and persistence of what we are prone to call the typhoid

state. It might better be described as the bacteriemic stage. The fever persists whether it be constantly high or low or extremely irregular in its daily fluctuations. There are the persistent malaise, chilly sensations or sharp chills, headache, apathy, or alternating apathy and a mild wandering delirium. The pulse is usually rapid. A persistently rapid pulse over 120 in an infection, when not accounted for by other reasons is most significant of a grave bacteriemia. Examination of the heart may elicit murmurs showing an endocarditis as well as the functional murmurs of the anemia. The myocarditis can also often be found in the persisting cases. Respiration is often shallower than normal and it is fairly common to have a bronchitis or a pneumonia of the bronchial type.

The tongue becomes coated, brown, dry, the breath foul, the lips and teeth covered with sordes. The stomach is irritable. Vomiting not infrequently occurs, at first of the food and stomach secretions, later of mucus streaked and stained with coffee-black blood. At times there is vomiting of larger quantities of blood from a pyloric or duodenal ulcer of toxic origin. The intestines show the irritation due to the elimination of the toxins by a diarrhea at first watery and fecal, then containing coffee-ground blood and in the cases of larger intestinal erosions the stools contain tarry blood. In many cases with severe nervous symptoms there may be incontinence of feces. Occasionally there is constipation.

The urine, unless the fluid supply to the body is very great, tends to become high in color, scant, and often contains red blood cells, albumen, and casts. Not infrequently bile pigment is found in the urine associated with jaundice of the tissues. In some cases there may be almost a complete suppression of urine from the intense irritation of the kidneys. Involuntary urination is at times associated with incontinence of the feces in delirium.

The skin becomes dry, wrinkled, at times jaundiced. Not infrequently there are petechial spots or larger ecchymotic areas. Often there is a fine scarletiniform rash.

The central nervous system is pretty sure to be one of the severe sufferers, as shown in the apathy, the mild delirium, the fine tremors of fingers, tongue, and face, that are almost always present. At times there are general coarser muscular twitchings and wild delirium. Frequently the apathy deepens into coma. The memory is often distinctly deficient. The clinical picture of senile pneumonia is not infrequent. With a pulse around ninety, temperature between 99.6° F. and 100.4° F., there is delirium and incontinence of feces. The man is septic, and the only localizing symptom is perhaps a muddy urine containing a heavy pus sediment. The nervous symptoms overshadow all the others. He may go into coma and die.

The blood examination shows a low hemoglobin percentage, a destruction of the red blood cells and a variation in the number of white blood corpuscles, most often a leucocytosis, in some a leucopenia. A blood culture may show bacteria. Their absence does not exclude the bacteriemia. Sometimes agglutination tests determine the bacteria growing in the body.

Some of the cases gradually recover. In others there develops the septic cachexia, the wasting away of the body, and death in coma from exhaustion.

In some of the cases instead of this slow sepsis there is a tremendous overwhelming of the body at the outset. A *fulminating hemorrhagic infection* which we see not only in the intense pyococcus infections but in black measles, hemorrhagic scarlet fever, malignant smallpox. In these cases there is a sudden prostration of the patient following the initial chill, an abrupt rise of temperature and often before there is time for any localizing symptoms or diagnostic signs to develop, the patient dies. We find hemorrhagic areas under the skin and the mucous membranes. It is only by the history or by associated less intense infections that the cause of the terrific invasion can be determined. Such cases seem carried away as by a whirlwind; they are gone in less than forty-eight hours. A pyococcus infection of a pin scratch on the finger may show the reddened lymphatics in the arm and the enlarged axillary nodes in a few hours; a chill, a steadily rising temperature and pulse, intense pain, delirium in the next few hours, hemorrhagic spots under the skin, and then collapse and death inside of twenty-four hours.

In the cases of *pyemia* we have to deal with another complication, the additional disturbances from involvement of the blood-vessel wall and the emboli therefrom. The lodgment of such emboli gives rise to a sharp chill followed by a high rise of temperature, 105° or over. Not infrequently a sharp twinge of pain indicates the site of lodgment of the embolus as confirmed by the later appearance of the metastatic abscess. Many of these metastatic abscesses occur in the lungs because the primary focus is in the general circulation and the pulmonary capillaries are the first filtration site. If the embolus starts from the mitral valve of the heart it lodges in almost any part of the body except the lungs. In the cases where the primary vessel involvement is in the intestinal tract the secondary abscesses are in the liver. They make the group of cases called portal pyemias, such as are found after appendix abscesses.

Diagnosis.—The differential diagnosis between septicemia and the similar conditions depends almost entirely on the blood examination. The other conditions which we wish to separate from what we think of as clinical sepsis are practically all bacteriemias: tuberculosis, typhoid fever, malignant endocarditis, acute articular rheumatism, and so on. The blood culture is of the utmost help in determining which germ is back of the particular case. Two other non-bacterial conditions give similar clinical pictures, malaria and actinomycosis. In malaria the periodicity in the chills may be a help in clearing up the diagnosis but finding the plasmodia in the blood is worth much more. In actinomycosis the examination of the pus and the evident low grade of the infection determine the diagnosis.

Prognosis.—In the cases of sepsis this follows the definition. If we put in the group of septicemias only those cases of bacteriemia where the bodily resistance is scarcely able to cope with the invasion, some of the cases may get well but the vast majority die. If we include all cases of bacteriemia the vast majority get well and it is principally the cases of pyococcus infection that get progressively worse.

Treatment.—First and foremost in the treatment of the bacteriemias comes prevention of the primary infection the principles of which are one of the greatest lessons that have been taught to the physicians and laymen in the present generation. Twenty years ago the text-books on surgery began the description of every operation with the cant phrase "Under all antiseptic precautions, the incision is made," etc. To-day the repetition of that phrase has become superfluous. Even the layman is rapidly learning the lesson. He puts bichloride or tincture of iodine on his cut finger of his own initiative. Sometimes to his sorrow he put on first one then the other of these commonly recognized antiseptics.

After the primary infection has occurred it demands local treatment appropriate to its type to prevent the bacteriemia. Whatever the method of treatment of the local infection there are certain principles to be kept in mind bearing on the prevention of the bacteriemia. First is adequate drainage and yet there should be no unnecessary tissue spaces opened up through which further absorption can take place. If a major operation is needed to supply this drainage,

care should be taken to avoid shock and to minimize the effect of the anesthetic in order to minimize the additional strain on the body defenses. Next comes a dressing which will promote exosmosis. The present war has shown that the value of local antiseptics is very little as compared with a hypertonic salt solution —perhaps five per cent. sodium chloride, which causes a pouring out of lymph from the wound. In the large wounds with much sloughing tissue or profuse discharge, constant irrigation with normal salt solution, or a continuous bath are the only way to get efficient drainage. If the infection is due to an anaerobic bacterium subcutaneous injections of hydrogen peroxide all around the seat of infection will probably control the development. Then if practical the blood should be sent in the largest possible quantity to the infected part and kept there long enough to fight the battle. This hyperemia increases the fighting force at the point of bacterial attack and there produces the antibodies that determine the results. The hyperemia may be produced either actively by local application of heat in an oven, an air blast, by a hot pack, hot baths, hot water bottles, alternate hot and cold applications, wet dressings, or passively by dry cups or constriction garters according to the principles laid down by Bier.

When, however, the infection has spread to the circulation and thus to the whole body we have to combat an infection that has gotten beyond the local barriers of the body defenses. Here in addition to our care of the primary focus our aim in treatment is to conserve the bodily defenses and stimulate their activities. At the same time and by the same means to a large extent we protect the other organs of the body and stimulate them to more efficient activity. The conservation begins with rest in bed and giving of sufficient if not a slight excess of nutrition in the most easily assimilable form and free from the elements that cause irritation and strain on liver and kidneys. If the patient will not take sufficient food it may be wise to give the necessary nutrition through a stomach tube.

The poisons should be eliminated as actively as possible by keeping the bowels moving freely with laxatives, if necessary, or enemata. The skin should be kept warm and moist, not clammy wet, and frequently washed and rubbed. The inhaled air should be as pure as possible and the exhaled air carried away from the body as quickly as possible, as in the breathing of out-door air. The value of breathing fresh air as advocated by Northrup in the pneumococcus bacteriemias should never be forgotten.

The kidneys should be kept active by giving the largest possible supply of water which not only lessens the irritation of the kidneys but dilutes the toxines throughout the body and saves irritation of all the emunctory organs and all the tissues producing antibodies. Water or fluid in any acceptable form should be given by mouth in as great quantities as possible at regular intervals. A glassful every hour is the general order. If that is not feasible on account of the condition of the stomach or for some other reason the water must be given by the drip method per rectum as long as the colon is not irritated. To these may be added when the other two methods fail to get in sufficient water, salt solution subcutaneously, or even intravenously in emergencies repeated every three hours until no longer needed, even if it has to be kept up for weeks. To the water may well be added certain alkaline salts such as the citrate, bitartrate or bicarbonate of sodium or potassium. The addition of glucose or lactose also adds nutrition and helps in controlling the acid intoxication. Hexamethylene tetramine (urotropin) in an acid urine will help save the bacterial action on the urinary tract.

The mouth and tongue should be kept clean, the teeth freely brushed. For the protection of the alimentary canal alkaline solutions are very efficient. Vomiting if persistent should be treated by washing out the stomach, diarrhea by laxatives and enemata rather than opium unless excessive. Duodenal hemorrhage is not an indication for operation on the ulcer but for antitoxins, alkalies, and opium.

For the protection of the heart an ice-bag over the precordium is most efficient. Digitalis and opium both have their place. Alcoholic stimulation is remarkably well borne and is very popular. It probably is efficient in certain conditions of cardiac weakness.

For the protection of the central nervous system an ice-cap to the head is a great relief. At times bromides, morphine, or even hyoscine may be temporarily needed. As to the hyperpyrexia, we believe that it should be encouraged rather than combated as at the higher temperatures all the bodily activities are increased. If we may learn our lessons from the clinical courses of the cases of typhoid fever we believe that the fever is a conservative process of nature. It is the cases of typhoid with a high fever that run the short uncomplicated course and without relapses, and the cases with low temperatures that run long courses and have repeated relapses. Hence the fever on its own account we would encourage. But the complications that go with the fever—the prostration, delirium, and apathy—are most undesirable, and it is by these that we would be guided in treatment. If we wish to reduce the body temperature the alcohol rub and the ice-cap are great helps, while the freshly diluted sweet spirits of niter and cool drinks are always acceptable. During the chills, blankets and hot-water bags are very comfortable. One of the most efficient stimulants to the body and protections of the nervous system is the cool bath. Start the water at perhaps 85° F. and cool down to 75° F. We use it not for its effect on the temperature but as a tonic. It reduces the irritation of the nervous system, strengthens the heart action, increases blood pressure, deepens respiration, and increases kidney elimination, to say nothing of the cleansing on the skin and superficial wounds.

For the pains due to joint effusions, pericarditis, pleurisy, sometimes for muscle pains, we strap with adhesive plaster. At times we need analgesics or even hypnotics.

The metastatic abscesses require the same treatment in appropriate application as the primary lesion: efficient drainage and hyperemia. If the site of the primary thrombus that gives rise to the emboli can be determined and it is at all accessible to operation it should be promptly removed to prevent further emboli. Otherwise a continuation of the pyemia and death are sure. The lateral sinus of the skull, the common iliac vein and many others have been shown perfectly amenable to operative treatment.

The use of *vaccines* and sera is certainly efficient in some cases though in the pyococcus bacteriemias it frequently is of no avail, and that is just where we need the most help. Neither our bodies nor those of the animals from which we try to get antibodies seem to develop efficient responses to the pyococcus. In any case the type of infection must first be determined by culture from the patient, preferably a blood culture though a pus culture helps also. The antitoxins which merely neutralize the toxins of the bacteria have an immediate effect and can be given in almost unlimited dosage. The vaccines, on the other hand, act only by making the body develop its own antibodies and hence the response is delayed. As a rule it is wise to use a polyvalent stock vaccine in repeated dosage, the exact dose to be determined by the strain of bacteria and the reaction of the patient. Roughly we may say that the initial dose should be about a quarter of that of the second dose which will follow in about eight days. A reasonable initial dose for the gonococcus would be ten millions; for the aurococcus, five hundred millions; for the pyococcus it is usually

desirable to make an autogenous vaccine and the initial dose would be about fifty millions. The time when the vaccine should be repeated may be determined by the opsonic index, but the clinical picture is more reliable as we wish to give the new dose during the stage when the symptoms are improving, not at the time of high fever and depression.

It has been suggested that as another way of bringing leucocytes to the bacteria and stimulating their production of antibodies that in the course of a septic condition a traumatism be inflicted to the patient at some point convenient for treatment. As the injured tissue is a point of least resistance, bacteria from the blood stream will lodge and grow there. Then as the abscess forms, a localized formation of antibodies follows and there is the possibility of producing a greater systemic reaction. The focusing abscess treated as any primary focus will not add to the dangers of the already existing bacteriemia and may be beneficial.

Throughout the treatment the picture of the bacteriemia and toxemia must be kept in mind and such treatment instituted as will assist nature in her methods of combating the infection by conservation of her resources and stimulation of response to the call for help against the bacterial invasion.

TRUMAN ABBE.

Pylorus, Stenosis of the.—The first description of this condition, though not under this title, appeared in an article published in New Haven by Dr. Hezekiah Beardsley in 1788. This paper was republished at the suggestion of Dr. William Osler in the *Archives of Pediatrics* for May, 1903. The description of this antique case was accompanied by the necropsy findings. Martin in 1826 and Pauli in 1828 described cases. The next mention of the disease was by Williamson in 1841. But the subject was brought prominently before the medical profession through a paper read by Hirschsprung before the German Pediatric Society in 1887. Since then the condition has been observed quite frequently, and numerous papers dealing with various phases of the subject have appeared. The main discussion has turned upon whether the condition is one of congenital hypertrophy, whether it is one of acquired hypertrophy, the result of spasm, or whether the stenosis is simply due to spasmodic contraction of a normal pylorus. From a consideration of the cases reported, together with the results of autopsy findings and of inspection during life at the time of surgical operations as well as the study of the sections removed at the time of the operation, it is definitely established that in most cases there is hypertrophy of the muscular coats of the pylorus and that in many cases this hypertrophy is congenital. It is probably true that the hypertrophy increases after birth because of the spasm which exists to a greater or less degree in all cases. There are various degrees of this congenital and acquired hypertrophy. Moreover, there are many cases that give some or all of the symptoms of cases of true hypertrophy in which there is no thickening of the muscular coat and the symptoms are produced by spasm alone. These last cases may be considered as closely allied to cases of severe vomiting from spasmodic closure due to gastric indigestion.

Hypertrophic pyloric stenosis, according to Pfaundler, occurs almost entirely in the Anglo-Saxon and Scandinavian races. From the Latin or Slavic countries few or no cases have been reported. Boys are more frequently affected than girls. More than one-half of the cases occur in breast-fed children and over one-third in those who have never had anything but breast milk up to the time of their sickness. The age of the child at the time when the attack comes on is from 1 to 4 days in one-fourth of the cases, 4 to 14 days in one-fourth of the cases, 2 to 3 weeks in one-fourth of the cases, and 3 to 8 weeks in the final quarter of the cases.

Pylorospasm.—Reports of pylorospasm in infants have come from the most diverse countries; so that this condition has a wide geographical distribution. There is perhaps also a family predisposition. Hereditary factors and especially a neuropathic taint seem to play a rôle in its production. The first signs of the disease appear on the average later than in the case of hypertrophic stenosis, not often, however, after the end of the first year. It occurs especially in artificially fed children suffering from some alimentary disturbance.

SYMPTOMS.—The infant who is healthy at birth, so far as appearances go, begins when two or three weeks old to vomit the nursings. At first the vomiting is not much more than frequently occurs from overloading the stomach, but it is persistent and increases. Sometimes the infant will not vomit for several feedings and then will eject forcibly a quantity of partly digested milk sufficient to represent several nursings. The vomitus is projected with such force that it may pass in a jet or stream to a distance of three or four feet, or "across the bed," as the mothers often report. The vomiting occurs without evident signs of indigestion, although the vomitus represents various stages of gastric digestion. If dietetic and medical measures fail to relieve the condition, the symptoms persist and increase. There is constipation, the stools being very small, and at later stages consist simply of brownish or greenish mucus like the meconium stools of the newborn baby. Meantime the baby loses weight, becomes emaciated, and finally presents the picture of marasmus.

Examination of the abdomen reveals peristaltic waves passing across the epigastrium, usually from left to right. These are more apt to occur shortly after food has been taken. The appearance has been well compared to that of a small ball rolling across under the abdominal wall. At times the waves are doubled, and occasionally their direction is reversed. Palpation in cases where the liver is not enlarged reveals a hard mass at the pyloric end of the stomach, feeling much like a spool or an olive under the abdominal wall. The peristaltic waves of the stomach can also be felt. Percussion reveals frequently enlargement of the stomach, its lower border extending a variable distance toward the umbilicus. The symptoms in detail are as follows:

(A) HYPERTROPHIC STENOSIS.—(1) *Vomiting* occurs at first only now and then, later more often, and finally after almost every feeding. The vomiting takes place either at once or from one to three hours after the nursing. The vomited material contains mucus, together with the partially digested food, and has a strong odor of butyric acid; it is seldom foul. There is, according to most observers, never any bile present, although exceptions to this rule have been reported by Schwyzer and by Saunders. The vomiting is not accompanied by any signs of nausea or collapse.

(2) *Visible peristalsis* is a characteristic symptom and one which is seldom absent. This is not accompanied by any pain. If the abdomen is in a good light, there can be seen traveling across the epigastrium from left to right successive waves; these generally stop at the median line, then begin again. At times they are multiple; and occasionally they pass from right to left. The significance of this symptom is less than formerly supposed, since cases of pyloric spasm show it, and it is also present in emaciated or rachitic infants that have gastric dilatation with vomiting. Again, according to Rotch, visible peristalsis may not be observed in true cases of hypertrophy.

(3) *Palpable Tumor of the Pylorus.*—This is to be felt in practically every case, unless the liver is much enlarged. Slightly to the right of the median line, often through the space between the rectus muscles,

there can frequently be felt a resistant tumor about the size of a hazelnut, an olive, or a spool. It was once thought that a palpable pylorus was absolutely diagnostic of hypertrophy, and that when present it demanded surgical intervention. It is now known, however, that cases can recover under medical treatment even when palpable pylorus is present. On the other hand, without the presence of pyloric tumor it is unsafe to make a diagnosis of hypertrophic stenosis of the pylorus, since visible peristalsis and the other symptoms are frequently present in cases of gastric or pyloric spasm without stenosis.

(4) *Loss in Weight.*—This depends upon the loss of water and fat. The infant may lose an ounce or more daily and finally present the picture of marasmus, with subnormal temperature, sunken fontanel, and anemic redundant skin hanging in folds over the extremities. Heubner saw, in two cases of pylorospasm, weights of 2.6 kilograms in a six months' child, and of 2.5 kilograms in a four months' child.

(5) *Obstinate Constipation.*—The stools are very small, or there may be none at all for from three to twelve days; then the stool is like that of starvation, and looks like meconium.

(6) *Scanty urine* depends directly on the amount of water absorbed. The urine passed is, of course, rich in solids.

Symptoms (4), (5), and (6) are a direct result of the vomiting.

(7) *Sunken abdomen and dilatation of the stomach* are symptoms of less importance.

(8) *Motor Insufficiency.*—If the stomach tube is used three or four hours after a feeding, there is withdrawn a large quantity of partially digested food, with usually more than the normal amount of mucus. At times, too, a mucous plug is obtained by lavage.

(9) *Hyperacidity* has been found in certain cases, as has also hyperchlorhydria. This finding is in contrast to the usual low acidity of most other digestive disturbances in infancy.

(B) Pylorospasm.—The early symptoms are similar to those of hypertrophy, but less severe. The vomiting is not so frequent nor so regular; the intervals between the spells being longer; moreover it is not so explosive, being more in the nature of regurgitation. The stools are often green, containing mucus, and the constipation alternates with diarrhea. In severe attacks wasting follows as a result of the digestive disturbances and the vomiting. Visible peristalsis of the stomach and occasionally also palpable tumor of the pylorus are present. Hyperacidity and hyperchlorhydria are both found at times. Infrequently a spasm of the pylorus is met with as a manifestation of some general nervous disorder, just as are also nystagmus and the signs of tetany.

Course.—Unless food is able to pass the pylorus in sufficient quantity, the patient naturally starves to death notwithstanding attempts at rectal feeding, because this is insufficient to maintain life for any length of time, although it may aid temporarily. Signs of improvement are as follows: There is a cessation of the vomiting and a reappearance of milk stools; the loss of weight ceases and the fretful whining disappears; finally the peristalsis becomes less evident and gradually disappears entirely.

Pathology.—Cases that have come to autopsy have revealed one of three conditions: First, a normal stomach; second, contracted pylorus without hypertrophy; third, a contracted and hypertrophied pylorus. It is of these last cases that most careful study has been made, and these are the ones that support the contention of a congenital hypertrophy. In nearly all the reported cases there is hypertrophy of the circular muscular coat of the pylorus. In most of them there is also hyperplasia of the submucosa, and in a few there is thickening of the mucous membrane. In Dorning's fatal case (not operated on), the anatomical diagnosis was "stenosis of the pylorus from fibrous thickening of the submucosa and hyperplasia of the circular muscular coat." According to Heubner the muscular hypertrophy affects the musculature of the whole stomach, but the pyloric region to a greater degree.

Pathogenesis.—There are many theories in regard to this condition. It is claimed by some (Cautley and Peden) that in her effort to supply an efficient pylorus Nature exceeded the needs of the case and deposited an excessive amount of muscular tissue in that region. Thomson thinks that there is hypertrophy due to excessive functioning depending upon nervous incoordination. He calls the condition congenital gastric spasm, and thinks that it is analogous to the spasm of the pylorus that occurs in Reichmann's disease in adults. Cunningham from his anatomical investigations on lower animals, and Neild from his clinical experience with adults, believe that the stenosis is due to spasm. Wernstedt thinks that the cases in which there is hypertrophy are really congenital, agreeing with Cautley as to their pathogenesis. But in regard to the other cases of stenosis, he thinks they are due to spasm. The accompanying table, taken from Pfaundler, gives succinctly the various theories as to the origin of the condition:

I. The hypertrophy is only apparent—(produced by persistent postmortem contraction—no increase in thickness, no true stenosis.	A. Stomach at necropsy absolutely normal; during life also, function is perfect.		
	B. Stomach at necropsy hardened in systole, for the same reason that during life there is an abnormal tendency to spasm of the pylorus.		
II. The hypertrophy is real (increase in mass); it is congenital and primary, producing the stenosis (and perhaps secondary spasms).	A. Simple excess of development; local overgrowth (*Cautley, Peden:* "Nature, in her anxiety to provide for an efficient closure of the pylorus, surpasses her aim").		
	B. True tumor, such as leiomyoma or fibromyoma (*Löbker* and other surgeons).		
	C. Atavism; phylogenetic retrogression (to conditions found in certain edentates; *Flynn, Murray*).		
	D. Ontogenetic retrogression (to condition present in early fetal life; *Ibrahim*).		
III. The hypertrophy is real but secondary (acquired in fetal or in extrauterine life.	A. An exercise hypertrophy, the result of primary spasm (*Thomson*).	Primary spasm:	A reflex spasm from the gastric mucous membrane, produced by erosions and fissures, dyspepsia, or overfeeding (*Pritchard*), hyperchlorhydria (*Knöpfelmacher*)—from other sensory zones, as phimosis (*Biedert*)—on the basis of hereditary nervous predisposition (*Freund* and others)—in fetal life, from developmental deficiencies in the nervous system which allow the two segments of the stomach to act antagonistically instead of in harmony (*Thomson*)—as a result of delayed adaptation of the stomach to its digestive functions.
	B. A compensatory hypertrophy following stenosis:		
	a. as a result of primary spastic stenosis;		
	b. as a result of primary obstruction of the outlet toward the bowel:		
	(*α*) by primary organic stenosis of the pylorus or folding of the mucous membrane (*Tilger*);		
	(*β*) from abnormal position, fixation, or kinking of the adjacent bowel by short mesentery, lig. hepato-duodenale, lesser omentum, etc. (*Mayer, Schotten, Pitt*) after fetal inflammations.		

Etiology.—There is a tendency to divide the etiology of the cases of hypertrophy from those of spasm, although this division does not seem to be very satisfactory. Race is supposed to play some rôle in the predisposition to hypertrophy, since these cases are reported exclusively from Anglo-Saxon and Scandinavian countries. Pylorospasm, on the other hand, is met with in all countries. As regards sex, it would seem also that boys are somewhat more liable to the affection than girls. Heredity seems to play a rôle, Rolleston having met three cases in the same family, and Henschel and Heubner having had the same experience. Rolleston thinks that this family peculiarity is comparable to that met in congenital obliteration of the bile ducts. As regards pylorospasm, one would expect that a nervous heredity would be a predisposing cause. Undoubtedly gastric indigestion, which is more apt to occur in artificially fed infants, is at times the causative factor in pylorospasm. In both conditions, however, there must be some underlying peculiarity either of the nervous mechanism or in the musculature at the pyloric end of the stomach. As a matter of fact, the etiology of the pyloric stenosis is still in obscurity.

Diagnosis.—The important signs for diagnosis of pyloric stenosis are: (1) projectile vomiting without evidences of indigestion; (2) visible peristalsis; (3) palpable pylorus. In addition to these symptoms, obstinate constipation and the finding of food remains in the dilated stomach several hours after the feedings are important. The *x*-ray plates taken at intervals after a bismuth meal often show the stenosis and determine an early diagnosis.

As regards the value of the various signs, peristaltic waves are generally pathognomic. There are, however, exceptions to this; for the most marked peristalsis of the stomach I have ever seen occurred in an infant eleven months old. The mother has noticed a peculiar swelling in the upper part of the abdomen whenever the child was given a bath. In this infant the hour-glass wave crossing the stomach was very prominent, the stomach wall was thick and could be picked up with the fingers and even the artery at the greater curvature of the stomach could be felt pulsating. The infant did not vomit and never had vomited any more than a healthy baby does occasionally.

The presence of the spool at the pyloric end of the stomach is, of course, diagnostic of pyloric stenosis. It does not, however, necessarily mean hypertrophy, and particularly it does not indicate that operation is necessary. All but two of my spasm cases had the spool very well marked and yet they recovered by medical measures. To my mind the most important indications for operation are two, viz., progressive loss in weight together with the absence of any food residue in the stools. So long as one sees evidences of food passing into the intestine he may use medical measures unless the general condition of the child is failing. It should be remembered that after a gradual loss of an ounce or two a day for several days the infant may suddenly go into a bad collapse so that slight indication of a change for the worse in the general condition must be seriously regarded.

As regards the diagnosis between hypertrophy and pylorospasm, it would seem at the present time to be impossible to determine at the outset which condition is present. The exact diagnosis must await the results of medical treatment. Even then it is possible that cases of hypertrophy, if of mild grade, may end in recovery without surgical intervention.

Differential Diagnosis.—Pyloric stenosis must be distinguished from gastric indigestion with severe vomiting. The important signs indicating stenosis are the absence of bile from the vomited matter, and palpable pylorus. In very rare instances pyloric stenosis might be confounded with congenital atresia of the pylorus or congenital stenosis or atresia of the duodenum. In these cases, however, the symptoms would exist from birth.

Prognosis.—The prognosis of pyloric stenosis varies with the time of onset and with the severity of the symptoms; the later the vomiting begins, the better the prognosis, as a rule. Inasmuch as all grades of stenosis may be present, and since even with hypertrophy there may be varying grades of spasm, the ultimate outcome of any particular case must depend upon the success of the various medical, dietetic, and surgical measures used in treatment.

Treatment.—*Medical.*—Since in any given case it is impossible to know at the outset whether one is dealing with a case of hypertrophy combined with spasm or a case of spasm alone, the aim of conservative treatment must be to prevent all irritation of the pyloric end of the stomach by food remains or by the acrid products of gastric indigestion. Moreover, in addition to these dietetic measures, treatment should be directed to removing acid mucus, to rendering the pylorus less sensitive, and to relaxing whatever spasm may be present.

As to the *diet*, breast milk is of course to be preferred; but inasmuch as many of the cases arise in breast-fed infants, it is evident that some modification of the milk or of the method of feeding is advisable. The nursings should be for a shorter period of time than usual in a baby of the given age, and the intervals between the nursings should be long, in order to allow the stomach to complete the necessary changes in the milk and to be thoroughly evacuated. The breast milk should be diluted if its fat percentage is three or over. This is best done by giving lime water or some mucilaginous or carbohydrate gruel before the feedings.

If it is impossible to obtain breast milk, modified cow's milk or goat's milk of low fat percentage, prepared with a thin cereal gruel rendered alkaline by lime water, and then peptonized, is the best substitute. The proprietary foods that are rich in maltose are apt to give rise to gastric fermentation and increase the trouble. Sutherland advises the use of raw beef juice and the administration of carminative waters between the feedings.

Drug Treatment.—The use of sodium bromide with paregoric has seemed to be of advantage in many cases. From five to ten grains of sodium bromide and from three to ten minims of paregoric, according to the age and strength of the patient, are given, about fifteen minutes before the time for feeding or, if the stomach is being lavaged, immediately after the stomach washing. Another measure that sometimes proves helpful is the administration of mineral oil, from one-half to one teaspoonful before the feedings. Lavage of the stomach, using one per cent. sodium bicarbonate solution, is also of benefit, especially in those cases that show an excess of mucus in the vomited material. Warm compresses or poultices applied to the epigastrium are of value in many instances.

Surgical Treatment.—When surgical treatment was first instituted, the mortality was very high, ranging from forty to seventy per cent., but as knowledge of the condition has increased and the different operative procedures have been tried out, the mortality of the operated cases has been lowered, so that in general it may be stated as between twenty-five to fifty per cent. At the present time the operations of choice are gastroenterostomy and Rammstedt's method of partial pyloroplasty. This latter procedure consists in dividing the circular constricting bands, splitting the longitudinal muscle layers down to the submucous coat. The contraction of the divided muscles relieves the stenosis of the pylorus. The advantages of the method are its simplicity, its quickness—less danger of peritonitis since the intestinal canal is not invaded—and lessened shock of the operation. On account of these advantages it is now being adopted very widely and will

probably become in most instances the operation of choice.

Downes, of New York, who has had a very extensive experience in these operative cases, reported this year that in thirty-one out of seventy-seven cases operated on in the last five years, gastroenterostomy was done, with a mortality of eleven or thirty-five per cent.; in the remaining forty-six cases the Rammstedt operation was done with eleven deaths, making a mortality of twenty-four per cent. In a personal communication, Downes gives as his reasons for preferring the Rammstedt method, that it is a much simpler operation, convalescence is much more rapid, and the continuity of the intestinal tract is preserved. A specimen removed from one of his cases dying three months after the operation showed that the tumor had entirely disappeared, and *x*-ray examinations eighteen months after operation have shown that such stomachs empty in normal time.

The after-care of operated cases is of extreme importance, for it is a common experience to have such patients do well for three or four days and then to die of exhaustion or respiratory failure even after there has been no vomiting and after good stools have been passed. Careful feeding, extreme quiet and the employment of the Murphy Drip are very important.

LINNÆUS E. LAFÉTRA.

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Pyoktanin.—(*Methyl violet.*) An aniline dye introduced in 1890, by Prof. J. Stilling, as a powerful antiseptic for surgical purposes.

It was employed for some time but its extreme coloring property proved objectionable and it rapidly fell into disuse. A weak solution is occasionally employed in conjunctivitis. It is also of some service as a deep injection in inoperable cancer and fungoid growths. During the past few years it has been recommended in the foot and mouth disease in cattle, a one per cent. solution being used for the mouth and a five to ten per cent. solution for the hoof and udder and other external ulcerations. In addition to its antiseptic and curative effects, the prophylactic value of its use is of much importance.

BEAUMONT SMALL.

Pyramidon—dimethyl-amido-dimethyl-phenyl-pyrazolon, dimethyl-amido-antipyrin, $C_6H_3N.N(CH_3)_2.CO.CH.NCH_3.CCH_3$—is a yellowish-white, tasteless crystalline powder, which is soluble in ten parts of water. With ferric chloride it gives an evanescent deep bluish-violet color, a distinction from antipyrin which gives a red color.

Employed in smaller dosage than antipyrin it has an antipyretic action like that body and a more sedative action on the nerves. It has also been used in cases of trigeminal neuralgia; in the pains of tabes, alcoholism, chorea, neurasthenia, and hysterical conditions; in the hectic fever of pulmonary tuberculosis. In pneumonia, asthma, typhoid, scarlet and other fevers the drug has been used with asserted good results. The dose is 0.06 to 0.65 gram (gr. i.–x.), and 3 grams have been given in one day without ill effects.

The pyramidon camphorates, both the acid and the neutral salts, are preferred by some therapists in tuberculosis. Bertherand recommends these compounds for preventing the excessive sweating of pyramidon. The dose of the neutral salt is 0.5 to 0.75 gram (gr. viij.–xij.), the larger dose representing 0.5 gram (gr. viij.) of pyramidon; the dose of the acid salt is 0.75 to 1 gram (gr. xij.–xv.).

Pyramidon salicylate is claimed to be especially valuable in neuralgia and rheumatism in dose of 0.75 to 1 gram (gr. xij.–xv.).

W. A. BASTEDO.
R. J. E. SCOTT.

Pyrethrum.—PELLITORY. *Pyrethri radix*, Br. P.; *Roman or Spanish Pellitory, Spanish Chamomile.* The dried root of *Anacyclus pyrethrum* (L.) DC. (*Anthemis p.* [L.], or of *A. officinarum* Hayne fam. *Compositæ.*)

The first-named is a pretty little perennial herb, which somewhat resembles the chamomile, whence one of its common names. It is a native of the Mediterranean basin, where it is cultivated not only as a drug but also as a garden flower.

Its root is from five to twelve centimeters (2 to 5 in.) long and one to two centimeters ($\frac{2}{5}$ to $\frac{4}{5}$ in.) thick, nearly straight and unbranched, cylindraceous, tapering or slightly fusiform, bearing a few tough, hair-like, yellowish rootlets and in the center of the crown usually a tuft of cottony or silky, whitish, fibrous tissue; externally deep brown, or slightly grayish brown, inconspicuously annular near the crown, very roughly wrinkled and pitted, harsh to the touch; fracture short and sharp; bark thick, the inner layer brown, containing about three circles of dark red resin cells, the outer layer dark brown; wood yellow brown, finely radiate, containing four or more circles of resin cells; inodorous, pungent, and acrid, producing a prompt and strong sialagogue effect.

The acridity of pellitory is due to a number of constituents, or possibly to some one which is carried in the former. These are a resin and two fixed oils, all present in large amount, as well as the alkaloid *pyrethrine.* The latter is readily decomposed into a derivative alkaloid, believed to be piperidine, and piperic acid. The resin contains a small amount of the alcohol-soluble body, *pellitorin.* The substance which has been sold as "pyrethrin" is merely a fatty and resinous extract. Tannin and volatile oil are present in small, and inulin in large, amount.

ACTION AND USE.—These have been but little investigated, notwithstanding that the powerfully active properties of the drug warrant a thorough experimental study. It is one of the most powerful of sialagogues, a property which we have not yet learned to utilize, in spite of the important digestive functions of the saliva. It is at least possible that so powerful an action upon the salivary glands is associated with a similar action upon the pancreas, but no observations are recorded upon this point. The most general application of the drug is as a dental anesthetic and counterirritant, and it enters into numerous "toothache drops" which have themselves largely gone out of use. There is a twenty per cent. official tincture, made with alcohol, the dose of which is a fluidram.

The second-named is *German pellitory* or *pyrethrum*, the nativity of which is not certainly known, but which is a product of cultivation. The root is very much more slender and elongated than the other, and usually comes to market with long portions of the stem attached, which should be removed before using. It has a circle of large resin cells in the bark, but there are none in the medullary rays. Its constituents and action are practically identical with those of the official variety.

HENRY H. RUSBY.

Pyretophorus.—A genus of anopheline mosquitos. *P. costalis* spreads malaria in West Africa and Mauritius. A. S. P.

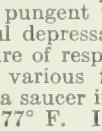
Pyridine (C_5H_5N).—A liquid base present in coal tar and separated by fractional distillation.

It is a colorless liquid, with a peculiar empyreumatic odor and pungent taste. In toxic doses pyridine is a powerful depressant, causing paralysis and death from failure of respiration. Germain Sée studied its action in various forms of asthma. One dram is placed in a saucer in a closed room, at a temperature of 68° to 77° F. In about an hour evaporation will have taken place, and the patient should then inhale the impregnated atmosphere for fifteen or twenty minutes, which may be repeated two or three times a day. The drug may also be inhaled by placing ten or fifteen drops on a handkerchief.

The drug has not established itself as a remedy of much value. Beaumont Small.

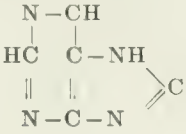
Pyrimidine is the name applied to a certain ringed compound, and its derivatives are known as pyrimidine bases. The pyrimidine bases found in nature are uracile, cytosine, and thymine (which see).

The pyrimidine ring is



Pyrimidine

and it may be regarded as the nucleus of the purine complex.



Purine

F. P. U.

Pyrogallol.—Pyrogallol is a triatomic phenol, $C_6H_3(OH)_3$, producible by the action of heat on gallic acid, whence the common name "pyrogallic acid." It is official in the United States Pharmacopœia under the title *Pyrogallol*, Pyrogallol. It occurs in long flattened prisms, or in needles; colorless, odorless, but with a bitter taste. It dissolves in 1.6 parts of water, 1 part of alcohol, and in 1.1 parts of ether at 25° C. (77° F.); very soluble in boiling water, and in boiling alcohol. In solution, exposed, it oxidizes, turning brown. Pyrogallol possesses the poisonous property, more or less common to the group of phenols, of affecting the blood and bringing about hemoglobinuria. Administered by injection to rabbits, this medicine has speedily caused chill, dyspnœa, tremor of the extremities, coming on in paroxysms, and death. The urine in such cases has shown the characteristic features of hemoglobinuria, and the blood has exhibited discoloration and destruction of the red blood corpuscles. In rapidly produced death by large doses, the blood has turned black or, in some cases, of a chocolate color and jelly-like consistence. In the human subject death has resulted, in one instance, from the application, to one-half the body at once, of a ten-per cent. pyrogallol ointment. In this case a violent chill, with vomiting and collapse, set in six hours after making the application of the salve. The patient rallied, but forty hours later a second attack ensued, ending in coma, with great reduction of temperature. Death occurred on the fourth day. During the illness the urine was much diminished in quantity, and showed, in highest degree, the condition of hemoglobinuria, being dark brown in color and, upon standing, depositing a thick sediment of amorphous, blackish material. The blood was found, postmortem, disintegrated, and the kidneys bluish black and stuffed with the same material as the urinary sediment. Pyrogallol has been used in medicine almost exclusively as a local application for the relief of certain skin diseases, notably *psoriasis*—an application often successful when other remedies may have failed. Applied in solution or in ointment, pyrogallol stains the skin somewhat, but the stain speedily disappears. Linen clothing, however, may be permanently injured by the action of the medicine. To avoid this latter effect, a solution of pyrogallol in flexible collodion has been proposed (Elliot). Such preparation, when dried to a film upon the skin, seems still to exert the therapeutic action of the medicine, but, being dried, is without action upon the clothing. Pyrogallol may be applied in ointment or in solution, and strengths are used ranging from five to fifteen per cent. of the remedy. The higher percentages, in ointment certainly, may irritate severely, and should be used with caution. Applications should never be extensive at any one sitting, for fear of enough absorption to bring about constitutional poisoning. Edward Curtis.
R. J. E. Scott.

Pyrosis.—Pyrosis or water-brash typically consists in a burning sensation in the stomach, accompanied with eructations of comparatively small quantities of liquid or semi-liquid chyme, without nausea or actual vomiting, causing a similar sense of burning in the pharynx, posterior nares, and mouth. Barring the accidental presence of various chemical irritants, the sensations are practically always due to hydrochloric acid secreted by the stomach or to fermentation acids. The sensory disturbance of the stomach is not itself abnormal, if the acidity is abnormally high but, as a hyperesthesia, it may occur with a normal degree or even a diminution of acidity. It may, of course, occur without eructations and thus the word pyrosis but not the synonym water-brash, is applicable in the literal sense. On the other hand, eructations may occur in non-acid states of the stomach so that there may be literally a water-brash without pyrosis (burning). A gastric pyrosis, in the literal sense, may also occur with mere gaseous eructations.

The chemical condition of the stomach can be satisfactorily determined only by an analysis of chyme. The writer's auscultation test, depending upon the effervescence of sodium bicarbonate swallowed in saturated solution, determines whether a notable degree of acidity is present or not, and whether such acidity is present at any definite time in the course of gastric digestion, or in the fasting intervals. A person familiar with the taste and odor of hydrochloric and the fermentation acids may interpret, objectively, the sensations produced by eructated chyme. But neither these tests nor those of qualitative nature derived from the examination of minute quantities of eructated matter, nor chyme obtained by buckets can compare with the quantitative tests of chyme obtained by the stomach tube at the height of digestion.

In many cases of pyrosis, hyperchlorhydria exists. In others, the hydrochloric acid is normal or diminished but gastric hyperesthesia causes a sense of burning in the stomach and if eructations occur an acid taste and sense of irritation are noted in the pharynx, posterior nares, and mouth. If hydrochloric acid is absent or present in small amount, a high degree of fermentation acidity may occur, though not necessarily. Marked fermentation acidity does not occur conjointly with an excess or even a normal amount of hydrochloric acidity unless ischochymia or marked impregnation of ingesta with germs capable of producing fermentation favors the latter

process to an unusual degree. Even if hydrochloric acid is practically absent and fermentation is not marked, water-brash may occur and gastric hyperesthesia or referred pains may result in a duplication of the symptoms of pyrosis.

Excessive motility of the gastric muscle, atony with other conditions favoring ischochymia, organic or spastic obstruction at the pylorus, even an obstruction of the intestine of organic or reflex nature may react so as to cause either the chemical conditions or the motor phenomena involved in eructation. Thus pyrosis is a symptom-complex of very different interpretations in different cases.

Without entering into the complexities of a discussion of the management of the very varied conditions upon which pyrosis may depend the following observations may be made: It is usually important to maintain or to restore the normal downward alimentary current. A drink of water or the stimulation of salivary secretion by a piece of candy, chewing gum, slippery elm, will tend to check reversed esophageal peristalsis. Stormy gastric peristalsis and spasm of the pylorus may be relieved by orthoform, cannabis indica, and a number of other more or less local anodynes, or by local sedatives such as bismuth subcarbonate. Various laxatives, by restoring downward intestinal peristalsis, are of value. Mineral oil is indirectly laxative and also protective, thus directly allaying the burning. For the throat, pure vaseline is better because of its consistence. The restoration of the normal alimentary current may even require surgical procedures. Strychnine is especially indicated if there is marked atony of any part of the alimentary canal.

In so far as pyrosis depends upon acidity, it may be more or less radically relieved by magnesium oxide or hydroxide, ammonium hydroxide, as in the aromatic spirit of ammonia, even by sodium bicarbonate. Various internal antiseptics and aseptic measures are especially applicable to fermentation acidity. To consider the dietetic and other management of these conditions would be out of place here. Water, mentioned for its effect in controlling peristalsis in the right direction, also allays the burning due to acidity, by dilution and, if taken cold, checks secretion and allays spasm. A. L. Benedict.

Pyroxylin.—Pyroxylinum (U. S. P.). Colloxylin, soluble gun-cotton, dinitro-cellulose. This official preparation of gun-cotton is made according to the following formula: take of purified cotton 100 grams; nitric acid, 1,400 c.c.; sulphuric acid, 2,200 c.c.; alcohol, ether, and water, of each the necessary quantity.

Mix the acids gradually in a glass or porcelain vessel, and, when the temperature of the mixture has fallen to 32° C. (90° F.), add the purified cotton. By means of a glass rod imbue it thoroughly with the acids, and allow it to macerate until a sample of it, taken out, thoroughly washed with a large quantity of water and subsequently with alcohol, and pressed, is found to be soluble in a mixture of *one* (1) *volume* of alcohol and *three* (3) *volumes* of ether. Then remove the cotton from the acids, transfer it to a larger vessel, and wash it, first with cold water, until the washings cease to have an acid taste, and then with boiling water, until they cease to redden blue litmus paper. Finally, drain the pyroxylin on filtering paper, and dry it in small, detached pellets, by means of a water bath or steam bath, at a temperature not exceeding 60° C. (140° F.).

Keep the pyroxylin, loosely packed, in well-closed vessels containing not more than about twenty-five grams, in a cool and dry place, remote from lights or fire.

Pyroxylin owes all its usefulness in medicine to the fact that it can be dissolved by a mixture of alcohol and ether, and forms with it an adhesive varnish which dries to a waterproof film or coating that can be made to cover and protect or hold injured surfaces, or be used as a vehicle for certain medicaments. This solution is official under the title *Collodium.* (See *Collodion.*) Henry H. Rusby.

Quain, Sir Richard.—Born at Mallow, County of Cork, Ireland, on Oct. 30, 1816. He began the study of medicine at University College, London, in 1837, and received from that institution, in 1840, the degree of Bachelor of Medicine. Afterward he occupied in succession the positions of House Surgeon and House Physician in the University College Hospital. In 1842 he received the degree of M. D. from the University of London, and in 1846 he was made a member of the Royal College of Physicians. From 1848 to 1875 he was connected with the Hospital for Consumptives at Brompton, first as Assistant Physician (1848–1855), then as Physician (1855–1875), and finally as Consulting Physician. He also held similar positions in other hospitals. He died March 13, 1898.

Of his published writings there is only one which calls for special mention, viz., that which is known as "Quain's Dictionary of Medicine," 1882 (2d edition in 1894). A. H. B.

Quarantine.—This term (from the Latin, *quadraginta,* Italian, *quarante*) was originally applied to a forty-day period of detention enforced for the purpose of preventing the introduction of communicable disease into a country. While the term had its origin in the restrictive sanitary measures imposed by Venice and the Hanseatic League upon maritime commerce, the idea dates from remote ages, apparently being originally a manifestation of the instinct which causes animals to avoid the sick of their kind.

History.—The history of quarantine is closely interwoven with that of medicine in general and of shipping and the movement of peoples. It was applied against leprosy in Biblical times and the English navigator, Captain Cook, records the fact that the savages of the South Sea Islands, when first visited by him, were found to resort to rude sanitary precautions in the case of arrivals from other places. Quarantine had its beginning principally as a protection against leprosy and plague. The first quarantines of which any mention is made in literature were the land quarantines imposed against leprosy. In the Old Testament, in Leviticus, Numbers, and the First Book of Samuel, directions are given for the sequestration of lepers, first in the desert, then outside the camp, and afterward without the walls of Jerusalem. The inspection of persons for the detection of leprosy is detailed and patients were isolated for a prescribed period. The Crusaders found lazarettos still in existence outside the walls of Jerusalem and utilized them after the capture of the city. On their return to Europe, lazarettos were built outside of practically all of the principal cities of Europe. Leper houses, which were really a form of land quarantine, existed at Metz, Verdun, and Maestricht, as early as the seventh century. The primitive views of the origin of epidemics necessarily hindered very greatly the institution of quarantine. Winds, thunder, lightning, fogs, flight of birds and insects, the aspects of the planets, evil spirits, the wrath of the Deity and everything which ignorant superstition could imagine was considered as a causal agent of disease, but it came to be very generally recognized that human intercourse and commerce played a rôle in the spread of epidemics. It is generally assumed that maritime quarantine had its origin in connection with the trade with the Levant, at any rate its early history is associated closely with the commerce between

Venice and Marseilles and the ports of Asia Minor. The plague of Constantinople (A.D. 534) is believed to have been introduced by ships and to this disease incursion is usually ascribed the foundation of the Mediterranean systems of quarantine establishments. In this the Venetians led and as early as A.D. 1000 created and maintained the office of overseer of the public health. There were several of these officers. Public funds were appropriated for their use in isolating infected vessels and their cargoes, and passengers and crews. The city also provided an officer for the treatment of the sick in quarantine, and by 1403 a well-equipped maritime quarantine had been established on the island of Santa Maria di Nazareth near Venice.

During the sixteenth century maritime quarantine stations consisted of an anchorage and a series of barracks for the well, the sick, the suspected and the convalescents. There was also a place for the crude attempts at disinfection which were then in vogue. In the absence of knowledge regarding the etiology the methods in use at this time were entirely empirical. Masters of vessels were required to give heavy bonds that they would not leave the harbor until pratique was granted, and to make this more effective quarantine guards were set and the ship's rudder removed. All persons, except the sick and a guard of seamen, were taken to the shore station, where all garments were taken from them. The entire personnel was then exposed to the fumes of boiling pitch and bathed in vinegar. Clothing was burned or washed, aired and perfumed for fifty days. Cargoes were similarly aired and perfumed for fifty days. The sails and cordage of the ship were taken down and submerged in the sea for a week and then hung on booms for the remainder of the quarantine period. The ship itself was fumigated with boiling pitch. Necessarily this interfered greatly with commerce and imposed a heavy burden on ship operators.

Modern Quarantine.—The term quarantine, as now used, implies detention, non-intercourse, and the exclusion of the human and animal vectors of disease. In its general sense, it usually is applied to the inspection, detention and disinfection of ships and their cargoes, and to the inspection, isolation and detention of passengers and crews. This is, properly speaking, maritime quarantine, but there are also overland quarantines, railway quarantines, shot-gun, house and room quarantines. Quarantine may be either incoming at ports of entry to prevent the importation of disease, or it may be out-going at ports of departure to prevent its exportation. Quarantine may be directed against special diseases, *e.g.* smallpox quarantine, yellow fever quarantine, cholera quarantine, out-going plague quarantine, or it may concern itself with specific animals or things, *e.g.* cattle quarantine or plant quarantine. Quarantine may be either foreign, *i.e.* directed against disease from abroad, or domestic, *i.e.* directed against the internal spread of disease within a country. When operated by a nation it is known as national or Federal quarantine. When conducted by a county, township, parish, district, or municipality, it is known as county, township, district, or municipal quarantine. In such situations it may include dwellings, places of business, manufactories, or schools, in fact, any place in which man lives, works, or congregates.

The rationale of quarantine conduct has as its legal basis the right of nations to control their own commerce and to prevent citizens from taking harm through the operations of commerce. In the United States this is a constitutional right of the Federal Government and finds expression in national and interstate quarantine. The legal basis of quarantine within the borders of sovereign States rests upon the police power which is specifically reserved to the States. States have an equal right to prevent the importation of disease from foreign countries, but the Act of Congress approved February 15, 1893, requires that the standards of quarantine so applied shall not fall below the minimum regulations imposed by the general government. Nearly all of the States have found that the dual system of quarantine does not afford additional protection, is expensive and is unduly onerous on commerce, and have therefore ceded their maritime quarantine rights to the Federal government. In those countries in which sanitation has made great progress and public health bodies devote themselves largely to questions of personal hygiene there is relatively small need for restrictive measures against foreign countries. Hence some countries, *e.g.* England, have no maritime quarantine. In the United States, which is still in the period of sanitary reform and is in close commercial relation with countries which are even more backward, maritime quarantine is a necessity and has been brought to a high degree of efficiency by the U. S. Public Health Service, a mobile sanitary corps of careful training and great experience.

Scientific Basis of Quarantine.—This is the knowledge of the causative agents of disease, the periods of incubation and infectivity, the methods of infection, and the means of spread and continuance. In the case of certain diseases, *e.g.* leprosy, all of these facts are not definitely known, but experience has shown that the careful application of quarantine, even though in such cases entirely by empiricism, controls their spread.

Causal Agents.—In the bulk of the communicable diseases the causal agent is known. For the most part these are vegetables, *i.e.* bacteria, and the organism does not develop outside of the living host. In such cases the host may be man, animals, insects, or arachnids, and quarantine is directed against these living vectors. Plants may also be the vectors of certain plant diseases, either of vegetable or animal origin, and in such cases quarantine measures are imposed on plants. With the exception of hides, and those other inanimate objects which harbor vegetable organisms in the spore stage, quarantine is not logically imposed on non-living things. Therefore logically ships and conveyances are disinfected only for the destruction of the living vehicles of pathogenic organisms, *e.g.* for the killing of plague-carrying rats or the specific disseminating agent of yellow fever, *Aedes calopus*. Those living things which are non-infected are not detained for observation beyond the incubation period. When such potential living vectors are released care is taken that they do not carry with them animals or insects which are capable of transmitting disease, *e.g.* lice which carry typhus or ticks which disseminate Rocky Mountain spotted fever.

Vectors of Disease Organisms.—A vector may be direct, *i.e.* a radius vector, or indirect, *i.e.* circumferential, vector being used in the sense of a living carrier of disease. In the former case the transference occurs from host to autosite without the intermediation of another host, *e.g.* the spread of typhoid fever by acute or chronic carriers or smallpox from the afflicted to the non-vaccinated. The path of infection is radial, proceeding directly from the focal center to its objective point. In the latter case the carrying agent transports the infectious agent from the sick to the well, either mechanically or biologically, *e.g.* the transportation of the plague bacillus from the sick rat to the well rat or to the well man by fleas or the transference of the malaria parasite by the anopheles. The paths of infection in such an instance may be circuitous.

These facts have a direct and important bearing on quarantine. In the case of radial vection, quarantine endeavors to control the sick person during the period of infectiousness and to disinfect the discharges so as

to render them innocuous to others. Thus in non-vaccinated communities rigid smallpox quarantine is necessary to prevent the spread of smallpox, but in places in which vaccination is general the disease affords relatively small menace. In the case of those diseases in which considerable proportion of the population habitually harbors the causal organism, *e.g.* the *B. diphtheriæ*, the *Diplococcus intracellularis meningitidis* of Weichselbaum, quarantine restrictions cannot logically be as stringent as in the case of unusual diseases to which no very general immunity has been evolved. When vection is circumferential control measures are directed at the prevention of vectors receiving the infection. In the case of yellow fever the quarantine attempts to prevent the Aedes from becoming infected, but in situations in which this species does not exist, no such measures are necessary.

Period of Incubation.—In order that quarantine may control contacts to infection it is necessary that the duration of the period of incubation of the disease in question be known. These periods are variant, hence it is not possible to lay down a fixed rule which will cover every case with fairness to those under observation and to the general public as well. Uniformity, however, requires that some arbitrary standard be fixed. This is admittedly inaccurate but constitutes a relatively safe rule of action. The following table is quoted from the Interstate Quarantine Regulations of the United States:

Disease.	Days from last exposure.
Plague	7
Cholera	5
Smallpox	14
Yellow fever	6
Typhus fever	12
Typhoid fever	14
Scarlet fever	7
Diphtheria	4
Whooping cough	14
Measles	14

This properly should be called the period of detention to be observed after the last possible exposure to infection or after the completion of disinfection.

Period of Infectiousness.—Closely allied to the question of the period of incubation is the period of infectiousness. The former deals with the length of time which elapses between the exposure of a non-immune period to a given infection and the appearance of the first symptoms and hence fixes the length of time they are to be held for observation. The period of infectiousness determines how long an infected person remains capable of passing the infection in a viable state to susceptible persons. This is of importance because it determines the time which infected persons must be held. Thus in yellow fever, the infected person can transmit the infection to the Aedes during the first three days of the disease but probably not afterward. The measles patient is infectious during the early stages only. Typhoid, diphtheria, and cerebrospinal meningitis patients remain infectious throughout the course of the disease and frequently for a considerable time after recovery. In fact, in the case of all three diseases acute carriers always exist and chronic carriers quite frequently. It is scarcely possible in the present state of our knowledge to prepare a table showing the duration of the period of infectiousness great though the need therefor.

Mode of Infection.—This is of importance in determining the methods to be put in force for the prevention of the spread of infection. In yellow fever quarantine methods focus themselves on the control of patients in the early stage of the disease, the prevention of the infection of the *Aedes calopus* and in the destruction of those members of this species which are presumably infected. Therefore a ship bringing yellow fever patients to infectible territory *i.e.* territory the habitat of the Aedes, debarks its non-immune personnel and passengers, is freed of all mosquitos and allowed to proceed. In plague quarantine all measures are focused on the rats, the patients are freed from ectoparasites and isolated, the ship is subjected to thorough deratization and given pratique. In the case of those diseases which are received through the alimentary canal, the discharges of the sick are disinfected while in the case of those cases spread by the secretions of the mouth, coughing and sneezing are controlled and the sputum disinfected. In diseases which are almost entirely spread by contact and the infectious agent is not known, the aim is the control of the patient.

Means of Spread and Continuance.—The way in which a disease is spread and continued determines the way in which it is to be controlled. This naturally hinges to a great extent on the method of infection, and the nature of the infectious agent. In malaria it is the anopheles which carries the causal agent therefore endeavor is made to exterminate this species, yet this measure alone is not followed by unqualified success unless the parasite is killed in the body of man who is the host which perpetuates the *Plasmodium malariæ* during the winter months when mosquitos are inactive. Cholera is spread through water, milk and foods, therefore, the aim is to prevent the carriage of the cholera spirillum by discharges from an active case or by chronic carrier and flies. In the case of typhus it is the body louse and the head louse which must be destroyed hence quarantine methods contemplate depediculization and the maintenance of body cleanliness. In plague it is the chronically infected rodent which keeps the disease alive in endemic foci and it is the infected rodent which infects the flea which carries the disease to man, hence the quarantine is against rodents and their ectoparasites rather than against man. Of course, in the case of pneumonic plague the situation is different for there it is man who distributes the disease just as it is the human being which disseminates the ordinary form of pneumonia.

Quarantine in the United States.—Massachusetts led all the other colonies in the enactment of laws for the control of communicable diseases, as it also led in the number of laws for that purpose enacted prior to the Declaration of Independence. In 1699 the general court passed "an act to prevent the spread of infectious sickness" and in 1701, another "authorizing to provide for those sick with contagious diseases;" other quarantine acts having been passed in 1716, 1730, 1731, 1737, 1742, 1743, 1750, and 1758.

In 1722 Virginia adopted "an act to oblige ships coming from places infected with the plague to perform their quarantine," and in 1769 a law regulating the inoculation of smallpox. Pennsylvania adopted, in 1700, "an act to prevent sickly vessels coming into this Government," other quarantine laws being adopted in 1742 and 1774. In 1722 Connecticut adopted "an act to prevent the smallpox being spread in this colony by peddlers, hawkers, petty chapmen;" other laws relating to contagious diseases being enacted in 1729, 1732, 1752, 1756, 1760, 1761, and 1769.

An act was passed in Rhode Island in 1743 and revised in 1748, "to prevent the spreading of the smallpox and other contagious diseases in this State," and since 1721 tavern keepers have been required to report cases of communicable diseases.

In 1726 Delaware adopted "an act to prevent infected vessels coming into this Government," and Maryland enacted quarantine laws in 1731, 1766, 1769, and 1774; while in the Carolinas sanitary legislation began in 1712 with "an act for the more effectual preventing the spreading of contagious distempers;" other acts being enacted in 1721, 1738, 1747, 1752, 1754, 1755, 1759, 1760, 1764, and 1774.

The first law of New York on the subject of quar-

antine was the act of May 4, 1784, "to prevent the bringing in and spreading of infectious distempers," successive laws having been enacted on March 27, 1794, April 1, 1796, February 10, 1797, and March 30, 1801, the last act creating a regular quarantine establishment and vesting it with adequate powers.

It will be seen from the above that practically all the laws enacted in this country before the adoption of the Constitution were aimed at preventing the introduction of disease from abroad, smallpox being usually the only disease contemplated.

Federal Status of Quarantine.—The Fourth Congress of the United States, at its first session, passed an act relative to quarantine, which was approved May 27, 1796. This law authorized the President of the United States to direct Revenue officers and officers commanding forts and revenue cutters to aid in the execution of quarantine and also in the execution of the health laws of the States, respectively, in such manner as might appear to him to be necessary. The Fifth Congress, in its third session, passed a law which was approved on November 25, 1799, repealing the former statute. This law required collectors of revenue, masters and crews of revenue cutters, and military officers to observe State health laws and also to aid in the execution thereof under the direction of the Secretary of the Treasury, who was authorized to conform customs regulations to the State laws governing quarantine. It provided further for the erection of warehouses, with wharves and enclosures where goods and merchandise might be unloaded and deposited from any vessel undergoing quarantine, and for the removal of the offices of the collectors of customs, the district and supreme courts of the United States, and any or all of the public offices of the United States to some safe and convenient place for the conduct of public business during the prevalence of contagious or epidemical diseases. With the exception of the act to encourage vaccination, approved February 27, 1813, and the act repealing it, on May 4, 1822, Congress passed no other laws bearing upon quarantine until 1832, when by the act of July 13, 1832, the Secretary of the Treasury was authorized to employ additional Revenue cutters and officers if those then in the service were deemed insufficient to aid in the execution of State quarantine and health laws. In order to provide for the better execution of the third section of the act of February 25, 1799, there was approved on December 20, 1864, an appropriation act providing for the purchase or erection of suitable warehouses or other conveniences for the storage of goods and merchandise imported in any vessel subject to quarantine and there restrained pursuant to the health laws of the State of New York at such convenient places within or near the port of New York as the safety of the public and the observance of such health laws may require. By joint resolution the Thirty-ninth Congress at its first session authorized the Secretaries of War and the Navy to place hulks and vessels at the disposal of the commissioners of quarantine or other proper authorities at ports of the United States for one year. The same Congress passed an act which was approved May 26, 1866, authorizing the Secretary of the Treasury to direct revenue officers and officers commanding revenue cutters to aid in the execution of quarantine and state health laws to guard against the introduction of cholera into the ports of the United States. By the authority of the act approved February 28, 1867, the Secretary of the Treasury and the Secretary of the Navy, respectively, were authorized to place gratuitously at the disposal of the commissioners of quarantine for temporary use hulks and vessels belonging to the United States not required for other uses; this authority to continue for two years. The Forty-first Congress at its second session authorized the Secretary of War to place at the disposal of the commissioners of quarantine or other proper authorities of the State of New York the steamer Illinois for quarantine purposes. A joint resolution by the second session of the Forty-second Congress authorized the Secretary of War to detail one or more medical officers of the regular army to visit each town or port on the coast of the Gulf of Mexico and the Atlantic Coast subject or liable to invasion of yellow fever for the purpose of conferring with the authorities of such places with reference to the establishment of a more uniform and effective system of quarantine. Similarly by resolution approved May 25, 1874, the Secretary of War was authorized and directed to detail one medical officer of the army to visit under the direction of the Surgeon General of the army in connection with the Supervising Surgeon General of the Marine Hospitals acting under the direction of the Secretary of the Treasury, the towns at which cholera prevailed during 1873 or such of them as in the opinion of the Surgeon General and the Secretary of the Treasury may be necessary, to confer with the health authorities and resident physicians of such towns and collect as far as possible all facts of importance with regard to such epidemic, the information when collected to be published by the Secretary of War.

It will be seen from the foregoing that Federal quarantine as such was not recognized during the early years of the Republic as a Federal function, and when the Federal government did undertake to perform any quarantine duties it was either in aid of State and local quarantine authorities or as a matter of general investigation. The Forty-fifth Congress at its second session passed an act which was approved on April 20, 1878, entitled "An act to prevent the introduction of contagious or infectious diseases into the United States." The Passage of this law was brought about by a realization of the need of a special corps to enforce the quarantine laws and to provide uniformity in the requirements and enforcement of such laws. This act provided that vessels and vehicles coming from foreign ports or countries where contagious or infectious diseases existed, and any vessel, or vehicle, having on board any person or persons, merchandise or animals, infected with any infectious or contagious disease, should enter no port of the United States or pass the boundary line between the United States and any foreign countries contrary to any of the quarantine laws of any one of the said United States, except in the manner and subject to the regulations prescribed under the act. The law further provided that when infectious or contagious disease appears in any foreign port or country and when any vessel shall leave an infected foreign port or have on board goods or passengers coming from any place or district infected with cholera or yellow fever, the consular officer or other representative of the United States at or nearest such foreign port shall immediately give information thereof to the Supervising Surgeon General of the Marine Hospital Service. This officer was required to make all needful rules and regulations subject to the approval of the President for the carrying out of these provisions. It was further provided that it was the duty of the medical officers of the Marine Hospital Service and the Customs officers to aid in the enforcement of National quarantine rules and regulations. The law further provided that at those places at which the Secretary of the Treasury deemed it necessary to establish quarantine, the medical officers and agents of the Marine Hospital Service shall perform such duties in the enforcement of the quarantine rules and regulations as may be assigned to them by the Surgeon General of the Marine Hospital Service. This act provided that none of the rules and regulations of the National quarantine system should interfere in any manner with the quarantine laws or regulations existing or adopted under State laws. This was the beginning

of the quarantine system of the United States. The following year, 1879, the National Board of Health was created and the act of June 2 of that year vested in the board the administration of National quarantine. The board automatically went out of existence on June 2, 1883, and was abolished by section 9 of the act of February 15, 1893.

The Federal legislation of 1796, and 1799, was brought about by widespread epidemics of yellow fever. That of 1832, 1866, 1878, and 1879, had its origin the actual or threatened epidemics of yellow fever or cholera of those years. The act of March 27, 1890, was an assumption of greater responsibility in the prevention of the introduction and spread of contagious and infectious diseases by the Federal government. It authorized the President to cause the Secretary of the Treasury to promulgate such regulations as might in his opinion be necessary to prevent the spread of cholera, yellow fever, smallpox, or plague from one State or Territory to another. This act was greatly amplified by the law of February 15, 1893, which established Federal supervision over maritime as well as Interstate Quarantine matters and vested in the Federal government far reaching quarantine authorities. Prior to the passage of this act there had been created, on August 7, 1882, an appropriation act which provided what is known as the epidemic fund. This has been amplified from time to time, and at present authorizes the President of the United States in case of threatened or actual epidemic of cholera, typhus fever, yellow fever, smallpox, bubonic plague and trachoma, to use the fund in aid of State and local boards or otherwise in his discretion, in preventing and suppressing the spread of the same and in the execution of any of the Federal quarantine laws. Following the yellow fever epidemic of 1905, an act was passed by Congress and approved on June 19, 1906, to further protect the public health and make more effective the National quarantine. By its terms the Public Health Service finally assumed charge of the maritime quarantine operations at all American ports on the Gulf of Mexico to prevent the introduction of yellow fever and other quarantine diseases and was authorized to eradicate such diseases should they gain entrance.

Foreign Commerce.—Under the above-mentioned laws there was gradually developed the present maritime quarantine system whose stations, with one or two exceptions, are operated by Federal officers. Under the act of February 15, 1893, regulations have been issued which automatically become operative on the occurrence of outbreaks of infectious diseases. The necessity of declaring quarantine against a particular foreign port is thus obviated, and uniformity of action at domestic ports is provided for.

Requirements at Foreign Ports.—The quarantine regulations referred to prescribe the measures that shall be observed at foreign ports, at sea, and at domestic ports to prevent the introduction of contagious or infectious diseases. At foreign ports these regulations are required by law to be enforced by American consular officers, or by medical officers of the United States Public Health Service detailed by the President for that duty at foreign infected ports. Such officers are required to report by cable or letter outbreaks of contagious and infectious diseases, make reports on sanitary conditions of their respective ports, and issue bills of health to vessels destined to the United States.

The officer issuing the bill of health is required to satisfy himself as to the efficacy of measures taken to insure freedom of the vessel, cargo, passengers, and crew from infection, and to certify that the regulations have been complied with.

Vessels, prior to stowing cargo or receiving passengers, are required to be mechanically cleaned in all parts, and any portions of the vessel liable to have been infected by any communicable disease must be disinfected before the issuance of the bill of health. The air space, ventilation, food and water supply, hospital accommodations, etc., must be in accordance with the provisions of the act of Congress approved August 2, 1882, regulating the carriage of passengers by sea. Presumably infected cargo is required to be disinfected, and passengers suffering from quarantinable disease or scarlet fever, measles, diphtheria, or other communicable disease are not allowed to sail. All baggage of steerage passengers destined for the United States is required to be labeled, and each steerage passenger is furnished with an inspection card.

At ports where cholera prevails special care is required to be taken to prevent the water and food supplies from being infected. The shipment of certain food products is interdicted, and steerage passengers and crews are required to be held under observation five days prior to sailing.

At foreign ports where yellow fever prevails precautions are required to be observed to prevent the introduction of mosquitos aboard the vessel, and where access of mosquitos is liable, fumigation to destroy them is prescribed. Non-immune persons who have been exposed to the disease are prohibited by the regulations from embarkation for six days after such exposure.

At plague-infected ports special precautions are required to be taken to prevent vermin and insects from getting aboard ship, and passengers exposed to infection are held six days.

Steerage passengers and crews from districts where smallpox prevails in epidemic form, or who have been exposed to smallpox are required to be vaccinated before embarkation, unless they show satisfactory evidence of having acquired immunity to smallpox by previous attack or successful vaccination within one year, and their baggage inspected, and if necessary disinfected.

Steerage passengers and crews who, in the opinion of the inspecting officer, have been exposed to the infection of typhus fever are by the regulations forbidden to embark for a period of at least twelve days after such exposure, and until their baggage has been disinfected and the destruction of vermin assured.

No alien who is a leper may be permitted to embark for ports in the United States.

Requirements at Sea.—Officers of vessels en route to the United States are required to observe specific regulations to preserve the health of passengers and crews aboard, and, in the event of outbreaks of disease, to take precautions to prevent its spread. The water-closets, forecastle, bilges, and similar portions of the vessel liable to harbor infection are required to be disinfected and frequently cleansed. Free ventilation and rigorous cleanliness are required to be maintained in all portions of the ship, and measures taken to destroy rats, flies, mosquitos, and all vermin. Special regulations detail the measures that shall be taken to isolate cases of infectious diseases, to care for them, and to prevent the spread of infection to others on board. The preparation and preservation of bodies dead of communicable diseases are prescribed, and directions given for the preparation and use of disinfectants.

Requirements at Domestic Ports.—At all of the principal seaports of the United States are maintained quarantine and inspection stations, and on arrival at such ports from abroad vessels are subject to quarantine surveillance. Inspections are required of all vessels from foreign ports except certain ports on the Canadian and Mexican border; any vessel with sickness on board; vessels from domestic ports where cholera, plague, or yellow fever prevail, or where smallpox or typhus fever prevail in epidemic form; and vessels from ports suspected of infection with yellow fever, having entered a port north of the

southern boundary of Maryland without disinfection, before entering a port south of that latitude during the quarantine season of such port.

The Inspection of Vessels.—The inspection of vessels is the most important part of quarantine practice. Indeed, successful maritime quarantine depends almost entirely upon proper inspection of vessels. In other words, the inspection of a vessel holds the same relation to quarantine practice that the process of making a diagnosis does to medical practice. An inspection of a vessel includes the consideration of the sanitary history of all ports visited by the said vessel, the present health status or quarantine credit of those ports, the inspection of all persons on board, and the collecting of collateral evidence bearing upon the sanitary status of the vessel. It follows naturally that the quarantine officer must keep himself posted concerning the sanitary history and the present sanitary status of all the principal ports of the world, and should consider the bearing which the general sanitary history of a port may have upon the recent real or alleged health status thereof.

In accordance with the regulations, inspections of vessels include examinations of the bills of health and clinical records of cases treated during the voyage, inspections of crews and passengers, examinations of manifests of cargoes, and sanitary inspections of different portions of the ship, including the living quarters. In the exercise of their authority, quarantine officers may take declarations and administer oaths.

The recent sanitary condition of a port is learned through a publication issued weekly by the Surgeon General of the United States Public Health Service, through the consular and other bills of health carried by the vessel, which bills of health are necessary to compliance with the United States Quarantine Laws, and from special information received either by wire or by letter from medical officers of the Public Health Service or from consular officers stationed at the ports previously visited by the vessel.

The inspection of a vessel consists in the examination of all persons on board, and when necessary, of the living apartments and holds. The first step in the inspection of a vessel is an examination of all sick persons on board. After visiting the sick the bodies of persons who have died at sea are viewed, and a necropsy is performed if necessary. A bacteriological examination is made of all suspected cases of either plague or cholera. Next in order comes the general muster. The method and extent of the examination of passengers and the personnel of the vessel vary with the disease or diseases existing at the vessel's port of departure or ports of call. In the case of vessels from plague-infected ports a glandular examination and the taking of temperature of steerage and crew may be necessary.

Even with a cursory inspection of a person standing in line, the officer may detect any condition denoting illness not warranting the person's appearance at muster. This is mentioned because more than once men have been compelled to get out of bed and stand in line. A convalescent from any disease may be easily recognized at a glance. By a quick inspection such symptoms of leprosy as the claw hand, drumstick fingers, elongated or nodular ear lobes, and frontal or cutaneous thickening may be seen. Cutaneous eruptions of any description naturally suggest a further examination of the person, with a view of fixing or eliminating a diagnosis of smallpox. Unusual or marked cases of "seasickness" from cholera-infected ports naturally demand further investigation. Cases of pneumonia either acute or convalescent from plague-infected ports are examined, especially for the presence of the plague bacilli in sputum.

The formal inspection of the vessel having been completed, the quarantine officer collects the collateral evidence as to the ship's sanitary status. The collateral evidence includes the general condition of the hull and the living quarters, the character and condition of the sanitary arrangements, and the condition of the decks and holds as to general cleanliness. It includes the question as to whether or not there are mosquitos on board, also the possible finding of dead rats during the voyage.

The source of the water and vegetable supply and the kind of cargo carried are also considered in the light of collateral evidence.

The Diagnosis or Judgment of a Vessel.—The last step, the judgment of a vessel's health status, is arrived at by weighing the findings of the inspection, that is, the conditions which were apparent at the time of the inspection against the possibilities of concealed infection or latent infection. Either concealed or latent infection, or even both of these conditions, may apply to a ship itself or to the personnel. Concealed infection is usually concomitant with dishonest or ignorant masters or captains, or with wily passengers and crew. Latent infection is a condition dependent upon the character and condition of a vessel, her conduct while in an infected port, and upon the character of the quarantinable disease present in such port.

When a captain of a vessel compels men sick with quarantinable disease to stand in line to pass inspection, or makes a false certificate regarding the finding of dead rats on board during the voyage, he may be said to be concealing infection. On the other hand, when a passenger or member of the crew has had a very mild, modified, or attenuated attack of a quarantinable disease which has escaped all notice, the disease on the ship may be said to be latent.

The determination of concealed or latent infection in vessels cannot be learned from books; it must be acquired or absorbed by long-continued experience and observation. Concealed or latent infection is the cause of most of the failures in maritime quarantine work, therefore it frequently happens that a quarantine officer is forced in the interest of public safety to impose the burden of proof as to the absence of latent or concealed infection upon the vessel.

The facts which may be gathered by the ordinary inspection of a vessel comprise the information obtainable from the bills of health and the ship's papers, and the sanitary facts gathered by the quarantine officer. The apparent presence or absence of quarantinable disease is the most that can be determined by an examination of the vessel and its personnel.

The quarantine officer must render his decision as to the vessel's status immediately after inspection so that the vessel, and consequently commerce, will suffer the minimum of hindrance compatible with sanitary safety to the community. While the opinion must be prompt it should be as exact as the facts at hand will warrant and the probability of latent or concealed infection to which a large vessel is liable renders this decision possible only after consideration of the sanitary history of the voyage, the likelihood of latent or concealed infection and the nature of the cargo. Way-port traffic involves a special hazard. The likelihood of latent infection must be reckoned with particularly in the case of such diseases as yellow fever or plague. Latent infection in the case of plague could be caused by an infected rat being introduced into the vessel with the freight, or by the embarkation of a passenger suffering from a case of ambulant plague. The passenger himself might recover from the illness without attracting attention, and yet leave infection to spread later on.

The inspections of vessels required by the regulations are made during daylight except in cases of vessels in distress, and exceptions may also be made in certain instances in favor of fruit vessels carrying perishable cargoes, and regular line vessels carrying passengers.

No person except the quarantine officer, his employees, United States customs officers, or pilots may be permitted to board vessels until after quarantine inspection, and towboats or any other vessels having had communication with vessels in quarantine may themselves be subject to inspection.

The Kind of Cargo Carried.—A cargo is dangerous according to its general character. Coal, oil, ore, nitrates, and the like are safe cargoes, while flour, cereals, grain, and food-stuffs are apt to harbor vermin and are therefore open to question. General merchandise is dangerous, but principally because the spaces which usually intervene between the parcels may harbor vermin.

A vessel may be found a safe risk in every respect, save the cargo. A decision depending upon the status of the cargo is a difficult one to make, as on the one hand, the public health may suffer and on the other hand, the vessel may be put to needless expense if quarantine treatment is not necessary. The quarantine officer must judge cargoes by the probability of their affording a habitat for the intermediate hosts of quarantinable diseases. In short, the judgment of a vessel's status can be obtained only by a process of deduction, and the most successful quarantine officer is the one who forms the largest number of correct deductions.

Segregation of Passengers and Crew.—In maritime quarantine practice, suspected or infected vessels, together with all persons and effects on board, are subjected to what is known as quarantine treatment. Under quarantine treatment, disinfection as a function and process is properly placed and will be here described.

All persons suffering from quarantinable diseases are first removed and placed in the lazaretto, the quarters just vacated by them being immediately subjected to fumigation by sulphur gas, which is quickly generated in small pots by firing. Next comes the removal of first class, second class, and steerage passengers in regular order followed by the ship's officers and crew. These groups of persons are taken off in numbers corresponding to the capacity of the disinfecting plant for doing the work required in the case of each group. After all persons have been removed from the vessel, the latter is subjected to the process of disinfection.

The treatment of persons from an infected vessel varies with the class of passengers, with the arrangement of the living quarters of the vessel, the type of vessel, the home port or port of arrival, and with the disease involved. Different classes of passengers may or may not be required to have their effects disinfected according to circumstances.

After arrival at a quarantine station of a vessel carrying immigrants and upon which there has appeared during the voyage a case of cholera, smallpox, typhus fever, or plague, and after the necessary quarantine measures have been enforced, the regulations prescribe that the commissioner of immigration at the port of arrival shall be notified, and requested to transmit by mail or telegraph the destination of the several immigrants to State health authorities to enable them to maintain such further surveillance as may be deemed necessary. The regulations also require that local health authorities shall be notified of the existence of any communicable disease on board as soon after arrival as possible and before the discharge of such patients from the vessel.

Vessels Required to be Placed in Quarantine.—These are: those with quarantinable diseases on board or having had such diseases on board during the voyage; any vessel considered infected with a quarantinable disease; any vessel arriving at a port south of the southern boundary of Virginia between April 1 and November 1 from a tropical American port, which is not known to be free from yellow fever; vessels arriving at ports north of the southern boundary of Virginia and south of the southern boundary of Maryland between May 15 and October 1, if from a tropical American port, which is not known to be free from yellow fever; vessels arriving at ports in the abovementioned zones via a northern port, from a tropical American port, known to be infected with yellow fever, unless six days have elapsed since the fumigation of the vessel at such northern port; vessels arriving at northern ports without sickness on board from ports where yellow fever prevails, and towboats and other vessels having had communication with vessels subjected to quarantine.

The general requirements at quarantine are prescribed in detail by the quarantine regulations to prevent the transmission of any infection from ships in quarantine to shore. In the judgment of quarantine officers, pilots may be detained in quarantine a sufficient time to cover the period of incubation of the disease for which the vessel is quarantined, and no communication whatever between quarantine and places outside may be had except under the supervision of the quarantine officer. Persons in quarantine are required by the regulations to be inspected twice daily, and scrupulous cleanliness is enjoined so as to prevent the spread of infection among the quarantined persons themselves. Convalescents are not allowed to be discharged from quarantine until after a sufficient time has elapsed to insure their freedom from infection, and the body of no person dead of a quarantinable disease other than yellow fever may be allowed to pass quarantine until one year has elapsed since death.

Duration of Quarantine.—Special regulations are prescribed for the handling of each one of the quarantinable diseases. In the case of cholera, five days is fixed as the period of incubation. Bacteriologic examinations are required to be made under certain conditions for the detection of cholera cases and cholera bacillus carriers. The water and food supplies are required to be strictly guarded and only cooked foods are allowed to be served. Persons believed to be capable of conveying infection must be bathed and their baggage disinfected before entering the place of detention, and articles of cargo liable to convey infection and living apartments presumably infected must be disinfected.

In the case of yellow fever, six days is prescribed as the period of incubation. When a vessel arrives on which a case of yellow fever has occurred during the voyage, all persons are required to be carefully examined and their temperatures taken. The sick must be immediately disembarked, protected against the bites of mosquitos, and transferred to a place of isolation. Other persons aboard are also required to be disembarked, and subjected to observations for six days dating from the last possible exposure. Persons under observation presenting an elevation of temperature of 37.6° C. are required to be isolated in a screened apartment. It is specified that the ship shall be moored at least 200 meters from the in habited shore and fumigated for the destruction of mosquitos.

Vessels which have lain in such proximity to shore of infected or suspected ports as to render liable the access of stegomyia mosquitos are required to be carefully inspected to have their personnel subjected to six days' observation, and to be fumigated to kill mosquitos.

Under the regulations, traffic without detention is authorized during the close quarantine season, from ports infected or suspected of infection with yellow fever to ports in the United States south of the southern boundary of Maryland, provided the vessel lies at approved moorings in the open harbor at the foreign port, the crew not being allowed ashore and every precaution being taken to prevent the ingress of mos-

quitos. On such vessels all passengers and officers who go ashore must be immune to yellow fever or must have been free from possible exposure to the disease six days prior to embarking. For the fumigation of ships a two per cent. volume of sulphur dioxide gas with at least two hours' exposure is prescribed, and where sulphur cannot be used pyrethrum powder or other culicide is authorized.

In the case of plague seven days is prescribed as the period of incubation. Ships aboard which plague has occurred in men or rats are required to be carefully inspected, the sick isolated, the destruction of rats effected, the personnel held under observation from five to seven days, and all personal effects liable to infection disinfected.

Vessels from plague-infected ports which have not been protected from ingress of rodents or effective measures taken for their destruction are required to be inspected and fumigated. Vessels engaged in trade from infected ports are required to have measures taken to free them from rats not less than once every six months. For the fumigation of vessels without cargo for plague not less than two per cent. of sulphur dioxide gas for six hours is required, for vessels with cargo four per cent. gas with from six to twelve hours' exposure, and for infected vessels fractional fumigation coincident with the discharge of cargo may be required.

In the case of smallpox fourteen days is prescribed as the period of incubation. On vessels arriving with smallpox, or having had smallpox on board during the voyage, any of the personnel exposed are required to be vaccinated or quarantined not less than fourteen days unless they show satisfactory evidence of successful vaccination within one year or of having had smallpox. When necessary precautions have been taken on vessels having smallpox aboard they are not required to be quarantined further than the removal of the sick, the disinfection of objects liable to infection, and the vaccination of the personnel. When proper precautions have not been taken, however, the quarantine officer is required to quarantine all persons presumably exposed, unless they have previously had smallpox or have been properly vaccinated within one year. Living compartments and their contents aboard ship, and the baggage and effects of passengers and crew, if exposed to infection, are required to be disinfected.

In the case of typhus fever, twelve days is specified as the period of incubation. Vessels in good sanitary condition, having typhus fever cases aboard and properly isolated, are not required to be quarantined further than the removal of the sick and such disinfection as will insure the destruction of vermin. When cases of the disease have not been isolated, or where it has spread from person to person, the vessel is required to be quarantined, the sick removed, and those exposed to the infection retained under observation. Vessels in bad sanitary condition, and having typhus fever aboard, are required to be quarantined, thoroughly cleansed, and the destruction of vermin assured. In addition, the sick are required to be isolated and those exposed to the infection detained.

In the case of leprosy, vessels are not permitted to be released from quarantine until cases of the disease are removed to the quarantine station. No alien leper is permitted to be landed. If he is a passenger his deportation must be effected as provided for by the immigration laws. If a member of the crew, he must be returned to his vessel on the outward voyage.

In the exercise of his authority under the act of February 15, 1893, the Surgeon General of the Public Health Service is authorized to inspect, or order inspected, any Federal, State, or municipal quarantine station, and he may in his discretion remand vessels to the nearest quarantine station having proper facilities for disinfection and treatment.

Finally, the measures of disinfection which are necessarily thorough, are prescribed in detail by the regulations issued under the above-mentioned law.

International Agreements Respecting the Control of Cholera, Plague, and Yellow Fever.—In order to prevent the spread of cholera, plague, and yellow fever in international traffic, the Federal Government is signatory to two international sanitary agreements arranged for that purpose, and the regulations above referred to are in accordance therewith. These agreements are revised from time to time through international sanitary conventions convened for the purpose. The international sanitary agreement, signed at Washington, is participated in only by the republics of the Western Hemisphere, while the international sanitary agreement of Paris is adhered to by Governments on other continents besides Europe. In accordance with this latter sanitary agreement, there is maintained at Paris an international office of public hygiene, which is governed by a permanent international board composed of delegates from the several countries. This office, which is in immediate charge of a director and secretary, compiles and publishes sanitary information and particularly data relating to the prevalence of diseases and the progress of epidemics. By reason of its participation in the maintenance of this international office, the United States Government derives benefit from the work carried on and contributes data regarding any special investigations that may be undertaken in relation to the control of communicable diseases.

Interstate Quarantine.—Problems of interstate sanitation have been steadily growing in importance. With the great development of transportation facilities, and consequent greater liability of the spread of infectious and contagious diseases from one State to another, the necessity of uniform measures for the prevention of such spread became apparent. Laws were therefore enacted to strengthen Federal, State, and municipal health administration and to bring about uniformity of action in such matters.

The first Federal provision for the prevention of the spread of infectious and contagious diseases from one State or Territory or the District of Columbia to another State or Territory or the District of Columbia appears to have been contained in an act of Congress approved March 27, 1890. By its provisions the President is authorized, whenever it shall be made to appear to his satisfaction, that cholera, yellow fever, smallpox, or plague exists in any State or Territory or the District of Columbia, or that there is danger of their spread, to cause the Secretary of the Treasury to promulgate such rules and regulations as in his judgment may be necessary to prevent the spread of such disease to other States and Territories.

In the subsequent act of February 15, 1893, above mentioned, the Surgeon General of the United States Public Health Service is required under the direction of the Secretary of the Treasury to cooperate with and aid municipal boards of health in the enforcement of their rules and regulations, and any rules or regulations that may be made by the Secretary of the Treasury under the act, to prevent the spread of contagious and infectious diseases from one State or Territory or the District of Columbia, to another. In case State and municipal authorities fail or refuse to execute such regulations as may in the judgment of the Secretary of the Treasury be necessary to prevent such spread, the President is required to enforce them and to adopt such measures as may appear to him to be necessary.

By the above-mentioned laws the relationship of Federal, State, and municipal health authorities in respect to the prevention of the spread of contagious and infections diseases in interstate traffic is defined,

and regulations have been issued by the Secretary of the Treasury from time to time for the prevention such spread.

Under such authority the Federal Public Health Service cooperates with State and municipal authorities and in some instances assumes supervision over the control of epidemics. In every instance, however, there is thorough cooperation on the part of the State and local authorities. The equity of our form of government requires that these authorities shall exercise their police powers to the fullest extent, and it is on request of these authorities that the Federal Government cooperates in local affairs. This coöperation may be advisory in character or may assume more active form.

When material aid is extended in combating epidemics in a locality, the Government's funds are required to be expended by officers of the Federal Public Health Service, who are therefore placed in charge and have the aid of State and local officials as well as that of officers of the Federal Government. The limitations of existing Federal laws in controlling the spread of contagious and infectious diseases in interstate traffic may be determined only by judicial interpretation.

Interstate Quarantine Regulations.—A number of interstate quarantine regulations have been issued from time to time by the Secretary of the Treasury in accordance with the provision of section 3 of the act of February 15, 1893. These regulations relate to the sanitation of interstate vehicles, including the cleaning and ventilation of such vehicles, the furnishing of adequate toilet facilities therein, the prevention of spitting, the prohibition of common towels and common drinking cups, the furnishing of pure food and drink to interstate passengers, the certification of water, the reporting of communicable disease, and the prevention of the travel of persons having certain diseases, such as plague, cholera, typhoid fever, yellow fever, etc. The most recent set of Interstate Quarantine Regulations was promulgated January 15, 1916.

Penalties for Violation of Federal Health Laws.—The Federal statutes authorizing the exercise of police powers in respect to the control of communicable diseases also provide penalties for their infraction. In the law of March 27, 1890, it is provided that "when any common carrier or officer, agent, or employee of any common carrier shall willfully violate any of the quarantine laws of the United States, or the rules and regulations made and promulgated as provided in section 1 of the act mentioned, such common carrier, officer, agent, or employee shall be deemed guilty of a misdemeanor, and shall, on conviction, be punished by a fine of not more than $500, or imprisonment for not more than two years, or both, in the discretion of the court."

By an act of March 3, 1901, amending the quarantine act of February 15, 1893, a penalty of $300 or imprisonment for not more than one year, or both, in the discretion of the court, is provided for persons convicted of trespassing upon quarantine grounds and anchorages. By the same act a penalty of not more than $500 or imprisonment for not more than one year, or both, in the discretion of the court, is provided for persons convicted of violating any provision of the act of February 15, 1893, relating to the inspection of vessels or to the prevention of the introduction of contagious or infectious diseases.

Quarantine by State Health Authorities.—The laws in general confer large powers on State Boards of Health in the issuance of rules and regulations and their enforcement. They may establish quarantines, isolate persons affected with contagious or infectious diseases, and disinfect persons, animals, property, and things. The wording of the laws varies according to the State but the underlying powers are essentially the same and aim at the institution of practical measures for the prevention and suppression of disease. Practically all such health laws specifically mention the power and even the duty of State health bodies to investigate outbreaks of disease, to inspect persons, and many also grant authority to perform vaccination. In such matters the quarantine authority of the State is supreme but it is the usual policy for the State authority not to interfere in local affairs unless its regulations are not enforced or when in the presence of an epidemic the local board is unable or unwilling to control it and there is danger of the spread of the disease to other parts of the State.

It is, of course, impossible to state in limited space the local quarantine requirements of each State. In general they enumerate the diseases which are considered as communicable and dangerous to the public health, require the reporting of cases of these diseases by physicians, local boards of health, and others; define absolute and modified quarantine; lay down rules for placarding, isolation, exclusion from school, and outline measures for disinfection and fumigation.

Quarantine by Local Health Authorities.—County, township, and municipal health authorities operate quarantine under State laws, charter provisions or local ordinances. These, as a rule, include the various points taken up above.

W. C. Rucker.

Quassia.—*Quassiæ Lignum* or *Lignum Quassiæ. Jamaica Quassia, Bitter-wood, Bitter-ash.* The dried wood of *Picrasma excelsa* (Swz.) Planch (*Quassia e.* Swz.; *Picræna e.* Lindl.; *Simaruba e.* DeC.—Fam., *Simarubaceæ*), U. S. P.

The Jamaica quassia tree is said closely to resemble a small or medium-sized ash tree. It occurs chiefly in Jamaica, but to some extent in other parts of the West Indies. Quassia was originally derived from a different plant, considered below, but was later replaced by this one. The wood occurs in billets of various sizes, dense, tough, of medium hardness, and of a nearly uniform yellowish-white color; internally porous, with a minute pith, indistinct rings, and medullary rays which, on tangential section, exhibit from two to five vertical rows of cells; inodorous and intensely bitter.

It is usually met with in the form of chips or raspings.

The powdered wood is devoid of stone cells, contains crystals of calcium oxalate, and exhibits the tangential appearance of the medullary rays described above.

Quassia contains neither tannin nor starch, and, if pure, yields not more than four per cent. of ash. Its bitter principle is the crystalline substance *quassiin*, freely soluble in alcohol and chloroform, Although it requires 1,200 parts of water for solution, the dose is so very small that water constitutes a satisfactory menstrum. Quassiin is further resolvable into two crystalline bodies, called respectively *α-picrasmin* and *β-picrasmin*. A minute amount of alkaloid has been reported, but is probably of no medicinal importance.

Action and Uses.—Quassia is generally regarded as a pure or simple bitter tonic, like gentian, and is mostly used as such, being given, either alone or in combination with aromatics and stimulants, as a stomachic and appetizer In debility, in convalescence from fevers, in dyspepsia, it has been, and is still, in considerable use. Its taste is, however, more bitter and disagreeable than that of gentian or quinine.

Quassiin is a powerful irritant and convulsive poison when concentrated or used in overdoses, and is apt after long administration to set up a gastric irritation. Its use is therefore better alternated with that of other

medicines. It is particularly poisonous to the lower animals, on account of which it is much used as a rectal injection for the destruction of ascarides. For the latter purpose, from a half pint to a pint of the ten-per-cent. infusion is employed. The death of an infant has followed such use. The freedom of quassia from tannin renders it a desirable bitter for mixing, in prescription, with the iron preparations. The Pharmacopœia provides an extract (*Extractum Quassiæ*), the dose of which is gr. ss.–iij. (0.03–0.2), but this is the least desirable preparation for use, since the patient fails to receive the beneficial effect of the bitter taste. The dose of the official fluid extract is fl. ʒ¼–i. (1.0–4.0) and of the tincture, which is by far the most efficient of all preparations, fl. ʒss.–ij. (2.0–8.0). The infusion is a popular form of administration, and should be of five-per-cent. strength. Another excellent method is to introduce cold water into cups made of quassia wood. The water becomes almost at once intensely bitter, the patient receiving the full benefit of the bitter taste, with little systemic effect.

Surinam Quassia.—This, the original quassia, is still the one chiefly employed in Southern Europe, and is official in nearly all pharmacopœias. Both varieties are recognized in the 1910 revision of the U. S. pharmacopœia. It is the product of *Quassia amara* L., of the same family, a shrub or small tree of Northern South America, whence it extends up into Central America and into the West Indies. The billets are much smaller, usually from one to three inches in diameter, crooked, and still bearing the bark, which is of an ashy gray color and nearly smooth. The wood is somewhat heavier than that of the Jamaica variety, and exhibits medullary rays only one row of cells wide on tangential section. The bark is full of large stone cells, which are seen in the powder, since bark and wood are usually ground together. The active principle of this variety is practically identical with that of the other, and the properties, uses, and doses are the same.

The same statements may be made concerning East Indian quassia and Japanese quassia, derived from other species of *Picrasma*. HENRY H. RUSBY.

Quercus.—Quercus alba, White oak, Oak bark. "The dried bark of *Quercus alba* L. (fam. *Fagaceæ*)," N. F. This species of oak-tree is one of the commonest and most abundant of its genus, as well as the largest, in eastern and central North America. It yields one of the most highly prized of American hard-wood timbers. The bark is in nearly flat pieces, deprived of the corky layer, about a quarter of an inch (6 mm.) or less thick, pale brown; inner surface with short, sharp, longitudinal ridges; tough; of a coarse, fibrous fracture; a faint, tan-like odor, and a strongly astringent taste. As met with in the shops, it is usually an irregularly coarse, fibrous powder, which does not tinge the saliva yellow. The last character distinguishes it from the largely employed bark of *Quercus tinctoria.* In nearly all temperate countries some locally occurring oak is used as an astringent; the British oak, *Q. Robur* L., in Europe, the holly oak, *Q. Ilex*, in France and elsewhere. In our own country, also, other species besides the white oak are sometimes used and were formerly official (*Q. coccinea vel tinctoria*, Gray, etc.).

White oak bark is simply an astringent. It contains from five to ten per cent. of tannic acid—probably identical with the *quercitannic acid* of *Q. Robur*—and a little coloring matter.

It is used in decoction (five per cent.) for cracked or tender nipples, indolent granulations, leucorrhea, nasal catarrh, etc., and is occasionally given internally, in doses of gr. xv.–lx. (1.0–4.0). Finely powdered white oak is often blown into the nares to check hemorrhage. HENRY H. RUSBY.

Queretaro.—See *Mexico.*

Quillaja.—SOAP BARK. The dried inner bark of *Quillaia Saponaria* Molina (fam. *Rosaceæ*). This bark is derived from a large evergreen tree, native and abundant in Chili. Doubtless a portion of our supplies is yielded by other and closely similar species. After the removal of the corky layer, the bark is flattened out and pressed tightly into bales, in which form it reaches the market. It is imported in considerable quantities for various purposes connected with manufacture—sizing, cleansing, etc.—and has found a not very commendable place in syrups for aërated waters, and in beers, to make them hold their froth.

DESCRIPTION.—In large, flat pieces, three to eight (⅛–⅓ in.) thick; outer surface brownish white, often with larger or smaller patches of the dark brown outer layer adhering, otherwise smoothish or lightly striate; inner surface pale yellowish or whitish, nearly smooth, or often with longitudinally elongated blister-like elevations; fracture tough and strongly splintery, the laminæ oblique to each other; transverse section checkered with pale brownish bast fibres embedded in the white tissue; inodorous, but the powder highly sternutatory; taste persistently acrid. The infusion foams like soap water.

The active constituent of soap bark is saponin (from eight to ten per cent.), which is in turn resolvable into several distinct substances, all of them poisonous. Sapotoxin, the more important of these, is soluble in water but not in alcohol, and is precipitated by basic lead acetate. It is the principal irritating constituent. Quillaic acid is soluble in alcohol and water, not in ether, and is precipitated by the neutral as well as the basic lead acetate.

USES.—Soap bark, or an infusion or tincture made from it, is useful as a detergent in washing fine linens, laces, etc., cleaning the surface of paintings, and other fine work of that kind. It is also an ingredient of some cosmetic preparations—lotions, hair washes, etc. Its use in syrups has been referred to; it has been further employed to a small extent as an emulsifying agent. Physiologically it is a pretty active substance, paralyzing voluntary muscles with considerable rapidity, and producing local anesthesia. It is also a local irritant. These properties have not, however, been put to therapeutic use. As an expectorant, in small doses, it has been recommended, also as an alterative in place of sarsaparilla, but its value is at least doubtful.

HENRY H. RUSBY.

Quince seed.—See *Cydonium.*

Quinoline.—This is a non-oxygenated basic body represented by the formula C_9H_7N, and obtained by the distillation of certain natural alkaloids—notably quinine and cinchonine—with potassium hydroxide, and also, synthetically, by a patented process (Skraup's), from a mixture of aniline, nitrobenzol, glycerin, and sulphuric acid. An isomeric body—*leucoline*—obtained from coal tar responds to chemical tests differently from quinoline, and is to be regarded as a distinct compound.

Quinoline is a colorless limpid fluid, of alkaline reaction, forming, with acids, crystallizable salts. Of such salts, those of the so-called mineral acids are mostly too deliquescent for convenient medicinal use, but quinoline *tartrate* is free from this objection and is available as a medicine. Quinoline tartrate is in minute, white, silky crystals of a faint combined bitter-almond and coal-gas odor, of a peculiar, sharp, yet cooling taste, having a flavor as of kerosene with a *soupçon* of peppermint, and slowly soluble in about twenty-five parts of cold water.

The effects of quinoline tartrate are analogous to

those of salts of quinine. In solutions ranging from 0.2 to 0.4 per cent. it has been said to inhibit fermentative and putrefactive processes (Donath), and in doses such as would be given of quinine, to prove antipyretic and antiperiodic after the manner of that alkaloid (Donath, Loewy, and others). As against quinine, quinoline tartrate has the advantage of comparatively low price, but the disadvantage of a decided tendency to sicken, vomiting being quite a common consequence of a medicinal dose. Furthermore, later experience has failed to confirm the claim of antiperiodic powers at first asserted. The drug is best given in a sweetened aromatic water, and a teaspoonful of lemon juice or a lump of ice after the dose is said to lessen the tendency to nauseate.

Neither quinoline nor any of its salts is official in the United States Pharmacopœia.

EDWARD CURTIS.
R. J. E. SCOTT.

Quinopyrin is an aqueous solution of quinine hydrochloride and antipyrin. It is used by hypodermic injection as an antipyretic and nerve sedative in dose of ℥ xv. (1.0) several times a day. Recently it has been employed as a local anesthetic in rectal surgery.

W. A. BASTEDO.
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Rabies.—*Synonyms:* Lyssa, Hydrophobia (Greek); La rage (French); Hundswut, Tollwut, or Wut (German); rabbia (Italian); rabia (Spanish).

Definition.—Rabies is a specific infectious disease of mammals characterized (1) by a variable incubation; (2) by a short course and a practically certain mortality after symptoms develop; (3) by the localization of the virus chiefly in the central nervous system and the salivary glands, and (4) by the pathologic changes and symptoms resulting therefrom. It is communicated usually by the bite of a rabid animal (chiefly a canine), less frequently by the introduction into a recent wound of the specific virus through contact with the saliva of an infected animal.

HISTORICAL NOTE.—Aristotle (about 300 B.C.) who gave the earliest written records of rabies, states that dogs are subject to rabies, and, when infected, communicate the disease by biting all other animals except man. The first written description of human rabies was given in the first century A.D., by Celsus. The saliva of dogs was shown to carry the virus in 1804. The majority of early writers uttered much superstitious nonsense as regards both the origin and the treatment of rabies. Even now some persons believe that dogs develop rabies because of lack of water, others think that "mad stones" (calculi from the alimentary tract of lower animals) cure, and still others think that there is no such disease—that deaths are caused by fright or by something else. This disbelief on the part of the people is due partly to the fact that so few people are bitten by mad dogs, and these with so long an incubation and such a low percentage of active infections. This scepticism in regard to rabies is entirely without foundation, since the specificity of the disease has long been proved.

Pasteur, who did most to prove the entity of the disease, announced in 1884 that he was able to immunize animals against rabies by inoculations of an attenuated virus. Neither he nor others, however, were able to discover the morphologic cause of the disease. They only determined that the cerebrospinal canal with its nerve tissue contents is practically a test-tube with living nerve cells as a medium in which the rabies virus grows. This helped, however, to solve the question of the specificity of the virus and of some other facts in regard to its nature.

Certain histological changes discovered have been made use of in diagnosis: (1) "the rabic tubercles" of Babès; (2) "the areas of spheroidal and oval-celled infiltration" of Van Gehuchten and Nelis; and (3) and most important, the cell inclusions known as Negri bodies, so called after Negri (1903), who first published their discovery. In 1913, Noguchi announced that he was able to grow the rabies virus *in vitro*, but, though several investigators have tried, no one has been able to corroborate his work. Proscher also claims that he can cultivate the rabies virus outside of the body, but neither has his work been corroborated.

GEOGRAPHICAL DISTRIBUTION AND PREVALENCE.—Rabies is reported as occurring in almost all parts of the world from the arctic regions to the tropics. Australia and several smaller islands are free from it because of the rigid carrying out of the six months' quarantine law in regard to dogs. England, also, because of quarantine and periodic muzzling of dogs, is now reported free from the disease. In the United States, Stimson (1911) stated that it had been reported in all but six States. As the disease is in most sections non-reportable, the statistics may be far below the actual numbers. Severe local epidemics have occurred, during which valuable animals (deer, sheep, cattle) have been lost.

Animals Affected.—All mammals, regardless of age, sex, or season, may be infected. Certain birds are slightly susceptible. Those mammals most frequently exposed to the bites of canines are most often affected. The dog himself comes first in frequency (eighty-five per cent.), probably because he is allowed to wander more at large. In areas where wolves or other canines are found, these animals may stand next to the dog in frequency. Cattle are the next most often affected (eight per cent.). Cats may contract the disease more often than is known, since they frequently develop the paralytic form of the disease, which may not be diagnosed. Less than one per cent. each of other domestic animals (goats, sheep, horses, pigs) are affected. Humans seem to be the least of all attacked. It has been stated but not proved that rabbits, skunks, and rats are natural carriers.

Not all of the animals bitten by rabid animals develop the disease. The number is proportionate to the intensity and site of the bites. The average mortality in dogs is forty per cent. Human beings now seldom show symptoms of rabies owing to the widespread use of the preventive treatment, so the percentage mortality must be gathered from old statistics which are very incomplete. Babès gives the following table, in which the mortality is arranged in order of site and intensity of bites from different animals.

PERCENTAGE MORTALITY IN MAN

Character and sites of bites.	By wolf.	By cat.	By dog.
Multiple and deep wounds about eye, nose, or lips	100	70	60
Multiple and deep wounds about other parts of face	80	50	50
Multiple and deep wounds on other parts of uncovered body	40	40	30
Single and deep, on finger or neck	20	20	15
Deep, on well-covered parts of body	15	10	3
Superficial, on uncovered parts of body	10	10	10
Same with hemorrhage	2	2	2
Contact of recent wounds with infected saliva	0.1	0.1	0.1
Contact of wounds more than twenty-four hours old with infected saliva	0	0	0

No authentic cases are on record of transference from man to man or to other animals. Glands from human beings are seldom infective for test animals. In New York City from 1900 to 1916 inclusive there were 129 deaths from rabies in humans reported.

Pathology.—Rabies germs immediately after entrance into the system probably pass chiefly, if not exclusively, along the nerve fibers to the brain. They progress slowly along the course of the nerve and they do not disturb its function. When they reach the brain they enter the nerve cells, which they first stimulate and then destroy.

No specific changes are seen in gross autopsy. This fact in itself might be considered characteristic. The central nervous system, the salivary glands, the thyroid, the pancreas, and the suprarenal capsules, are often congested. Pin-point hemorrhages and minute areas of softening may be seen in them on section. All mucous membranes may show catarrhal inflammation. The condition of the stomach in the dog may be of aid in diagnosis. This organ is usually empty of food and may be contracted over a mixture of foreign substances such as pieces of cloth, hair leather, wood, and straw.

The histologic pathology is more important as an aid in diagnosis. The "rabic tubercles," first described minutely by Babès (1892) are the first lesion that is seen on microscopic examination of stained sections of the spinal cord from a case of rabies. These consist of groups of small spheroidal cells surrounding many of the blood-vessels and the large nerve cells, especially marked in the anterior and posterior horns. These groups are not always found in cases of rabies, and when present are not developed until late in the disease, so they are of limited use in diagnosis. Another important pathological change was found by Van Gehuchten and Nelis (1900) in the cerebrospinal ganglia. This is the disappearance of many of the large nerve cells and in their places are groups of small infiltrating spheroidal cells, and proliferated cells of the capsules. These changes may appear quite early, so, though not absolutely specific, may be of help in diagnosis. The most important histologic discovery of all—that of the specific cell inclusions called Negri bodies—will be discussed in the next section.

Etiology.—Though we know very definitely where the rabies virus is found, and though we find it free from other organisms, that is, growing in pure cultures in the central nervous system and in certain glands of the body, we are not yet able to grow it freely outside of the body. We know, however, some of its important characteristics. (1) It is filterable under certain conditions of dilution and suction, gland virus more so than brain virus. (2) The virus is more resistant to certain agents than are many cultured bacteria. This fact has a practical bearing in certain methods of treatment and in diagnosis; for example, in the use of glycerin and other disinfectants in preserving the vaccine and in ridding from contaminating bacteria decomposed brains sent in for diagnosis. On the other hand, Caterina and also Cumming have shown that formalin quickly kills the rabies virus in low dilutions. Hence the best disinfectant for contaminated material next to boiling water is formalin.

The resistance of rabies brains and spinal cords to drying and heating has also been made use of in vaccine preparation. Thus slow drying at a moderate constant temperature (about 20° C.) causes a gradual loss of virulence (see Pasteur Treatment). Very rapid drying at any temperature up to 36° C. preserves much of the virulence. At 60° the virus is killed in five minutes. The virus remains virulent for a long time when kept in a cool, dark place, protected from the air.

The structured cell inclusions now known as Negri bodies, after Negri (1903), have been studied extensively by many investigators, among them Williams (1904–13) and Lowden (1906). Williams concluded with Negri that they are probably protozoa and the cause of rabies, and she gave them the name of *Neuroryctes hydrophobiæ*. She based her conclusions chiefly upon the following facts:

1. The bodies show a distinct cyclic morphology, *i.e.* a series of forms indicating growth and multiplication—small, rounded or oval plasin-staining granules; similar forms in twos or groups; larger forms containing a definite central or eccentric chromatin-staining mass (nucleus); forms with smaller chromatin-staining masses arranged in a ring about the central mass; evidence of division of these larger forms as well as of the small ones; both by segmentation and by budding, phenomena which account for the appearance in the same cell and at the same time of both large and small forms, and also help to account for the rapid spread of the organism and for forms small enough to pass certain filters.

2. The bodies are found in all parts of the infectious central nervous system, seen first as extremely minute forms in large nerve cells, before symptoms appear, *i.e.* on the fourth day in rabbit fixed virus infections and on the seventh day in rabbits inoculated with street virus; thus they are found early enough to account for the infectivity of the host tissue.

Manouélian (1914) has demonstrated the bodies in the ganglion cells to the salivary glands in the dog. Watson (1914) states that he has found, in addition to the forms described above, spore-like bodies similar to myxosporidian spores.

Several other explanations of the nature of these bodies have been given, the more likely of which are (1) The specific microorganisms are the small chromatin masses seen within the plastin-staining (cell reaction) portion of the bodies (Volpino, Babès, Prowazek, and many others). (2) They are degenerations due to the cell reaction caused by the rabies toxin. They may or may not contain the organisms (Marie and others).

Whatever their nature, the specificity of these bodies has been accepted, therefore their practical use in diagnosis is established. The methods for the demonstration of these bodies are given in the section on Diagnosis.

Incubation.—The incubation period varies; it is longest in man, and is shorter in cases more severely infected on the shorter nerve trunks. Anything that lessens vitality, shortens incubation. There is nothing to characterize the period of incubation. The time from the bite to the appearance of the first symptoms in man is rarely earlier than twelve days or later than ninety. The limits given are eight days and several years. The average limits are from three to eight weeks. Cases reported as occurring one year or more after the bite have not absolutely reliable data. In dogs the limits are from eight days to one year, with an average of two to eight weeks. Cats and swine generally have a slightly shorter incubation, while cattle and horses have a slightly longer one.

Symptoms.—The symptoms may be divided generally into two groups or stages: (1) those of cerebrospinal excitation or irritation (furious rabies); (2) those of nerve-system degeneration (dumb rabies). Many cases show mixed symptoms, and a few are quite atypical.

Symptoms in the Dog.—Furious Rabies.—The character of the animal usually shows a change, becoming more affectionate or less so. Sputum may be virulent for fifteen days before symptoms, so we should beware of dog's licking. The appetite may be abnormal, and the dog may begin to be morose and to bite at things and animals, especially at dogs. He may seem better and then he becomes worse and begins to have spasmodic seizures. His bark may become characteristically altered to a low howl followed by an irregular

series of low-pitched barks between unclosed jaws. He generally drinks as long as he can. His saliva usually drops, but he may not "froth at the mouth." This stage passes gradually into that of paralysis. Pupils are irregularly dilated, spasms become less, and muscles get weaker until death. Duration from four to eight days.

Dumb Rabies.—About one-fifth of the cases show paralysis, usually of the lower jaw ("drop jaw"), as the first symptom. Though the animal does not bite, its sputum may be virulent, so contact with a recent wound should be avoided. The rest of the body quickly becomes paralyzed, and death follows.

Symptoms in Man.—Furious Rabies.—For about forty-eight hours there may be indefinite nervous symptoms such as a sensation of constriction in the throat, or of difficulty in walking or breathing, or of precordial anxiety, or of neuralgic pains in different parts of the body. The wound may tingle, itch, and pain. Temperature may be 38° to 39° C. The fear of water usually develops, due to painful spasm from attempt to swallow. Characteristic spasms may be caused by a draft of air (aerophobia), or loud noises (hyperacusis). Remissions usually occur, except in the very severely infected cases. At about forty-eight hours the excitement increases accompanied by hallucinations, and even mania; though usually no attempt is made to injure others. The mind is clear between attacks. The voice becomes hoarse, but there is no real barking. The eyes may show photophobia, nystagmus, strabismus, and unequally dilated pupils. Vomiting usually occurs. The patient may die suddenly after one to four days during this stage, but he usually passes into the paralytic stage, with muscles relaxed, jaw dropped, ropy saliva flowing, and he finally passes into a comatose condition and dies in about two to eighteen hours. Just before death the temperature may be high (42–44° C.).

Paralytic (Dumb) Rabies.—This type of rabies is less frequent in man than in lower animals. Its recognition is particularly necessary so that it may be differentiated from the paralyses which occur occasionally during or just after the Pasteur treatment. The proof of the relation of the disease to street rabies rather than to laboratory rabies, in these cases, is given by animal inoculations. The onset may be convulsive, but the lower extremities feel heavy and numb; then there quickly develops a condition of ataxia and progressive paralysis. Death occurs in from two to eight days from heart paralysis.

Diagnosis.—The chief conditions to be differentiated are hysteria (lyssophobia), delirium tremens, tetanus, and the condition produced by the action of certain poisonous drugs.

If there has been no exposure to infection from a rabid animal and if there is no reflex irritability, rabies may be eliminated. In hysteria, the symptoms are amenable to suggestion. In tetanus the spasms are tonic.

If the person has been bitten by an animal that cannot be diagnosed clinically, the laboratory tests must be relied upon: (1) the microscopic test, (2) animal inoculation.

The rapid spread method recommended by Williams (1904) for demonstrating the Negri bodies, is used in the New York City Health Department for the microscopic test. If Negri bodies are found, the case is considered one of rabies. Infrequently a brain does not show these typical bodies, yet it produces rabies in test animals. All such brains show suspicious small forms, and are treated as rabies, pending the result from the animal inoculation. In our laboratory during the year 1914 of eight brains diagnosed as suspicious, all proved to be rabies, while of those classed as doubtful (454), only one proved to be rabies. So the percentage of failures by the spread method is very small.

In the New York City Health Department, the material sent in for diagnosis is handled as follows:

1. Spreads are made by pressing between a glass slide and a cover-glass a small, thin section of the gray matter from each of these parts of the brain: (*a*) the cerebral cortex, (*b*) Ammon's horn, (*c*) the cerebellum. The material is spread along the slide by moving the cover-glass down with the finger. The amount of pressure to be used must be learned by experience.

2. When partly or completely air-dried the smears are fixed for about ten seconds in neutralized methyl alcohol (C.P.) containing one-tenth per cent. of picric acid. The slide is then blotted with fine filter paper and stained in a modification of the solution proposed by Van Gieson:

Saturated alcoholic solution of fuchsin	0.5 part
Saturated alcoholic solution of methylene blue	10.0 parts
Distilled water	30.0 parts

The stain is poured on the smear, which is held over the flame until steam arises and is then washed in tap water and blotted. The Negri bodies are stained a magenta color, the nerve cells blue, and the red blood cells yellow or salmon color. Giemsa's stain also gives good results. If no Negri bodies are found smears are examined from other parts of the brain. Then, if none are found an emulsion is made in 10 c.c. normal salt solution of a piece the size of a bean from the three parts of the brain, from which an intracerebral inoculation ($\frac{1}{4}$ c.c.) is made into each of three guinea-pigs. Krause says the amount to be inoculated should not be less than one-thirtieth gram of cord in order to be sure of results, since street rabies virus varies so much in virulence. Some of the brain is preserved in sterilized neutral glycerin in the cold for later tests if necessary. By this method contaminated brains are rid of their extraneous organisms, while any active rabies germs usually remain virulent for several months. If the brain is decomposed when received, the emulsion preserved in glycerin is inoculated after two weeks, unless positive results have been gotten from the first inoculation. Sections may be made, but usually they give no more definite evidence than do the spreads. The serological tests—complement-fixation, precipitation, and agglutination—have not yet given satisfactory results in diagnosis. Recently Wohl claims that Abderhalden's test is promising.

Treatment.—The principle of treatment in rabies is chiefly that of prophylaxis by means of a specific vaccine. The good results depend upon the fact that the virus becomes active only after a comparatively long incubation period. We do not yet know of a cure for the disease after symptoms appear. Antiserum has not given any help in cure, though it has been used by some combined with vaccine in prophylactic inoculations. The few cases reported as cures in man at this stage have lacked proof that the diagnosis was correct. It has been shown, however, that experimental animals may occasionally, after showing symptoms, recover spontaneously, therefore the possibility of the same thing occurring in man cannot be ruled out; and one may still hope for a cure at a late stage, if not from a specific serum, perhaps from a special drug, though quinine has not fulfilled its promise, neither has salvarsan nor any other drug so far tried. The only treatment used after the disease has developed is symptomatic. Large doses of chloral hydrate and the bromides may be given in enemata. Hyosine hydrobromide may be given hypodermatically in one-hundredth-grain doses. Cocaine may be administered to the larynx. Chloroform may be used to control severe spasms.

Prophylactic treatment may be divided into local and constitutional. *Locally,* free bleeding should be induced and the wound should be cleaned with any

fluid antiseptic solution. Then it should be thoroughly cauterized with fuming nitric acid. If this cauterization can be done within twenty-four hours after the bite, and the wound has not been too deeply lacerated the case may be protected, since the virus travels so slowly. Tincture of iodine cannot be trusted to act as well as does fuming nitric acid. In treating *constitutionally*, the specific vaccine is used. It is often difficult to decide whether the case has been infected with rabies. The suspected animal may have indefinite symptoms or may have been killed too early, or may be a stray who has disappeared, or the brain may be in too bad a condition for microscopic diagnosis. Unless we can rule out rabies, we must be guarded in advising no treatment, especially in communities where cases of rabies have been reported.

We advise treatment, therefore, under any of the following conditions: (1) When the animal gives definite evidence of rabies. (2) When the animal cannot be found just after biting. This is always a suspicious symptom, when no facts can be learned to account for it. (3) If the biting animal has been killed too early to give microscopic evidence of rabies, or if its brain is in too bad a condition for immediate diagnosis, and if the bite is unprovoked, treatment should be advised pending the results of inoculation of test animals. If these test animals show no symptoms in twelve days the treatment may be stopped, to be begun again if the animals show symptoms later. (4) If the animal is apparently healthy or has only suspicious symptoms, it should be kept under observation for at least three weeks, and treatment should be begun if suspicious symptoms appear or become more marked. (5) If the animal has been killed and no evidence can be obtained for or against rabies, treatment should be advised in areas where rabies is prevalent. (6) If anyone has been exposed to an animal's saliva only, unless exposed fresh cuts or abrasions can be ruled out, treatment should be advised.

The specific treatment of rabies, known as the *Pasteur treatment* was brought into use in 1885 by Pasteur and his coworkers. With certain modifications, this method is still used all over the world. Pasteur found that by passing the virus obtained from dogs—"street virus"—successively through certain species of animals (notably rabbits) by subdural inoculations, it became markedly increased in virulence for these animals shown both by the shortened incubation period and the smaller doses required to produce death. After many passages through rabbits (about fifty) the virus in rabbits dying from the infection would bring down fresh rabbits with the disease in a fixed time (about seven days). He called this virus, *virus fixe* (fixed virus), and from it he obtained by drying at a constant temperature a regulated series of doses from completely attenuated vaccine up to fully active virus. He found also that the fully virulent rabbit fixed virus did not so often cause death in animals when given subcutaneously as did street virus. Others found that by inoculating themselves subcutaneously with emulsions of fully virulent fixed virus no ill effects were produced. A fixed virus may be obtained sooner (in sixteen passages according to Högyes) if young rabbits are used. Babès claims that many strains of street virus will become fixed for the rabbit by three to four preliminary passages through the guinea-pig.

Animals are inoculated as follows for the production of fixed virus or for testing the infectivity of animals sent in for diagnosis. The skin over the point of inoculation is washed with five per cent. carbolic solution, which deadens pain and helps disinfect skin. After a fourth of an inch incision is made through the skin back of the eye on one side of the median line, the skin is held apart and a small opening is made with a guarded sharp-pointed instrument through the skull bone just large enough to admit the fine short (one-fourth inch) hypodermic needle of the syringe containing the emulsion (0.2 c.c.) to be inoculated intracerebrally. The needle is withdrawn, the skin is allowed to come together, and the wound is covered with a little cotton and collodion.

After the virus has become fixed, rabbits inoculated for obtaining virus for making the vaccine are killed on the seventh day after inoculation and the spinal cords are removed aseptically and dried in sterile aspiration bottles over caustic potash at 20° C. (70° F.) for successive days, so that a series of cords are obtained from one day old to fourteen days old (Pasteur's original method) or eight days old (present modified method) or three days old (Berlin intensive method). After twenty-four hours' drying the cord is known as one-day cord, after two days, as two-day cord, etc. The patients are inoculated subcutaneously daily, with emulsions of definite quantities of these cords.

Pasteur carried on his treatment for eighteen days in the lighter cases and twenty-one days in the more severe ones. His method was adopted in many lands and was later modified in various ways. One modification, indicated above, was intensifying the treatment by beginning with a fresher cord. The New York City Health Department, in 1913 after investigation changed the method they were using (the old Pasteur method) to that used first at Berlin and then at the Hygienic Laboratory at Washington. The scheme is as follows:

Days.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Age of cord.		8 7 6	4 3	5 4	3			2	1	5	4	4	3	3	2	2	4	3	2	3	2	1
Amount injected in cubic centimeters	Adults	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	5 to 10 years	2.5	2.5	2.5	2.5	2.5	2	2.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	1 to 5 years	2.5	2	2.5	2	2	1.5	2	1	2.5	2.5	2.5	2	2	2	2	2.5	2.5	2	2	2.5	2

Each dose contains one-half centimeter of the indicated cord

Pieces of cord cut off at any time and put into glycerin will retain about the same strength for several weeks. The glycerin method was used in sending treatment by mail, but now only carbolic acid, one-fourth per cent., is added as a preservative. The lead of the New York City Health Department in sending out treatment by mail was soon followed by most other laboratories where rabies vaccine is prepared.

In Berlin since 1910 they have been using a much more intensive treatment, beginning with a three-day cord for both children and adults. Several other methods of attenuating the virus for dosage have been recommended, such as, heat (Babès, Puscariu),

carbolic acid (Fermi), rapid drying in cold (Harris), formalin and dialysis (Cumming). The methods of Harris and of Cumming are being tried out now by Dr. Poor in the New York City Health Department laboratories, with promising results.

A few laboratories have used fresh fixed virus for inoculations, regulating the doses by dilutions. Högyes was the first to use this method, and he and his followers claim very good results from it. Rambaud combines this with serum in his treatment. The use of unmodified fixed virus in large doses has been given the name *superintensive method.* Ferran in Barcelona and Proescher in Pittsburgh, have used this method. Though the use of this method has demonstrated the harmlessness in the majority of people of large subcutaneous doses of fixed virus, until we know more of the conditions causing the susceptibility to fresh fixed virus infection which occurs in a small percentage of people, such large doses given at the beginning of treatment cannot be recommended.

Serum-vaccine Method.—After Babès, Marie, at the Pasteur Institute in Paris, began using a serum-vaccine mixture in treatment. This mixture which contains a slight excess of the vaccine is injected each day for four days, after which the treatment proceeds according to the regular Pasteur schema, beginning with the use of a six-day cord. The antirabic serum is obtained from sheep which have had a long and strong course of treatment with fixed virus. It is claimed that a quicker immunity is produced by the serum-virus mixture than by the original Pasteur scheme, an advantage of especial value in the treatment of cases liable to become infected with a short incubation, such as bites on the head.

Remlinger, Marie and others claim that dogs inoculated intraperitoneally or into the anterior chamber of the eye with only one injection of an unsaturated virus-serum mixture are protected against rabies.

The nature of the antibodies in rabies serum is still under discussion. Some claim that the antibodies are not specific. They have found that the serum of certain animals which are more or less refractory to rabies possesses a small amount of rabicidal strength.

Contraindications for Treatment.—No obvious contraindications exist. The treatment may cause only slight local discomfort and erythema. Very occasionally cases of slight neuritis and transient paraplegias and paralyses of various parts of the body have been reported. In a very few instances, the paralyses are marked and the patient dies. Simon (1913) reported eighty-four cases occurring during the years 1888 to 1911 inclusive, and mentions a few others about which he could not get sufficient data. The mortality in these cases is less than 1 in 10,000. Högyes' method of treatment showed the fewest number of these paralyses. The largest number of fatal cases occurred after the hyperintensive methods. No doubt, the people so affected have a special susceptibility.

Results of Antirabic Treatment.—While the results, on the whole, are markedly good, the statistics have not been kept uniformly or minutely enough to be able to determine the comparative worth of the different methods of treatment. In getting statistics for mortality from rabies after treatment, fifteen days must be allowed for the establishment of immunity (by the treatment). Any deaths that occur within fifteen days after the last treatment, are considered to have been too severely infected or too susceptible or infected with too virulent a virus to have given time for the production of immunity by the treatment. Two figures are therefore given in mortality statistics: the absolute mortality and the corrected mortality, *i.e.* that occurring beyond the fifteen-day limit.

In keeping statistics, the following details should be carried out by all: (1) diagnosis of the case, (*a*) rabies, (*b*) probably rabies, (*c*) questionable, (*d*) not rabies, (*e*) nothing known; (2) Method of making diagnosis, (*a*) by animal inoculation, (*b*) by microscopic examination, (*c*) by clinical diagnosis; (3) site and character of bites (number, depth, laceration, protected by clothing, etc.); (4) time elapsing between bite and beginning of treatment, (5) method of treatment, (6) complications, particularly paralysis, (7) character and time of death.

In New York at the Health Department laboratories, where the results compare favorably with those of other laboratories, 5,134 persons infected with rabies were treated from 1906 to 1914 inclusive, with a total mortality of 0.46 per cent. and a corrected mortality of 0.18 per cent.

Immunity.—In human beings, the immunity produced by the vaccine treatment lasts a variable time. It may not last longer than fourteen months. Dogs may be completely immune (Marie) eighteen months after treatment. ANNA WESSELS WILLIAMS.

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Rachitis.—See *Rickets.*

Radioactivity.—In the year 1895, W. K. Roentgen[1] discovered that when an electric current passes through a glass tube from which the air has been largely removed and the walls of the tube opposite the negative pole or cathode have become brilliantly phosphorescent, rays are given off which are capable of passing through a sheet of black paper or cardboard and inciting phosphorescence in substances such as barium platinocyanide when within a short distance of the tube. The invisible rays thus produced can also affect a photographic plate, and if suitable dense substances such as fragments of metal are interposed in the beam of light, shadow-pictures will be produced on the sensitive film, which can be developed in the ordinary manner. On further experimentation he found that, as a general rule, the greater the density of the substance, the greater the opacity to this new form of invisible radiation. He also found that this new type of ray, which he called the *x*-ray, was propagated in straight lines from the point at which the cathode rays of the tube struck the glass wall or any other article in the tube itself; that the rays could not be deflected by the action of a magnet, and that they showed none of the phenomena ordinarily observed in light of ordinary wave lengths; that is, diffraction at the edge of an opaque screen or refraction in passing through media of different densities. Influenced by this discovery of Roentgen, Henri Becquerel was led, in 1896, to examine substances which were known to phosphoresce under the influence of strong light, in order to see whether these substances emitted any rays similar to *x*-rays. Using uranium salts which were known to phosphoresce when exposed to light, he discovered that if they were exposed to sunlight and then laid upon a photo-

graphic plate wrapped in black paper, a developable image appeared on the plate after a considerable time. He found also that it was not necessary to expose the uranium salts to light, for they were just as effective photographically when this exposure had not been made. He then demonstrated that the uranium itself was photographically more effective than the salts, and that, therefore, invisible rays were given off by the element uranium. Care was taken by Becquerel to eliminate the possibility that the uranium gave off vapor, thus affecting the photographic plates. This was shown not to be the fact, and Becquerel announced that he had discovered a body which spontaneously emitted rays which were not visible to the eye, but which could affect a photographic plate; in other words, was radioactive. It was soon after shown by Becquerel that the rays from uranium were able to discharge electrified bodies; in other words, they were able to ionize the air through which they passed, just as *x*-rays do. Hence, the three distinguishing features of *x*-rays—photographic, ionizing, and fluorescent action—are exhibited by a body like uranium. These are the two fundamental discoveries which immediately led to active investigation and ultimately to the accumulation of a very large amount of knowledge which greatly supplemented our views of the constitution of the atom, and showed the lack of permanence of certain elements hitherto supposed to be stable.

Roentgen Rays.—The physics of the Roentgen ray is most easily understood if some of the preliminary experiments which led to their discovery are reviewed. In 1859 Plücker discovered that when a closed glass cylinder some ten to twenty centimeters long, provided with two sealed-in metallic terminals, is connected by these terminals with a source of high-potential electricity such as the Ruhmkorff coil, no discharge will occur through the tube so long as the air in it is at the ordinary atmospheric pressure, unless the potential applied is very large. If, however, the air is pumped out of the tube, a series of characteristic phenomena make their appearance. As the pressure is reduced, the current begins to pass and by the energy thus set free in the residual gas gives rise to a series of luminous streamers usually pinkish in color which fill the tube with a diffuse glow known as the positive column. A violet color, known as the negative glow appears about the cathode. The amount of electromotive force required to pass the current through the tube rapidly decreases as the pressure is lowered, the rarified air being a good conductor of electricity. When the pressure reaches some eight to ten millimeters of mercury, a dark space, called the Faraday space, appears between the two luminous glows which occupy the region about the cathode where the electric current leaves the tube, and the anode where it enters. As the exhaustion proceeds, a dark space, known as Crookes' or the cathodal dark space, appears about the terminal with which the negative pole of the coil is connected. If the pressure falls still further, this dark space increases in width, and with higher rarifaction of about approximately one-fiftieth of a millimeter of mercury, both of the poles lose their brilliant halos and the entire tube is filled with the cathodal dark space. At this stage the walls of the tube itself begin to shine, first in the region of the cathode and then over the glass of the tube with the brilliant apple-green fluorescence well known to those who are accustomed to work with *x*-ray tubes. This color can be seen only in tubes made of sodium glass, lead and lithium glass yielding a bluish fluorescence, while in the new Coolidge Roentgen ray tube no such color is produced. If the evacuation of the tube is pushed beyond this point, the current gradually diminishes and finally it is impossible for any current to pass unless the coil used is a very powerful one and the tube small. Plücker studied the green fluorescence thus produced on the glass wall of the tube, and ascertained that a suitably interposed obstacle was capable of producing a shadow on the walls of the tube, thus suggesting that the rays from the cathode were some sort of light, and Goldstein in 1876 proposed the name of "cathode rays," because this light appeared to be projected from the cathode, or negative electrode in the tube. It was found that these rays traversed a straight line; that they started at right angles to the surface of the cathode; that they could be deflected by a magnet, and concentrated into a point by using a concave cathode. When so concentrated a high degree of heat was produced at the focal point and an active phosphorescence from suitable minerals.

Roentgen Ray Tubes.—The original Geissler-Plücker tube (known also as the Hittorf, or Crookes' tube) as employed by Roentgen in his discovery of the *x*-ray, was a pear-shaped structure with electrodes let into one end and one side of the tube. Roentgen found that the *x*-rays were generated at the point of impact of the cathode rays on the glass. Shortly after this, Campbell-Swinton modified the original construction of the Roentgen tube by inserting in the path of the ray a piece of platinum placed at an angle of about forty-five degrees to the perpendicular from the cathode plate. This was to avoid the softening of the glass walls of the tube by the heat coming from the cathode. Shortly afterward, Jackson replaced the flat cathode which Roentgen had used, by a concave one which Crookes had shown in 1874 brought the rays to a focus, thus concentrating a large amount of cathode rays upon the platinum anticathode or target. This was the first important technical improvement in the construction of the *x*-ray tube.

The present commercial tube does not differ in essentials from the original experimental apparatus A cathode, usually of aluminum, is supported on a stem which is recessed in a long projection from the main bulk of the tube; and this stem is usually covered with glass or porcelain to prevent the escape of electricity to the walls of the tube. The anticathode is made of platinum or tungsten, and in the modern powerful tubes, arrangements are made by which water may be circulated behind the target, or air blown into a cavity behind it, or the target fixed to a large mass of highly conductive metal such as copper, thus carrying off the heat there evolved. This prevents the melting of the platinum by the heat of the cathode rays which fall upon it. The requirements for the anticathode metal are that it shall be of high atomic weight, because the quantity of *x*-ray produced is greater than from impact with metals of low atomic weight; it must have a high melting-point to resist the heat, and a high thermal conductivity, so that the heat generated does not remain local at the focal point; also its vapor pressure at high temperature should be low. In other words, it should not volatilize easily under the conditions of working, otherwise the walls of the tube would be covered with metal which had sputtered from the anticathode. Usually tubes of modern make contain an additional anode normal to the surface of the cathode. They usually have also some means of regulating the air pressure in the interior, for the reason that when the tube is run the vacuum constantly tends to become higher owing to the absorption of the remaining gaseous content by the walls of the tube and the metal portions of the apparatus. In consequence, it is necessary from time to time to introduce a small amount of gas, so as to reduce the vacuum and permit the passage of the current again, making the tube less hard, as it is technically called. Several types of "reducers" are in use, one, a sealed-in palladium or platinum tube closed at the outer end, the lumen of which is connected with the interior of the *x*-ray tube. This tube can be warmed by a match, candle, or Bunsen flame; the hydrogen from the flame then passes through the metal into the interior, and thus reduces the vacuum. The second type has a spark arrangement by which, when the

resistance of the tube rises to a certain point, sparking occurs through a small collateral tube containing some substance which gives off vapor when heated by an electric current. A third form has a tap or mercury seal admitting air to a small porous porcelain plug through which a minute quantity of air may be admitted to the main tube. A large number of modifications of the methods, not necessary to particularize here, are employed in the commercial tubes.

The Coolidge Tube.—For nearly two hundred years it has been known that a gas in the neighborhood of red hot metal or other substance, is a conductor of electricity, and it was shown by Becquerel in 1853 that air, at a white heat, would allow electricity to pass, even when the potential difference was but a few volts. Further investigation showed that a discharge of electricity from a hot substance depended upon the temperature, the pressure of the gas surrounding the hot material, the nature of the gas, and also the nature of the substance itself. In the invention of a new and more efficient variety of *x*-ray tube, Coolidge has taken advantage of the fact that a hot wire gives off negative corpuscles or electrons carrying electric charges, which is the explanation why a gas is rendered conductive in the neighborhood of a hot substance. The velocity of these particles is not very great; in fact it diminishes somewhat with the increase of temperature of the wire. But if the wire is made the cathode and impressed with a high electrical potential, the particles are driven away from the wire toward the anode, their velocity depending entirely upon the voltage which is applied. In the Coolidge tube, a coil of tungsten wire is used, heated by a small independent battery of storage cells. The temperature may be high, even a white heat. From such a highly heated wire enormous quantities of negatively electrified ions pass out into the surrounding medium. The lumen of the Coolidge tube is exhausted to an extremely high vacuum, and when suitable voltage, of, say, 100,000 volts is applied to the terminals of the tube, a stream of negatively charged ions or cathode rays is driven from the hot wire toward the anode, where they are stopped, by the impact giving rise to *x*-rays. The speed at which the corpuscles travel is dependent on the voltage, so that if this remains the same and the heating current also is constant, a very even supply of *x*-rays of any desired quality can be obtained from such a tube for a long period. A tube of this type may carry a secondary current of twenty-five milliamperes for five or six hours without damage.

The Current.—The high-voltage electric current used to light the *x*-ray bulbs is produced in three ways: (1) By influence machines; (2) by induction coils; (3) by a step-up transformer.

The voltage so obtained is usually about 100,000 volts. The influence machines are most frequently of the Wimshurst type. These machines give a very steady current and a satisfactory yield of *x*-rays, but are difficult to handle, expensive, and not very reliable.

The induction coils are merely an improved form of the old type of Ruhmkorff coil. Their design shows nothing especially new, except improvements in the methods of winding and insulating both primary and secondary circuits so as to withstand the powerful electric surges which occur in them.

The current interrupters necessary with this form of coil are of two varieties, chemical and mechanical. The Wehnelt type is made by immersing two electrodes in dilute sulphuric acid of a density of about 1.20. The cathode is a large lead plate; the anode consists of one or more adjustable platinum points projecting from an insulating sleeve of glass or porcelain. The amount of anode which dips in the liquid may be adjusted, and determines the quantity of current which passes and the rate of interruption. A direct current must be used; and for a satisfactory working of a Wehnelt interrupter at least ten amperes are required. A very large current causes the apparatus to give out a great deal of noise, the fluid heats rapidly and the interrupter does not functionate very satisfactorily. The voltage also must not be much over 110 volts, as above this pressure the interruptions are not regular. The explanation of the method of producing the break is that bubbles of gas as they are liberated periodically make and break the current, but other factors unquestionably come in. It is not necessary to use a condenser with the Wehnelt interrupter.

Mechanical interrupters are now usually so constructed that a jet of mercury connected with one pole of the exciting current is swept past a series of metal vanes connected with the other pole of the current, the whole process being conducted in an atmosphere of coal gas. With these a condenser is usually necessary in order to prevent excessive sparking.

The third type of *x*-ray apparatus is that originally devised by Snook, which consists of a step-up transformer in which a pole-changing switch rectifies the high potential alternating currents obtained from the secondary of the transformer. In order to procure synchronism it is necessary that the generator supplying the alternating current to the transformer and the rectifying commutator be mounted on the same shaft. The resulting current is not quite uniform but pulsating, and in amount varies in a large machine from a half to one hundred milliamperes. For general work these transformers are more efficient than the induction coil, as they are easily controlled, there is no inverse current, and no interrupter is needed. They, however, do not as a rule furnish a potential greater than 100,000 volts and for certain purposes coils are of advantage, especially if therapeutic applications of the *x*-rays are being made when very high voltages are needed to produce the short wave lengths necessary for deep radiotherapy.

Methods of Estimating the Quantity and Quality of the X-ray as Generated by the Tube.—Inasmuch as the total amount of energy emitted from an *x*-ray tube in the form of *x*-rays is but a minute fraction of the total energy supplied in the form of electric current to the high potential apparatus, either in the form of a Ruhmkorff coil or of a transformer of the Snook type, the measurement of the quantity of current entering or leaving the machine is of little value in determining the quantity of *x*-rays emitted by the tube. Rough approximation of the output of the rays may be obtained by experts from an examination of the color emitted by the tube while running—with the exception of the Coolidge tube which shows no color—and by measurement with a milliamperemeter of the current passing through the tube itself. As, however, the milliamperemeter measures both the direct current passing through the tube, which is useful in the production of *x*-rays, and also the indirect or reverse current, which is of no value in such production, its readings are not of great accuracy. The distance across which the secondary current can jump in air, or the spark-gap distance, is also of some value in determining the hardness of the tube. If the tube is running with a spark-gap distance of only a few centimeters, it is emitting low or soft rays of long wave length. If, on the other hand, the spark-gap has to be moved out to a distance of say thirty centimeters in order to prevent sparking across the gap instead of the current passing through the tube, the tube is emitting hard *x*-rays. The quantity, however, is not in any way determined by the difference between the sparking points.

The best method of determining the quantity of *x*-rays is by measuring the ionization produced by the passage of the *x*-ray through a suitable gas; but the apparatus ordinarily employed is complex and cannot be applied in the practical use of the tube. However, a portable form has been designed by

Szillard, called the iontoquantimeter, which acts upon the ionizing principle. The instrument consists of an electrometer and a small static machine which charges it and is connected up with one of the electrodes, a second being connected to earth through the water pipe system of the laboratory. When the *x*-ray strikes the gas in the ionizing chamber, the electrometer is discharged and a needle moves along a scale, the divisions of the scale having been calibrated by the use of pastilles of barium platinocyanide so as to determine an erythema dose. Inasmuch as the ionization also varies with the penetrating power of the *x*-ray, the instrument has also been calibrated for various qualities of radiation by the use of a series of screens. As yet it has not been extensively employed.

The other methods of estimating the total quantity of *x*-rays which reach the patient are based either upon the changes in color of a disc of barium platinocyanide or upon the effect of the rays on a slip of sensitive bromide of silver paper. The method most frequently employed is that of Sabouraud and Noiré. When discs of barium platinocyanide are exposed to the *x*-ray, the pale greenish-yellow color gradually changes to reddish or brownish, and the color showing results which will cause the hair to fall out, the so-called Teinte B dose, is estimated by a tablet of this color which is supplied with the apparatus. If an exposure, for example, of eight minutes causes the disc to assume Teinte B, another two minutes exposure will cause a reddening or slight inflammation of the skin to appear at an interval of fourteen to twenty-one days.

In a modified form of this instrument devised by Holzknecht, the pastilles are not compared with a standard, but with unexposed pastilles of the same material placed under a celluloid wedge of a reddish brown color which can be moved over an unexposed pastille until the color is the same as the one that has been exposed.

Another form is the Kienböck quantimeter. This instrument has a scale made up of eight different depths of gray tone which bromide paper will assume after development when exposed to the influence of increasing quantities of *x*-ray. Strips of paper are exposed and developed with the standard developer and then compared with the scale. 10X units according to the Kienböck instrument are equivalent to five Holzknecht units and Teinte B of the Sabouraud-Noiré method. Other methods are employed practically, but for further details the directions which come with the apparatus should be consulted. It may be said that none of these processes offer very accurate information of the *x*-rays. The Kienböck silver bromide method is especially inaccurate, because the soft and hard *x*-rays have different effects upon the paper, and this must be carefully allowed for. Comparisons have even been made by this procedure between the gamma radiations of radium and the *x*-ray, and the statement published that the gamma rays have a very much less effect than *x*-rays. This is entirely due to ignorance of the fact that the gamma rays act relatively very little upon the sensitive photographic paper, while the *x*-rays have a very great effect, so that the results cannot at all be compared quantitatively.

The quality of the rays or their hardness can, as has just been stated, be roughly estimated by the spark-gap, this being slowly narrowed until sparking takes place across the point. Then the points are drawn a little further apart and the space measured.

Another instrument is the Bauer qualimeter which measures the hardness of the tube indirectly by determining the voltage in the secondary circuit. It is very useful and more accurate than the spark-gap, but still does not give an absolute measurement of the quality of the ray. Other instruments for determining the penetrating power of the rays depend upon the absorption of the ray by various thicknesses of metal. Three forms are in use. That of Walter consists of a piece of lead with eight circular holes, combined with an adjustable fluorescent screen. The holes are covered with platinum foil of increasing thickness, and the estimation of the hardness of the ray is dependent entirely upon the number of holes visible on the fluorescent screen when the excited tube is examined. Another form, the Walter-Benoist radiometer, compares the brightness of the *x*-ray on the fluorescent screen after passing through a series of aluminum plates of various thickness contrasted with a standard silver disc. A third form is the Wehnelt crypto-radiometer. This is provided with a wedge-shaped aluminum slip and parallel with it a strip of silver foil. The wedge is moved over a brass plate provided with a narrow slit until the absorption is the same as that of the silver as seen on a fluorescent screen. A scale on the wedge gives the hardness.

These various instruments give different values for different qualities of rays and the operator must familiarize himself with the form which he will use. A given instrument merely permits the reproduction with fair accuracy of a required hardness of *x*-ray such as is suitable for a given purpose, but there is no measurement in absolute units.

In all quantitative measurements of *x*-rays it must also be remembered that the effect of the rays varies inversely as the square of the distance from the anticathode, so that the point at which the measurement is made is less important than the evaluation of the amount of energy delivered at a given depth of tissue which is to be influenced. For further information, the article on *Radiotherapy* should be consulted.

The Physics of the X-ray.—Ever since the discovery of the *x*-ray, attempts have been made to show diffraction, refraction, or polarization of these rays, assuming them to be like light waves only of very much shorter wave length. These experiments all failed, until one originally suggested by Laue was carried out by Friedrich and Knipping.[2]

These experimenters showed that if a narrow beam of *x*-rays was permitted to fall perpendicularly upon a plate cut from a natural crystal of zinc sulphide, a diffraction pattern was produced by reflection from the planes formed by the molecules in the crystal. The extension and verification of this work by the Braggs,[3] using reflection from cleavage plates or crystal surfaces of various substances, have added a great deal to our knowledge of the nature of *x*-rays. These rays are now known to be light waves of exceedingly short wave length, from 0.2 to 7.4 times 10^{-8} cm. in the abbreviated nomenclature used by physicists;* or in other words, the wave length of the *x*-ray is from one twelve millionth to one five hundred millionth of a centimeter.

For comparison with this the following table may be given of various electromagnetic wave lengths:

The length of the electromagnetic waves used in wireless telegraphy, 15,000 meters to 0.5 centimeter.

Infra red or heat rays from	0.01 cm.	to	7.7×10^{-5} cm.
Visible light	7.7	to	3.6×10^{-5} cm.
Ultra violet rays	3.6	to	0.6×10^{-5} cm.
X-rays about	0.2	to	7.4×10^{-8} cm.
Gamma rays from radium B and C, from	0.42	to	0.07×10^{-8} cm.

It has long been known that *x*-ray tubes with low vacua give off rays of low penetrating capacity, while a highly exhausted tube furnishes "hard" rays of high penetrating power. The soft rays are those of

* Some confusion may arise from the variety of terms used in technical literature. The following are in common use. A tenth-meter or one ten millionth of a meter or 1×10^{-10} meters. This is the same as an Ångström unit. A micromillimeter or $\mu\mu$ is a millionth of a millimeter and a micron or μ used in microscopy is a thousandth of a millimeter. Thus the wave length of the sodium line may be expressed as follows: 0.5896μ or 589.6$\mu\mu$ or 5896 Ångström units or tenth meters or 10^{-10} meters or 5.896×10^{-5} cm.

greater wave length and are used chiefly for photography because of their being more easily absorbed by dense tissues, giving sharper contrast shadows of bones or other structures, whereas the hard rays or those of short wave length, have been used for therapeutic purposes chiefly.

The kind of ray which the tube gives off depends upon its vacuum and the voltage applied to the terminals of the tube; so that a soft tube will run on a five to ten centimeter alternative spark-gap and give rays which are produced by low velocity cathode particles, have a wave length of some half to one tenthmeter, and show very marked shadows, whereas the hard tube requires a much higher potential to drive the current through the high vacuum which exists in such a tube, and requires a spark-gap of twenty to twenty-five centimeters. The cathode particles have in consequence very high velocities, even two-thirds those of light, and give Roentgen rays which will easily penetrate considerable thicknesses of metal and have a wave length of 0.4 to 0.2 tenth meters.

The work of Barkla, Laue, and Bragg has shown that an *x*-ray tube of the ordinary commercial variety emits not only a great series of waves of differing wave length—in other words, what may be considered as a white light spectrum—but that it also emits certain characteristic or homogeneous *x*-rays of a particular wave length which is entirely dependent upon the nature of the metal forming the anticathode. These special monochromatic waves were discovered by Barkla and Sadler[4] by permitting *x*-rays to strike upon plates of metal and then studying the reflected *x*-rays. They found that each metal gave off scattered *x*-rays similar to those impinging on the material used, and in addition at least two varieties of *x*-ray which were characteristic of the metal itself, hence the name characteristic radiation or ray.

The two kinds of radiation which they described have been called series K and series L. For each metal, the K radiation is about 300 times more penetrating as measured by absorption in aluminum than the L radiation from the same substance. Further investigation has shown that each of these series is composed of a group of spectral lines of slightly differing wave lengths. Both types of rays become harder or, what is the same thing, the wave length shorter, as the atomic weight of the radiator increases. Such characteristic radiations can only be excited by the impact of an *x*-ray of greater hardness than the radiation which it is to excite. For example, with metals of high atomic weight, the rays from an ordinary *x*-ray tube can only excite the soft L radiation. From some of the lighter elements, only the K radiation has been detected up to the present time. It is probable, however, that all elements give off both radiations, as well as other types of which we as yet know nothing. If a very thin plate of the same metal as generates the "characteristic" radiations is used as a filter *x*-rays of other wave lengths are largely held back and only the characteristic rays pass in any quantity, thus affording a means of obtaining *x*-rays of known wave length in sufficient quantity to permit of their use therapeutically.

The practical point about these radiations is that a certain velocity of cathode ray, consequently a certain minimum difference of potential, is required to incite these characteristic radiations from the anticathode. For example, in a tungsten anticathode tube the potential difference in order to drive the cathode particles at a sufficient rate to excite the K radiation of tungsten, must be at least 95,000, of platinum 108,000 volts, pressures only afforded by large coils of very great capacity. The soft L radiation of tungsten, on the other hand, can be induced by a voltage of only 13,000 or of 15,000 in the case of platinum, which means a pressure sufficient only to jump about 1.5 centimeters between the points of the terminals of the induction coil. This voltage corresponds to a velocity of the cathode ray of some 7.3×10^{-9} centimeters per second, which is about one-fourth of the speed of light. At the higher voltages, say 110,000 volts, the velocity is two-thirds that of light, and the shortest observed wave length from a tungsten tube is 1.71×10^{-9} centimeters. On the other hand, the velocity of the most rapid beta particles from radium is about 0.998 per cent. of that of light. Hence the gamma rays which are produced by the impact of these very high velocity beta particles on the element radium which is present in the tube, have much shorter wave lengths than any *x*-ray which we have as yet been able to produce. The wave length of the gamma ray from radium C is not over one-third of the shortest *x*-ray which has been as yet produced. Rutherford[5] has calculated that to produce rays of the same wave length as the gamma ray from an *x*-ray tube would require a potential difference of 1,000,000 volts. More recent observations by Duane and Hunt[6] and others cast some doubt upon this estimation, but even by their computations the required voltage is far beyond present commercial electrical apparatus.

When a beam of *x*-ray strikes any substance, it expels from the atom of that substance a certain number of negatively charged particles or cathode rays. These cathode rays are capable of causing ionization of a gas, and similar ions are in all probability the agents through which the *x*-ray displays its biological effects. The actual presence of ionized particles of gas thus produced has been shown by C. R. T. Wilson,[7] who demonstrated the ions produced by a beam of *x*-ray by condensing moisture upon them and then photographed them by means of the instantaneous illumination furnished by an electric spark.

The absorption of *x*-rays by metals or the tissues of the body follows an exponential law which is discussed in some detail in the section on the beta rays of radium. As the rays are not homogeneous but consist of greatly varying wave lengths, there will of necessity be equal variations in their absorbability. In aluminum very soft *x*-rays have an absorption coefficient (μ) in reciprocal centimeters ($cm.^{-1}$) of about seven, the very hardest a μ of 0.60 $cm.^{-1}$. Three millimeters of aluminum will therefore absorb 88 per cent. of the soft variety and only 16.5 per cent. of the very hard.

In tissues, μ for soft rays of about 4 on the Benoist scale is 0.84; hard rays of 8 Benoist filtered through three millimeters of aluminum have a μ of 0.18 $cm.^{-1}$ in tissue. The soft rays fall to one-half value in 0.8 centimeter, hence are but slightly effective below that depth, while those with a μ of 0.18 fall to half in some four centimeters and therefore act efficiently to that depth. With the Coolidge tube the wave length obtained may be much shorter and the penetration correspondingly greater, but heavy screening is necessary to abstract the easily absorbed burning waves, at least three millimeters aluminum with one centimeter paper or leather to catch the secondary rays given off by the metal. One millimeter copper has also been recommended which permits of long exposure through a single portal, but very long exposures are required to produce destructive effects at a depth, and many portals employed to avoid skin burns.

The following table (p. 452) from Guilleminot is of interest as showing the rapid falling off of intensity from absorption. The filter used in the last five lines was aluminum of the thickness indicated in the second column. The law of light, that the intensity varies inversely as the square of the distance, is too often forgotten by practical workers. Cole[8] has also published some salutary observations in this line.

Physics of Radioactive Substances.—Radioactivity is a property of the atoms of certain substances of high atomic weight which seem to be in an unstable

Quality of rays.			Depth of tissue.								
		Surface.	0.5 cm.	1 cm.	2 cm	3 cm.	4 cm.	5 cm.	6 cm.	7 cm.	8 cm.
4 Benoist		Amount transmitted, 100	65.0	43.0	22.0	13.0	8.0	5.2	3.8	2.6	1.8
5 Benoist		Amount transmitted, 100	72.0	53.0	32.5	21.9	15.5	11.6	8.8	7.0	5.5
6 Benoist		Amount transmitted, 100	78.0	63.0	44.0	33.0	26.0	21.0	17.2	14.4	12.0
7 Benoist		Amount transmitted, 100	81.0	68.0	50.0	39.0	32.0	26.5	22.8	19.7	17.2
8 Benoist		Amount transmitted, 100	83.2	69.9	52.7	42.0	34.8	29.5	25.5	22.3	19.6
8 Benoist	Filter 1 mm.	Amount transmitted, 100	86.5	76.2	61.1	50.6	43.0	37.3	32.6	28.5	25.4
8 Benoist	2 mm.	Amount transmitted, 100	89.2	80.4	67.0	57.1	49.4	43.3	38.2	33.8	30.1
8 Benoist	3 mm.	Amount transmitted, 100	91.0	83.5	71.8	61.8	54.5	48.0	42.5	37.8	34.8
8 Benoist	4 mm.	Amount transmitted, 100	92.8	86.0	74.5	65.4	57.8	51.3	45.7	41.0	37.0
8 Benoist	5 mm	Amount transmitted, 100	95.0	87.0	76.1	67.2	60.0	53.8	48.5	44.0	40.2

condition. The break-up of the atom is accompanied by the setting free of energy both in the form of heat and also as rays, either corpuscular or ethereal. The rate of this energy emission is not affected by any physical or chemical influence. Some thirty-six bodies are now known to be radioactive.

The discovery of radioactivity was made, as previously stated, during some experiments by Henri Becquerel while attempting to find whether rays similar to x-rays were produced by fluorescent bodies; for it will be remembered that Roentgen described the fluorescent spots on the glass wall of a cathode tube as the source of the x-ray. Becquerel had assumed that possibly fluorescing substances might also give off similar rays. He used salts of uranium and found that while they fluoresced under the influence of light, the photographic impressions which they produced upon a screened sensitive plate were not dependent upon such fluorescence or upon previous exposure to light, but they could be equally well produced if the uranium salts had been kept in the dark for a long period. These experiments were published in February, 1896. He found that the rays given off by uranium penetrated paper and thin sheets of metal and produced shadow pictures of the same type as those produced by x-rays. He also found that these rays from uranium had the power of ionizing gases just as the x-rays had been shown to do. He found that the action was dependent entirely upon the content of uranium, and that in consequence a fragment of uranium metal was 3.6 more powerful than a crystal of potassium-uranium sulphate, the measurement being made by estimating the rapidity of the discharge of an electroscope. He very shortly noticed that the rays were absorbed by air and also by other gases, the amount of absorption depending entirely upon the density of the gas. He then found that the same proportion existed between the lighter and the heavier metals; aluminum for example absorbing relatively little, while lead almost completely absorbed the rays which were given off. He found that the temperature of the active substance exerted no influence on the rate of discharge of the electroscope or on the photographic effect. Both at high temperatures and at that of liquid air, the activity was quite the same.

In 1899 further investigation of the phenomena of radioactivity was taken up by Rutherford, who showed that the absorption of the radium rays in gases increased with the density and according to the well-known formula for the absorption of light, where $I_d = I_o\epsilon^{-\lambda d}$.

In 1898 Schmidt and Curie[9] independently of each other discovered the radioactive powers of thorium salts. At the suggestion of Becquerel, Mme. Curie studied by the electrical method the radioactivity of a large number of minerals and found that those which were radioactive contained either uranium or thorium or a mixture of both. She therefore in conjunction with her husband, Pierre Curie, and G. Bémont, investigated the chemical composition of a mineral containing a large amount of uranium, viz., pitchblende from Joachimsthal. The mineral was first dissolved and then put through a regular course of chemical analysis. It was found that an active substance was separated with bismuth, to which the name of polonium was given by Mme. Curie. This has since been shown to be a degradation product of radium. Another substance was separable with barium, and to this was given the name of radium. This new element is extracted from pitchblende or other uranium minerals by the same methods of analysis which separate barium, to which radium is very closely allied in chemical properties. After the separation of all inactive impurity, the radium mixed with barium can be separated by the fractional crystallization of the bromide salts. After ten or twelve crystallizations of a fairly pure salt the radium is very largely separated from the barium. With the preparation of considerable quantities of relatively pure radium, it was found that this substance like uranium and thorium compounds emitted rays of two varieties. One variety, named the alpha rays, can be stopped by thin paper; the other, known as beta rays, is much more penetrating and will pass through considerable thicknesses of metal, even up to two millimeters of lead. The alpha ray gives a bright green fluorescence on a screen of phosphorescent zinc sulphide or of willemite, while the beta rays produce a somewhat fainter phosphorescence in barium platinocyanide and willemite also.

In 1900 P. Villard discovered by the photographic method that another type of rays was also given off by radium which resembled the x-rays and were very penetrating. These are the gamma rays of radium. Becquerel found that the alpha rays could be deviated by a magnet to one side, while the beta rays were deviated in the opposite direction, showing that one carried a positive charge of electricity and the other a negative charge. The gamma rays were not in any way influenced by a magnet, but were propagated straight through air and heavy substances, passing layers of lead ten or twenty centimeters thick, and easily recognizable after traversing thirty centimeters of iron. The nature of the alpha rays was suggested by Rutherford and Soddy, who demonstrated helium in the decomposition products of radium emanation, and finally determined by Rutherford and Royds in 1909 by enclosing radium emanations in a small glass bulb whose walls were not thicker than 0.01 millimeter, and then enclosing this bulb in another evacuated glass tube. As the alpha particles can pass through glass of the thickness given, the investigators were able to demonstrate the presence of helium in the space outside of the small enclosed bulb. Since then it has been shown that an alpha particle consists of a helium atom which has lost two negative electrons and hence has a positive charge. The beta

rays were also shown to be electrified particles corresponding to the cathode rays—that is, electrons bearing negative charges. In 1915 as has been said the gamma rays were shown to be ether waves of extremely short wave length, but otherwise similar to ordinary light.

Curie in 1903 showed that radium is continually giving off heat which is produced chiefly by the energy set free when the alpha rays are stopped by the container holding the radium. For this reason a tube containing radium may be as much as several degrees hotter than the surrounding air.

are reasons for the belief that they also ultimately furnish lead.

The breaking down of the atoms of any of these substances is accompanied by the emission of one of two types of particles, forming the alpha and beta rays already described. With the emission of an alpha ray, the chemical position of the element changes two places lower down in the periodic series. For example, uranium 1 breaks down and is transformed into uranium X_1, which in its chemical qualities corresponds to thorium, an element which already occupies a place two spaces below uranium in the periodic table.

Table I.—Radioactive Elements.

Substances.	Transformation constant, sec.$^{-1}$.	Half value period.	Radiation.	Alpha rays in cm. at 15° C.	Absorption coefficients.		
					Beta rays in aluminum cm.$^{-1}$.	Gamma rays in aluminum cm.$^{-1}$.	Gamma rays in lead cm.$^{-1}$.
Uranium 1	4.3×10^{-18}	5×10^{9} yr.	α	2.50			
Uranium Y	5.4×10^{-6}	1.5 days	β	.	about 300		
Uranium X_1	3.3×10^{-7}	24.6 days	β	. . .	510.0	24; 0.70; 0.140	0.72
Uranium X_2	0.01	1.15 min.	β	. . .	14.4	24, 0.70, 0.140	0.72
Uranium 2	1.1×10^{-14}	2×10^{6} yr.?	α	2.90			
Ionium . .	2.2×10^{-13}	1×10^{5} yr.?	α	3.11			
Radium	1.26×10^{-11}	1,690 yr.	$\alpha\beta$	3.30	200.0	354; 16; 0.27	
Radium emanation	2.085×10^{-6}	3.85 days	α	4.16			
Radium A	3.85×10^{-3}	3.0 min.	α	4.75			
Radium B	4.33×10^{-4}	26.7 min.	β	. .	75.0	230; 40; 0.51	
Radium C_1	5.93×10^{-4}	19.5 min.	$\alpha\beta$	. .	13.5	0.115	46; 6; 1.5; 0.50
Radium C_2; radium C. .	8.3×10^{-3}	1.4 min	β				
Radium C' . . .	7×10^{6} sec.?	10^{-6} sec.?	α	6.94			
Radium D (radio-lead) .	1.39×10^{-9}	1,583 yr.	β	. .	130.0	45; 0.99	
Radium E	1.6×10^{-6}	5.0 days	β		43.3	45; 0.99	
Radium F (polonium) .	5.9×10^{-8}	136 days	$\alpha\beta$?	3.84		585	
Actinium . .	1×10^{-10}	200 yr.?	α?	3.56			
Radioactinium .	4.25×10^{-7}	18.88 days	$\alpha\beta$	4.2	170.0	25; 0.19	
Actinium X . . .	7.6×10^{-7}	11.4 days	α	4.26			
Actinium emanation . . .	0.18	3.9 sec.	α	5.57			
Actinium A	350	0.002 sec.	α	6.27			
Actinium B	3.2×10^{-4}	36.1 min.	β	. .	very soft	120; 31; 0.45	
Actinium C_1	5.37×10^{-3}	2.15 min.	$\alpha\beta$?	5.15			
Actinium D	2.26×10^{-3}	4.71 min.	β	. .	28.5	0.198	1.2 to 1.8
Actinium C'	700	0.001 sec.	α	6.45			
Thorium	1.2×10^{-18}	1.5×10^{10} yr.	α	2.72			
Mesothorium 1	4.0×10^{-9}	5.5 yr.					
Mesothorium 2	3.1×10^{-5}	6.2 hr.	β	. .	30.0	26; 0.116	0.62
Radiothorium	1.09×10^{-8}	2.02 yr.	α	3.87			
Thorium X	2.20×10^{-6}	3.64 days	α	4.30			
Thorium emanation	0.0128	54 sec.	α	5.00			
Thorium A	5.0	0.14 sec.	α	5.70			
Thorium B	1.8×10^{-5}	10.6 hr.	β	. .	110.0	160; 32; 0.36	
Thorium C_1	1.9×10^{-4}	60 min.	$\alpha\beta$	4.80	16.3	0.096	0.46
Thorium D . . .	3.7×10^{-3}	3.1 min.	β	. .			
Thorium C'	7×10^{10}	10^{-11} sec.?	α	8.60			

The factors given in the Table are:

λ = radioactive constant or transformation constant expressed in reciprocal seconds by λ in the formula $p = p0\epsilon^{-\lambda t}$.

The second column contains the half value period which is $T = \frac{0.693}{\lambda}$ and is the time required for the substance to be half transformed into the form of lower atomic weight.

The absorption coefficients (μ) are expressed in reciprocal centimeters, the formula being $Id = I_0\epsilon^{-\mu d}$.

Chemistry of the Radioactive Elements.—As far as is now known, all of the thirty-six radioactive substances are primarily derived from two elements—uranium and thorium. Rubidium and potassium give off a certain form of radiation, but its nature is not clear and these elements are usually not included in the radioactive group. It is probable that uranium in the course of its disintegration gives rise to a secondary series known as the actinium series which are included in the table, while thorium does not split in this fashion. The ultimate product of the uranium series is probably lead, but that of the thorium and actinium group remains experimentally unknown, though there

Uranium X_1 then emits a beta particle and returns one place up the table toward its parent element and becomes isotopic, as it is called, with tantalum. In a similar fashion thorium breaks down into mesothorium 1, which cannot be separated from bismuth, and also bodies resembling thallium; and as just stated the three series most probably end in lead. Radium D has the same chemical properties as lead, but it has been shown within a short time that its density and atomic weight differ slightly from those of ordinary non-radioactive lead, being 11.289 and 206.3 as compared to a density of 11.337 and atomic weight of 207.3 for ordinary lead,[10] though chemically

these two substances cannot be separated. The lead from radium-bearing minerals is, therefore, a different element from that of the ordinary lead ores that are not radioactive. For further details on this subject, the reader must be referred to Soddy.[11]

Radium.—The only medically interesting products of all this series of new elements are radium and mesothorium, and the chemical preparation of these two elements will be given here in some detail. As radium is a break-down product of uranium, it is found only in the ores which contain that metal. The most famous deposit is at St. Joachimsthal in Bohemia, where a vein of pitchblende or uranite has been worked for a long period. There are also mines in Saxony, in Cornwall, Eng., in North Carolina, and in Connecticut, which yield small quantities of pitchblende. The most important ore at present is carnotite, which is a uranium potassium vanadate found chiefly in Colorado. The ore contains only two per cent. of uranium oxide as it comes into the market, but at present it forms the chief source of commercial radium. Other forms of the uranium minerals are found in Portugal and Australia, but the amount is small. The quantity of radium in the uranium ore is extremely minute. When the radium is in equilibrium, there should be theoretically 323 milligrams of radium element per ton of uranium element. In a ton of Joachimsthal pitchblende, which contains about sixty per cent. of uranium, there is present some 200 milligrams of radium. In the Colorado carnotite which is only a two per cent. ore, the amount of radium is correspondingly small, being only one part in 200,000,000.[12]

The methods employed in the separation of radium from carnotite are comparatively simple. The ore is ground and dissolved in hot nitric acid; the solution is precipitated with sulphuric acid after the addition of a certain percentage of barium chloride. The sulphuric acid precipitates the barium as sulphate, and this precipitate aids by adsorption in the complete removal of the minute quantities of radium present, the sulphate of which is equally insoluble. Practically all the radium is thus separated from the other constituents of the crude ore. The mixed radium and barium sulphates are reduced to radium and barium sulphides by heating with charcoal. They are then dissolved in hydrochloric acid, and the mixed radium and barium chlorides separated by crystallization, which when the radium has reached a sufficient concentration is transformed into a bromide and the further crystallization carried out as a bromide salt. In the process of fractionation the radium chloride separates out first, so that if half of the mixed salts is removed there will be fifty per cent. more radium in the crystals than in the solution left behind. The number of crystallizations required is not large; some ten or twelve will produce approximately pure radium-barium bromide containing from fifty to sixty per cent. of radium element. This is the strength usually sold commercially, as it requires a long series of crystallizations to produce a radium salt of higher purity and there is no especial advantage in its use as the presence of barium does not interfere with the practical application of the radium. The salts usually sold are radium bromide, the crystals of which contain two molecules of water, and the sulphate which is anhydrous. There is an advantage in the anhydrous salts and for ordinary purposes the sulphate is most convenient, as there is no decomposition of the water of crystallization, for the radioactivity may decompose the water and set free hydrogen and oxygen in the tube. Should a spark pass the tube may then explode. If, however, the radium is to be used for purposes of obtaining emanation, the chloride is the preferable salt.

The dry crystals of the radium salt are now collected and placed in thin glass tubes the walls of which do not measure over half a millimeter, the diameter being not over three millimeters for convenience of use. The usual amount sealed in is ten, twenty, or fifty milligrams of radium considered as element, the total weight of the mixed salt being at least three times this amount. In the end of the tube is sealed a small platinum wire to conduct off any electrical charge which may accumulate owing to the alpha radiation; otherwise there is the possibility of explosion from sparking in the tube. These tubes are then set aside for one month for the radium to come into equilibrium with its emanation, and the total quantity of element estimated by balancing the gamma ray radiation from the tube with that from a standard tube, the element content being determined in comparison with the primary standard provided by Mme. Curie and kept in the archives at the Bureau of Weights and Measures at Paris. Duplicates of this standard have been prepared and are deposited in the National Physical Laboratory in England, in the Bureau of Standards in Washington, and similar institutions where standards of measurement are kept. In determining the quantity of radium element present in a tube, the following method is generally employed, which is accurate to about 0.3 of one per cent. The apparatus is first calibrated by placing a tube containing a standard quantity of radium element on a condenser made of two plates of lead separated by an air space. A potential is applied to these two plates which are insulated from each other and the saturation current which passes measured either by a suitable electroscope or an electrometer. The current is due to the ionizing effect of the gamma ray which passes through one sheet of lead and ionizes the air between it and the other plate. It is a constant for constant conditions of temperature and moisture. A small battery of about 100 cadmium cells is usually employed to give the necessary potential difference in the two plates. After the current has been balanced by the introduction of suitable compensation, the tube of radium to be measured is placed on exactly the same spot on the condenser on which the standard was placed and the proportionate ionization current measured. This gives an accurate relationship between the amount of radium element in the two tubes. Details of this and other methods are given in Makower and Geiger.[13]

Thorium, the parent of the other commercially important radioactive substance, is prepared in enormous quantities from monazite sand, which is found in Brazil and in South Carolina, U. S. A. Monazite is a phosphate of the rare earths with some four to five per cent. of thorium and is used for the manufacture of incandescent gas mantles. The sand is treated with concentrated sulphuric acid, and the mesothorium which is a radioactive element, being an isotope of radium and inseparable from that substance, is precipitated as an insoluble sulphate and remains in the residues after the removal of the thorium and other rare earths. The precipitation of the mesothorium may be aided by the addition of some barium sulphate, and later separation may be made by crystallization of the mixed chloride or bromide of barium and mesothorium. For further details see article on Mesothorium in this Handbook, vol. vi., p. 457.

Radium Emanation.—The only other product of the radioactive elements which is extensively used in medicine is the emanation or niton which is formed from radium. This is a very dense gas of an atomic weight of 222 as compared to radium with an atomic weight of 226. Its density is 111 times that of hydrogen. The amount in equilibrium with one gram of radium element is 0.63 cubic millimeter. Half of this quantity is formed in about four days. The emanation gives off only alpha rays, but its half change period is 3.85 days and radium A, B, and C are formed, the latter of which gives off beta and gamma rays. If a radium salt, preferably the chloride, is dissolved in water, the emanation which is formed accumulates and can be removed

either by boiling or by applying a vacuum to the solution. The gas so formed can be purified by the removal of the oxygen and hydrogen by passing an electric spark through the tube containing it, and further treated by reducing it to solid form by the use of liquid air, the freezing-point being −71° C., and pumping off any residual gas. When solid, the emanation glows brilliantly with a bluish color, gradually changing to a brilliant orange red at a lower temperature. After purification the emanation is allowed to volatilize and by suitable means can be passed into glass or steel tubes and sealed off. Such tubes rapidly lose their activity, falling to one-half in 3.85 days, and to one-fourth of the original value in the next 3.85 days and so on, as shown in the chart, Fig. 4371, the point of crossing of the curves being the half value. In the meantime the original radium solution has regenerated one-half of the emanation in the same period and a fresh supply of emanation can be pumped off. As most of the radioactivity of the radium itself is due to the emanation, the advantage of employing this gas is evident; for the tubes containing a given amount of emanation are much smaller than those which contain a radium salt of a corresponding radioactivity, and there is no danger of loss of the valuable salt. They can, therefore, easily be placed in small cavities such as the uterus, or can be inserted into the substance of the tumors if the emanation is collected in small sealed steel needles. For this reason those who have large quantities of radium available prefer to employ the emanation. The unit of the emanation is the amount which is in equilibrium with one gram of radium element, and is called a curie. A millicurie is the thousandth part of a curie and has the same effect as a milligram of radium. The amount of emanation in a tube can be determined by measuring the gamma radiation which reaches a maximum about three hours after pumping off, this being the time required for the formation of an equilibrium amount of radium C.

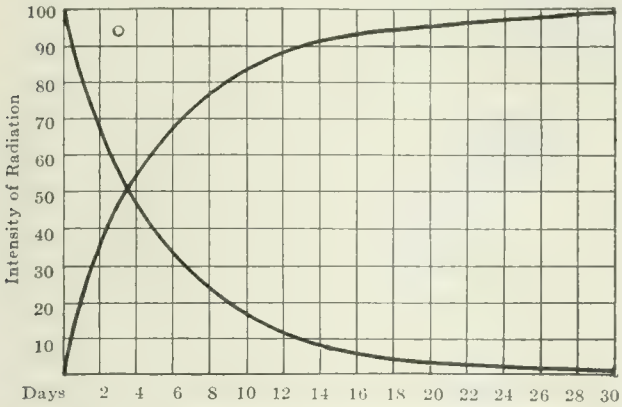

Fig. 4371.—Decay and Regeneration of Radium Emanation.

As the emanation decays, it forms radium A, B, and C. These substances are solid and can be collected upon a metal plate and are, therefore, known as the radium active deposits. Such preparations of active deposits give off alpha, beta, and gamma rays, but as their half life period is always short, the active product rapidly loses its radioactivity. Plates carrying the active deposit have been used occasionally in the treatment of tumors where they can be laid directly upon the surface of the neoplasm, thus obtaining all the benefit of the alpha rays, which come off in large quantities from this deposit.

Alpha Rays.—The alpha rays have been shown to be positively charged atoms of helium projected from the disintegrating atoms of radioactive substances with a velocity of about $\frac{1}{10}$ or $\frac{1}{15}$ of that of light. They give rise by the energy imparted to the atoms with which they come in contact to a very intense ionization of the air which surrounds the substance producing the ray, affect a photographic plate, but in spite of their high speed have but very slight power of penetration, even through gases. Roughly, their comparative ionizing power is 10,000; while the beta ray is 100, and the gamma ray is one. This is only an approximation and varies of course for the different radioactive substances. As a rough working rule, also, it may be assumed that beta rays are about 100 times as penetrating as the alpha ray, and that gamma rays are from 10 to 100 times as penetrating as the beta ray. To the alpha rays is due the greater portion of the energy emitted by radioactive substances in the form of heat. After traversing a few centimeters of gas at atmospheric pressure, the alpha particles slow down very rapidly, collect two negative electrons from the surrounding gas, and then become uncharged atoms of helium. For an individual active radioactive product the ranges of all particles are the same, but those from different origin have different ranges. The range depends also on the density of the gas, varies inversely with the gas pressure, and directly as the absolute temperature. The limit of range from the various products is 2.5 centimeters in air for uranium to 8.6 centimeters for alpha rays from thorium C_2. Further details will be found in the table of the radioactive elements. In general those products whose lives are short, emit alpha rays with a very long range, while substances of very long life, like uranium, give off alpha particles of low speed and short range. Alpha rays are stopped by thin paper such as cigarette paper, or by very thin layers of any metallic substance, the absorption varying with the density of the material. For example, all of the alpha rays from polonium (radium F) with a range in air of 3.77 centimeters, are absorbed by a thickness of 0.029 of a millimeter of aluminum, as is shown in the diagram (Figs. 4372 and 4373). The absorption of the alpha rays being so complete by any substance of greater density than air, it is evident that they do not play any part in the effect of radium or its emanations when enclosed in ordinary glass tubes, which are usually about 0.5 millimeter in thickness.

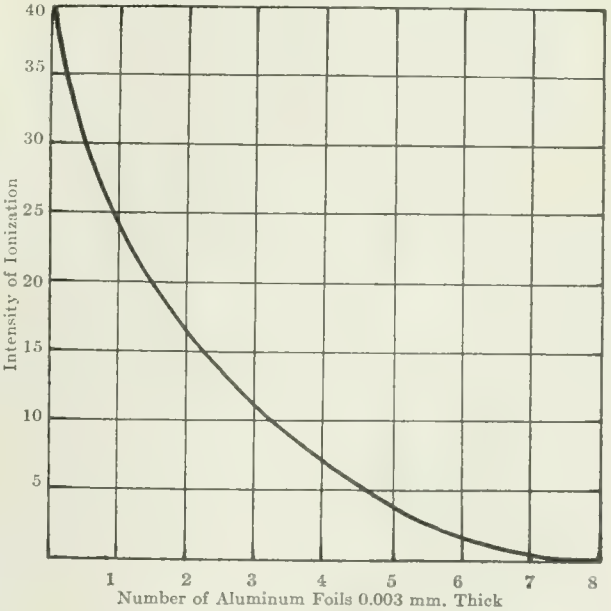

Fig. 4372.—Absorption of Alpha Rays from Polonium.

The only way in which their effects can be obtained is by the use of radium either bare or contained in applicators covered with an exceedingly thin layer of mica, or enclosed in a thin layer of varnish. The absorption in tissues is so great that the effect only extends a fraction of a millimeter into the cellular material, the absorption being about that of water, or not over one-tenth of a millimeter.

Computation of the penetrating power of alpha particles in substances as compared with their penetration in air, may be taken approximately as inversely as the density of the material through which the particle is passing. For instance, if the range of an alpha particle in air is seven centimeters, as is that of the alpha radiation from radium C, the penetration in water will be $\frac{7}{800} = 0.0087$ cm. In aluminum which is about 2,000 times as dense as air, the penetration will be 0.0035 centimeter.

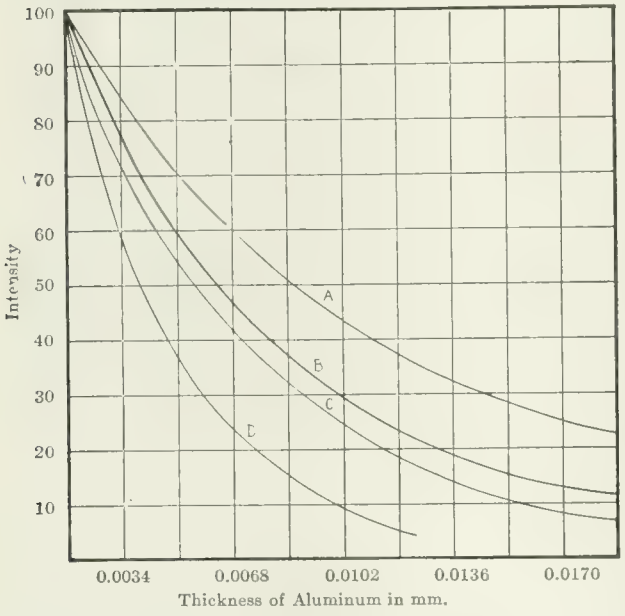

FIG. 4373.—Absorption of Alpha Radiation by Aluminum. *A*, Alpha rays from active deposits of radium and thorium; *B*, alpha rays from thorium; *C*, alpha rays from radium; *D*, alpha rays from uranium.

Beta Rays.—In 1899 Giesel discovered that radium gave out rays which were deviable by a magnetic field and resembled very much the cathode rays produced in an *x*-ray tube. This observation was followed up by Pierre Curie and Becquerel in 1900, who showed that two groups of rays were present, one of which now known as the alpha rays, was only very slightly deviable by a magnetic field, and the other, the beta rays, was very much more easily deflected owing to their much smaller mass.

By depositing a small amount of radium in a lead box the top of which contained a narrow slit, and then placing an uncovered photographic plate over the box and subjecting the rays which came through the narrow slit to a magnetic field, Becquerel showed that the beta rays are very complex and are composed of a large series of rays of different velocities, the most deviable being the softer group or those most readily absorbed by matter. The nature and amount of the electric charge was soon determined, for when beta rays are stopped in matter, they give up their negative charge and the quantity of negative electricity communicated to a metal plate is thus a measure of the total quantity carried by the absorbed particles. This charge of electricity for a given time can easily be measured by a suitable electrometer, and thus if the number of beta particles is known, the charge per particle can be determined. The number of such particles emitted by radium B and C in equilibrium with one gram of radium is about 70,000,000,000 per second.

The velocity of the beta rays expelled by various radioactive substances varies between 0.30 and 0.998 of the velocity of light; that is, from 66,000 to 186,000 miles per second; or in metric nomenclature, from 0.49 to 2.97 cm. $\times 10^{10}$. When the beta rays strike matter, they are partly absorbed, partly transmitted, and partly reflected, the amount respectively depending upon the substance and the nature of the radiation. The higher the atomic weight, the greater the percentage of absorbed and reflected beta radiation. The faster the beta rays in general, the greater amount is transmitted. As they are actual particles, they gradually lose speed as they pass through the atoms of matter, or become "softer," hence the rate of absorption continually varies. The absorption of the beta rays follows roughly, however, the exponential law by which the transmission absorption of Roentgen or radium rays is $I_d = I_0\epsilon^{-\mu d}$ where I_0 is the value of the unabsorbed ray, I_d the value after passage through a thickness d in centimeters of any substance absorbing any of these rays, and μ the coefficient of absorption of the material for the ray in question. The value of μ, therefore, varies with each variety of ray and with each element. It is smallest for Roentgen and radium rays with substances of low density and atomic weights such as aluminum (atomic weight 27) and highest with heavy substances of high atomic weight such as lead (atomic weight 207). If d is such a thickness in centimeters as to reduce the passing rays to one-half the value they had before impinging on the absorbing material, $\mu = \frac{\text{natural log } 2}{d} = \frac{0.693}{d}$, or if $\mu d = 0.693$ cm.$^{-1}$ (0.693 being the natural logarithm of 2) $\frac{I_d}{I_o} = 0.5$ or $\mu = \frac{1}{d} \log \epsilon \frac{I_o}{I_d} = \frac{2.302}{d} (\log_{10} I_o - \log_{10} I_d)$ or if μ is known by experiment $d = \frac{0.693}{\mu}$. It follows that if the ray is reduced to one-half its value after traversing 1 cm. of substance $\mu = \frac{0.693}{1}$ cm.$^{-1}$ = $\frac{1}{0.693}$ cm. or 1.44 cm. That is, the value of the absorption coefficient in the given substance is 1.44 cm.

Or again if we wish to know the thickness of lead which will cut down the beta rays from radium C_1, which have a μ in lead of about 90 cm.$^{-1}$ to 1 per cent. of their original value, then the equation becomes $d = \frac{2.302}{\mu} (\log._{10} - I_o - \log._{10} I_d) = \frac{2.302}{90} (2 - 0) = \frac{4.604}{90} = 0.051$ cm. or 0.5 mm.; to reduce to a tenth of one per cent. 0.76 mm. of lead are necessary.

Again if we wish to know what fraction of the hard gamma rays from radium C_1 are absorbed by a screen of 1 or 3 mm. of brass, μ for gamma rays in brass = 0.325, we employ the original form of the absorption law $I_d = I_o\epsilon^{-\mu d}$ where I_d is the amount passing and 100 $- I_d$ the amount absorbed. Then $I_d = I_o\epsilon^{-\mu d} = \epsilon^{-0.325 \times 0.1} = \epsilon^{-0.0325} = 0.97$. $I_d = 100 \times 0.97 = 97$ per cent. passing, 3 per cent. absorbed for 1 mm.; for 3 mm. $\epsilon^{-\mu d} = \epsilon^{-0.325 \times 0.3} = \epsilon^{-0.0975} = 0.90$. Hence $I_d = 100 \times 0.90 = 90$ per cent. passing or 10 per cent. absorbed.

Tables of the value of $\epsilon^{-\mu d}$ are given in many books on mathematics or the values can be computed from any logarithmic table, ϵ being taken as 2.718.

To find the percentage of hard beta rays from radium C_1 absorbed in brass of 1 and 3 millimeters thickness, μ being about 60 for brass. Here $\epsilon^{-\mu d} = \epsilon^{-60 \times 0.1} = \epsilon^{-6}$ and $^{-60 \times 0.3} = \epsilon^{-18}$ which are respectively 0.00248 = 0.25 per cent. passing, 99.75 per cent. absorbed and 0.000,000,015 = 0.000,001,5 per cent. passing and 99.999 per cent. absorbed. Thus very little absorption is gained by adding the extra 2 millimeters of brass, but there is a 7 per cent. loss in the gamma rays.

The residue of beta rays from 2 and 3 millimeters of lead is very small, the absorption coefficient being 90 cm.$^{-1}$. Hence $\epsilon^{-\mu d} = \epsilon^{-90 \times 0.2} = \epsilon^{-18} = 0.000,000,5$ per cent. of passing and 99.999 per cent. absorbed for 2 millimeters, while for 3 millimeters $\epsilon^{-\mu d} = \epsilon^{-27}$ or 0.000,000,000,19 per cent. passes and 99.9999 per cent. is absorbed.

The absorption of the gamma rays by lead can easily be determined by inspection of Fig. 4376, the soft varieties being stopped by 2 or 3 millimeters, the remaining hard rays then possess a μ of 0.50 in lead.

While $\frac{1}{\mu}$ is the average path or the distance to which the rays penetrate before their intensity is reduced to $\frac{1}{\epsilon}$ or 0.367 of their original value, it is more convenient to use a formula giving the thickness necessary to give a half value to the emerging ray. The capital letter D is usually employed, and from the previous equation it is obvious that $D = \frac{0.693}{\mu}$. The value of μ in lead of the hard gamma rays from radium is 0.50, hence the half value would be obtained by $\frac{0.693}{0.50} =$ 1.38 cm. of that metal.

Exactly the same equation is used for determining the rate of decay of the radioactive elements and the amounts remaining after a given period. A change in the letters used is made to avoid confusion. If P_0 represents the number of atoms of any radioactive substance at time taken as zero, the number of atoms P present after t seconds is $P = P_0\epsilon^{-\lambda t}$ where λ is the transformation constant measuring the rate of disintegration, just as μ is the absorption constant. Then $1/\lambda$ is the average life of the atom, or the time required for $1/\epsilon$ or 0.367 of the number originally present to break up; but as in absorption work, it is often more convenient to employ the period of half decay or half life T where $T = \frac{0.693}{\lambda}$ just as above where the value of D is obtained in the same fashion. Therefor the half decay period multiplied by $\frac{1}{0.693}$ or 1.44 will give the average life.

The decay of uranium into uranium X and the gradual breaking up of the uranium X so formed furnishes a good illustration of this law of rates. If about fifteen grams of uranium nitrate at least six months old, so as to be in equilibrium with its product uranium X, is dissolved in water and some twenty milligrams of ferric chloride in solution are added, the mixture diluted to 150 c.c. and boiled while a strong solution of ammonia containing ammonium carbonate is slowly added, ninety-five per cent. of the uranium X will be precipitated. During the process the mixture should be stirred so as to facilitate the solution of the uranium oxide in the ammonium carbonate. The mixed oxides of iron and uranium X are removed by filtration and dried. The uranium solution will now show no beta ray activity, the metal giving off only alpha rays; but gradually as uranium X is reformed, the beta activity will rise until it reaches its original value (curve A) in some four months. During the same time, the beta ray activity of the uranium X will gradually fall (curve B) until it is negligible in four months. It will be noticed by inspection of (Fig. 4374) that the sum of the beta ray activity of both substances is the same; when the uranium is at zero, the uranium x is 100. When uranium has regained its full value it is in equilibrium with its decay product which means that the uranium X decays just as fast as it is formed. If, then, λ is the constant of disintegration of

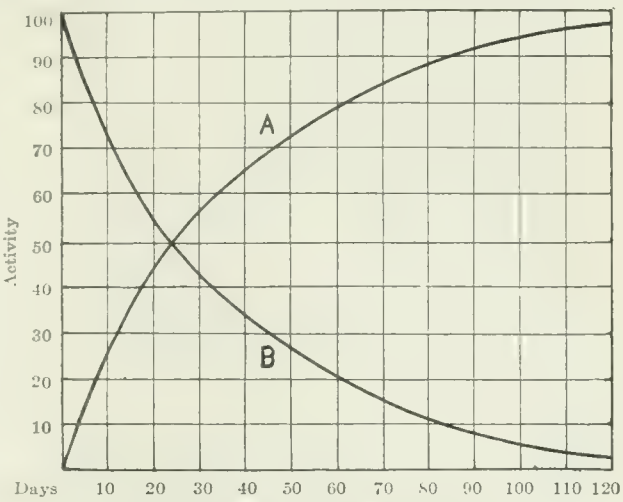

Fig. 4374.—Decay and Recovery of Uranium X.

uranium X the quantity of this substance left at any time, t, in that portion separated from the uranium is given by the equation $Q = Q_0\epsilon^{-\lambda t}$ where Q_0 is the quantity originally separated, while the quantity of uranium x reformed in the uranium at any time t is $Q = Q_0(1 - \epsilon^{-\lambda t})$ the sums being constant as stated above. Where the curves cross is the half value period of uranium X or 24.6 days. This curve, with the necessary change of values for time of decay is true of all radioactive decompositions.

As has been stated, the beta rays are not homogeneous, but vary enormously in speed. The complexity of this radiation from radium B and C can be judged from the fact that Rutherford and Robinson have shown that at least sixty-four different wave lengths can be isolated by the magnetic deflection of a narrow pencil of these rays, the velocity varying from 0.36 to 0.998 of that of light. The absorption coefficients for the beta rays of the various radioactive elements are given in the table. They are usually in terms of aluminum for the beta rays, but observations have also been made using screens of lead which shut off a very large portion of the softer rays. Even two millimeters of this metal does not remove, however, all of the high velocity beta rays, some 0.15 per cent. escaping but three millimeters absorb all but a minute fraction at the same time, however, holding back twenty-eight per cent. of the gamma rays. The secondary beta rays, however, given off from the lead itself under the influence of the gamma radiation must be considered in practical work. They are very soft, being half absorbed by 0.25 millimeter of aluminum and largely stopped by one centimeter of paper. In air there is very little absorption, the hard beta rays from radium C having an absorption coefficient of 0.004 cm.$^{-1}$. In other words they are only reduced to half value in passing through 360 centimeters of air.

In treatment it is important to know the absorption of tissues for various beta radiations, and the following

table taken from Russ[14] shows roughly that four and one-half millimeters of tissue will absorb all but about three per cent. of the beta radiation from radium of all wave lengths. If, however, the radium is screened with one and one-half millimeters of aluminum, so only the harder rays pass, transmission through four and one-half millimeters of tissue only reduce the effect about seventy-five per cent. Very little influence, however, can be expected from the beta rays in tissues after the passage of one centimeter of thickness. Biologically these rays are immensely more effective than the gamma rays, but their rapid absorption even in the tissues prevents their use in the treatment of deep-seated neoplasms unless the radium tube can be placed in the tumor. The curves shown in Fig. 4375 show this. With the radium unscreened except by the glass container the action is rapid; when the soft beta rays are removed by a thin brass screen the lethal effect diminishes, and the potency is still less when a brass screen of 1.2 millimeters is used, which removes all but 0.1 per cent. of the hard rays leaving only the gamma passing through.

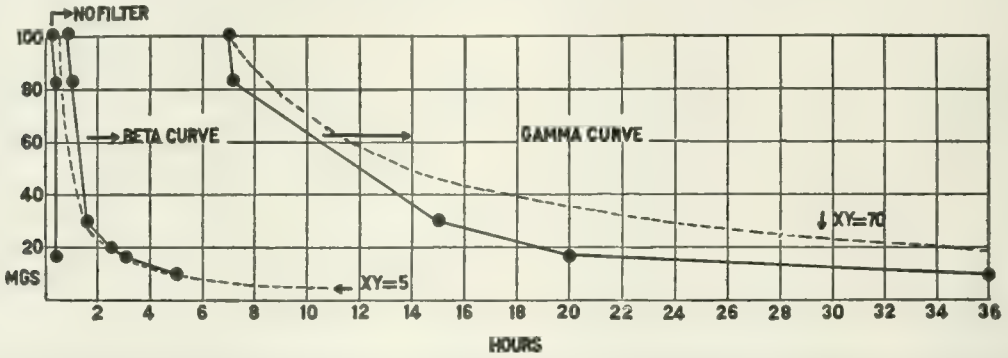

Fig. 4375.—Plottings of curves of observed minimal lethal exposures on the abscissæ against milligrammes of radium on the ordinates. The first curve from the left shows the time required to kill carcinoma and sarcoma cells when the glass tubes containing the radium are unscreened. The observation includes 100, 83, 30, 20, and 10 mgm. of element. The second solid curve gives the results when the glass tubes are screened with 0.4 mm. of brass. The dotted curve is that of $xy = 5$. The solid curve furthest to the right gives the results with gamma rays, obtained by screening the radium tubes with 1.2 mm. of brass and 5 mm. of filter paper. The dotted line is the curve of $xy = 70$. From this chart the approximate time of exposure necessary to kill all tumor cells at a given distance can be estimated for each weight of radium, or, if preferred, the time of exposure can be found on the chart, and then by following up one of the vertical lines the amount of radium required to kill the cells at the given distance can be determined.

Absorption of Composite Beta Rays from Flat Applicator No Screen.

Thickness of tissue, millimeters	Muscle (density 1.25). Ionization.	Liver (density 1.21). Ionization.	Spleen (density 1.17). Ionization.	Brain (density 1.12). Ionization.	Fat (density 0.92). Ionization.
0.00	100.0	100.0	100.0	100.0	100.0
0.65	32.5	36.0	36.7	36.8	40.2
1.30	. . .	18.0	. .	. .	. .
1.95	10.3	11.4	12.4	12 2	13.0
3.25	4 5	5.4	5.8	5.7	6.4
4.55	2.3	3.5	3.1	3.5	3.4

Absorption of Composite Beta Rays from Flat Applicator. Screen 1.5 Millimeters Aluminum.

Thickness of tissue, Millimeters.	Muscle. Ionization.	Spleen. Ionization.	Brain. Ionization.
0.00	100.0	100.0	100.0
0.65	85.5	90.0	.
1.95	62.0	56.2	57.0
3.25	43.0	41.4	36.6
4.55	26.3	29.9	26.7

The use of a metal of low atomic weight as a screen to remove the beta rays and yet permit of the maximum gamma effect, is based upon the fact that such metals emit a softer beta secondary than those of high atomic weights such as gold, platinum, or lead. Pound[15] has shown that the secondary rays from lead and aluminum are completely absorbed by 0.16 and 0.4 millimeter of these substances respectively, while the primary beta rays from radium require 0.9 and 7 millimeters for their complete absorption. These figures which are experimentally obtained, do not agree exactly with some of those computed above or with those of Keetman & Mayer[16] and therefore indicate the practical difficulties which still beset the study of the complex beta radiations of some of the radioactive elements. The intensity of the secondary radiation is also much greater with the heavy metals, that from lead being almost twice that from brass and three times that from aluminum.

Gamma Rays.—Many of the elements of the radioactive group give off rays which are ether vibrations comparable to light, only of extremely short wave length. These rays are not deviable by a magnet and have great penetrating power, as evidenced by the fact that the effect from a relatively small amount of radium can be demonstrated after passage through twelve inches of iron. They can also easily be shown by placing a lead screen four or five millimeters thick over a small tube of radium and then noting the luminosity which the rays induce in a crystal of willemite or a barium platinocyanide screen. Apparently all those bodies which emit beta rays also emit gamma radiation, though not in all cases has this gamma radiation been detected. The most penetrating ray from radium which has been studied has a wave length of 0.71×10^{-9} centimeters and fourteen different series have been noted from this wave length up to a wave length of about 5×10^{-9} centimeters from radium B and radium C. Still shorter wave lengths are emitted by thorium D with μ in lead of 0.46 cm.$^{-1}$ as compared with the hardest radium rays having a μ in lead of 0.50 cm.$^{-1}$.

It is probable that the projection of the beta particle is in some way connected with the generation of the gamma rays, just as x-rays are induced by the impact of cathode rays upon the metal of the anticathode, the radiating substance being in this case the molecules of the radioactive element under consideration.

As the rays are not homogeneous but vary greatly in their wave length, their absorption shows a corresponding irregularity as Fig. 4376 shows. There is a

very rapid initial fall induced by a thickness of one to two millimeters of lead, but after the rays have passed through about three millimeters of lead, their absorption falls in line with the exponential law as given above. Roughly the absorption varies as the density of the element through which the gamma rays pass. In their passage through the atoms of matter the gamma rays are scattered, and the softer or less penetrating rays much more than the harder or more penetrating radiation. These scattered or secondary rays are given off in all directions, but in addition the passage of gamma rays through material of any sort gives rise to secondary beta rays most of which are projected in the direction of the original beam, though a considerable percentage is reflected backward or laterally throughout the substance through which the ray is passing. The absorption coefficients for light substances such as gases, are very low. For example, the gamma rays from radium are only half absorbed in a distance of 115 meters of air; but for heavy material such as lead the absorption coefficient is 0.5 centimeter, or the half value for lead is 1.38 centimeters.

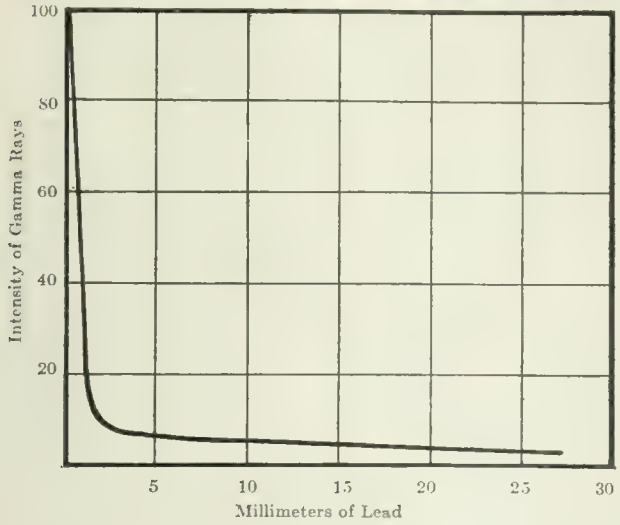

FIG. 4376.—Absorption of Gamma Rays from Radium by Lead.

The amount of secondary radiation also varies according to the atomic weight of the atom of the element through which the gamma rays pass, but not regularly. For example, aluminum gives off more secondary radiation than iron or copper or silver; while the very heavy atom of uranium gives off the most secondary beta radiation, as is shown in the chart, Fig. 4377. The practical importance of this observation lies in the selection of screens where the secondary beta radiation is to be reduced to a minimum in order to avoid surface burning. For this reason brass is usually selected as a convenient and easily worked metal, for a screen which gives off a minimum of secondary rays and therefore causes but little local burning; whereas platinum and lead should not be so used unless the secondary rays are very thoroughly absorbed by layers of paper and by keeping the tube at a considerable distance from the part to be radiated. Current practice tends toward the use of large quantities of radium with very heavy lead screens of three to four millimeters, and a number of centimeters of gauze or paper, the radium being spread over a considerable surface and left for a long period. Thus the tissue is attacked almost entirely by gamma rays, as all the beta radiation is absorbed, the secondary beta rays arising from atoms of low atomic weight, such as the carbon, hydrogen, and oxygen of the paper, are almost nonpenetrating for tissues on account of their low speed. However, it is not yet proved that all of the action of the gamma rays on the cells of the body is due to their transformation into beta rays of an easily absorbable variety as they are produced from substances of low molecular weight. The iron and calcium are the elements of the highest molecular weight commonly present in the body, and therefore the most rapid beta rays are generated in these substances. As, however, many of the gamma rays must pass through the tissues and escape on the other side of the body without absorption, attempts have been made by the injection of suspensions of heavy metals to cause great local absorption of the rays with setting free of energy in the form of beta secondary radiation, but as yet nothing striking has been achieved. The whole question of the action upon the cells is ultimately one of energy set free, and the rays that escape do not set free any energy in the tissues. For this reason similar exposures to the gamma rays have relatively slight action as compared with the alpha and beta rays, and this explains the lack of effect which has been noted and which has led many to believe that they have no destructive action upon the cells of the body. It is not probable, however, that their effects in any way differ from a very high speed beta radiation of low intensity. Attempts have been made to determine which part of the radiation was active biologically by magnetically removing the alpha and beta rays. Exner[17] was one of the first to show by such separation of the beta and the gamma rays that each possessed destructive power. He exposed the skin of the mouse at a distance of three centimeters to radiation from fifty milligrams of radium bromide for eighteen hours. Some fifteen days later burning appeared and ulceration followed. The lesion produced by the beta rays was more shallow and the alopecia less extensive than was the case when gamma rays were used.

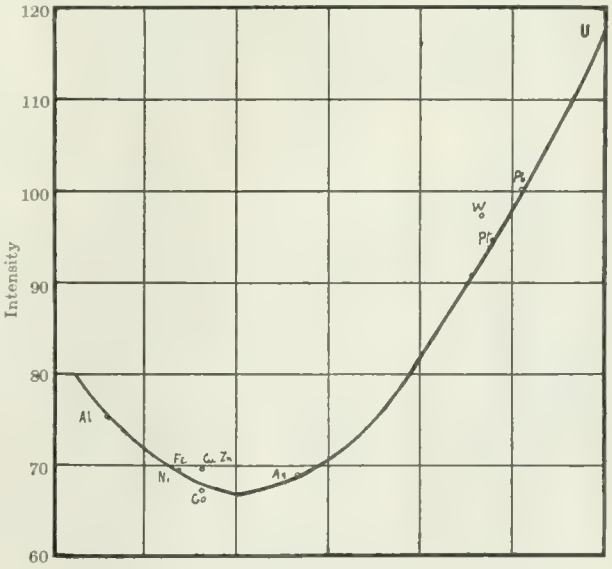

FIG. 4377.—Secondary Beta Radiation from Metal Screens.

Abbe[18] has recently repeated these experiments in a different way, and found no action from the gamma rays; this is evidently due to the fact that the exposures were not sufficiently long. Abbe claimed that no

stimulating effect could be obtained with beta rays, but this also is unquestionably an error, as when exposures below a certain threshold value are given stimulation can be obtained as easily with the beta rays as with the other varieties of radiation.

F. C. Wood.

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Knox: Radiography, *X*-ray Therapeutics and Radium Therapy.

Wickham and Degrais: Radium Therapy, London, 1910.

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Radiolaria.—An order of the class Sarcodina. These protozoans are largely marine, and are never parasitic. See *Protozoa.* A. S. P.

Radiotherapy.—Radiotherapy is the term applied to the treatment of disease by Roentgen rays and by the radioactive substances—radium and thorium or their products. This term is applied indiscriminately to the application of various forms of radiant energy in therapeutics and it is liable to be confused with the more restricted radium therapy. Degrais, therefore, suggests the advantage of calling radium therapy "Curie therapy" as we now speak of Roentgen therapy when the *x*-rays are used in treatment. The literature on radiotherapy has now reached enormous proportions and space does not permit more than the barest summary. Not only are there a great number of articles but many volumes and even journals are devoted solely to radiotherapy. To this literature the reader is referred for any adequate conception of the subject. In this article a mere outline of the technique used, the variety of conditions which have been treated, and the general results obtained can be described.

Since the discovery of Roentgen rays in 1895, of radium in 1898, and of mesothorium in 1905, these sources of energy have been utilized for the treatment of a great variety of both external and internal diseases. The earliest, and perhaps the most useful, field of application has been in dermatology and as this form of therapy proved of value in treating some of the most intractable skin diseases, such as lupus and carcinoma of the skin, it resulted that overenthusiastic claims have been made for radiotherapy even in many incurable diseases.

The therapeutic application of radium was developed by the French, notably by Dominici, Wickham, and Degrais. The Germans began the use of mesothorium and elaborated other forms of radiotherapy. Radioactive substances and their products have such remarkable physical properties that the discovery and investigation of them has radically altered even fundamental conceptions regarding matter. With this in mind and with the realization that radioactive substances and their products are so varied and may be used for therapeutic purposes in the solid, gaseous, or liquid form it is not surprising that they have within recent years been the subject of extensive scientific experiment and also of widespread clinical application even to a degree of exploitation.

Soon after the discovery of radium by the Curies it was found that radioactive substances produced effects similar in many ways to the Roentgen ray for in 1901 Becquerel was burned by carrying radioactive material in his pocket. In 1906 the Laboratoire Biologique du Radium was established in Paris and here Dominici, Danne, Wickham, Degrais and their co-workers developed the therapeutic application of radium. In 1909 the Radium Institute at London was established for the treatment of disease by radium. In 1905 mesothorium was discovered by Hahn.*

Throughout Germany and Austria there has been rapid increase in the extension of radiotherapy. In Berlin a Radium Institute has been established and is under the direction of Dr. His and Dr. Gudzent of the first medical service at the Charité. Radioactive substances are also extensively used in various clinics, notably those of Bumm and Lazarus. In Heidelberg at the Samariterhaus radiotherapy is used by Werner in Czerny's clinic in the treatment of cancer; it is also employed in Freiburg by Kroenig and Gauss. In the majority of instances in Germany the *x*-ray has been used either as adjunct to or in parallel with radium.

In Austria the government has established a central station in the Allgemeines Krankenhaus in Vienna for the distribution of various forms of radioactive material to the different clinics, notably those of von Noorden, Schauta, Wertheim, and von Eiselsberg, from which numerous articles have been written concerning radiotherapy. There is also in Vienna a Radium Institute supported by private funds for the strictly scientific study of radioactive substances. In this country the names of Kelly, Abbe, and Morton are associated with the development of radiotherapy. In Baltimore in Kelly's private hospital radium is used extensively. In New York at the General Memorial Hospital radium is used for the treatment of cancer, and in Boston at the Huntington Hospital of the Cancer Commission of Harvard University radium is used for the treatment of cancer and allied conditions and also for scientific research.

Radium is an element in the strontium-barium group. Its properties are now quite generally known. It is a metallic element designated by the symbol Ra. Three of the commonest salts are the bromide, chloride, and sulphate of radium. It is derived from uranium. Other members of the radioactive group are thorium and actinium. Radium is constantly undergoing transformations into other substances, that is, radium becomes successively—emanation, ra-

* The initial cost of mesothorium is less than that of radium but it loses its activity in very much shorter time, the half life period of mesothorium being about seven years while that of radium is about 2,000 years. Therefore, at the present time the use of radium has for the most part replaced that of thorium.

dium A, B, C, D, E, F (or polonium) which is probably converted into lead. The rate of this transformation cannot be altered by any known process or condition. During these transformations energy is radiated from the substances in the form of the so-called alpha, beta, and gamma rays upon the various effects of which the therapeutic action depends.

Alpha rays are positively charged atoms of helium. They travel at the rate of 20,000 miles a second. Their penetration is slight; indeed, they are stopped by even a thin sheet of writing paper. They may produce marked chemical change but cannot be used practically in treatment except in superficial lesions of the skin.

Beta rays are negatively charged electrical ions, electrons, the same as cathode rays but of about the velocity of light (186,000 miles a second). They penetrate about eight millimeters of tissue, but do not penetrate over two millimeters of lead, or 1.2 millimeters of brass. They also induce chemical change in organic matter.

Gamma rays are not particles of matter but vibrations of the ether similar to ordinary light and to the *x*-rays but of much shorter wave length and greater penetration. They are said to have less power than the alpha or beta rays to produce chemical change.

In medical work we may use the three sorts of rays together or by appropriate screens exclude either the alpha or beta rays. Ten per cent. of the gamma rays are absorbed by one centimeter of tissue. They readily pass through 1.2 millimeters of brass, only about three per cent. being absorbed. In passing through metal screens, however, soft secondary beta rays are generated. These may be absorbed by placing filter paper five millimeters in thickness about metal screens. In experimental work by means of the electromagnet it is possible to use the alpha and beta rays alone. Clinically, we can approximate this by varying the time of application and the thickness of the screens because of the relatively greater amount of alpha and beta than of gamma rays; the proportion is respectively ninety, nine, and one per cent. when no screens are used.

Radium may be used either externally by methods similar to the *x*-ray or internally, *i.e.* medicinally. Radium may be used as salt when spread evenly over applicators and retained in position by special varnish or it may be employed in tubes or in special containers.

The emanation or radioactive gas evolved from a solution of radium has the properties of a gas, that is, diffusion, solubility in liquids, condensation, and liquefaction at a certain pressure and temperature. It is also radioactive, that is, it ionizes air, discharges electrical bodies, affects photographic plates, passes through bodies opaque to light, and provokes phosphorescence in different substances and even in the glass which contains it. Emanation may be freed from the admixture of hydrogen and oxygen and reduced to a very small volume by Duane's method of passing it over a heated copper coil or by condensing the "impurity" of hydrogen and oxygen by liquid air. Then it may be passed by mercury pumps into capillary glass tubes which are sealed off into lengths suitable for various containers. The emanation may also be compressed into special containers and used without "purification." It may be set free into special chambers for inhalation or dissolved in water for drinking or for injection.

Radium A, B, C, or "active deposit" from the emanation may be used for external application by various appliances or when deposited on salt according to Duane's method it may be used medicinally by injection, etc. As radium loses half its strength in about 2,000 years it may be regarded as practically constant for therapeutic purposes. The emanation, however, loses half of its strength in 3.8 days, that is, practically one-sixth a day, therefore allowance for this must be made in treatment. The deposited activity, radium A, B, C, loses half its strength in one hour. Because of the technical procedures necessary for purifying the emanation and for obtaining the active deposit and because of the relatively short period of their activity these forms of radium are in less general use.

The use of radium emanation, however, has certain practical advantages particularly in avoiding loss of the radium by theft or accident. The solution of radium may be kept carefully locked in a safe while the emanation is constantly being formed from it. The emanation may be put into containers of various sorts and conveniently sent away by post. It should be borne in mind, however, that half the strength is lost in 3.8 days, therefore, the emanation can be sent only a limited distance. The disadvantages of using emanation are that it is constantly losing its radioactivity as above indicated and it is, therefore, somewhat more difficult to apply very exact dosage which may be important in certain cases.

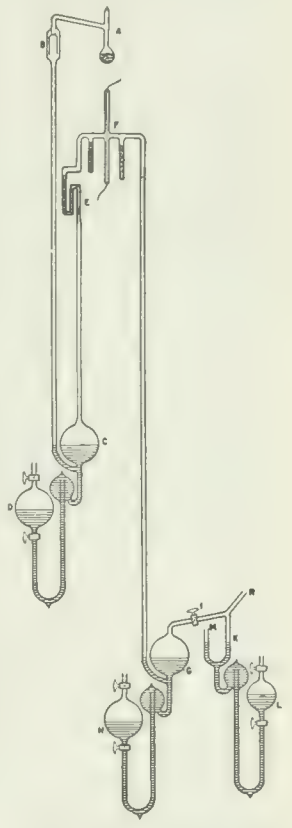

Fig. 4378.—Duane's Apparatus for "Purifying" Radium Emanation. The radium solution is in sealed flask *A*, the heated copper coil is at *F*, the adjacent tubes contain phosphorpentoxide and potassium hydroxide which absorb the water vapor produced and the carbon dioxide gas respectively; *C*, *D*, *H*, *G* and *L* are systems of mercury pumps. The purified emanation is collected at *N* in a capillary tube or other container. (From the 2nd Annual report of Huntington Hospital, Cancer Commission of Harvard University.)

It has been said that radium acts merely as the most expensive and efficient form of cautery as yet discovered. It has, on the other hand, been claimed that the radiation has a marked action in destroying pathological tissue without affecting normal tissue. Between these extreme views, however, a mean should be taken. While it is true that the alpha and weak beta rays produce a very marked chemical change and that the hard beta and gamma rays do exert a somewhat selective action, this, however, is only relative, the more embryonic and cellular tissue being chiefly altered. By prolonging the exposure, however, even dense fibrous tissue may show changes. There is great variation in the effect of radiation upon different growths and also on normal tissues. The lymphatic organs are specially sensitive and easily destroyed and also the hair follicles, the glands of the skin, and the reproductive portions of the ovary and testis. The endothelium of the blood-vessels may swell up and cause occlusion of the vessels with marked diminution of the blood supply. Cartilage, bone, and ordinary connective and nerve tissues are very resistant. It is not in many cases possible to predict by histological examination which growths will be easily affected and which will prove refractory to the action of the rays. Although it has been supposed that the action is purely local and direct upon the cells themselves there may also be an indirect, possibly cytolytic or other "immunity" reaction secondarily

produced. The destruction of tissues exposed to radium is usually by necrobiosis, the nuclei become swollen and vacuolated, the nucleoli become enlarged and fragmented, the staining characteristics of the tissues are altered, and the death of the cell ensues. It is believed that the effect of the radiations* is to produce ionization of the atoms of the different substances the rays penetrate and that chemical changes follow as a secondary result of the ionization.

After exposure to *x*-ray or to radioactive substances there is usually a latent period of longer or shorter duration before the effects become evident. This latent period varies from one to two days to even two or three weeks or longer. It depends in most instances upon the strength of the source of energy and upon the amount of filtration and protection used. In certain instances it may depend upon personal idiosyncrasy.

The effects of exposure to *x*-ray or radioactive substances may be either local or general. Local effects on the skin may vary in intensity from erythema to vesiculation or even ulceration of varying degree and even cancer. General effects such as sterility, changes in the blood, and constitutional disturbances occur.† To these dangers the attention of those engaged in radiotherapy is particularly called.

Certain toxic symptoms have been described in patients treated by the *x*-ray. Edsall has reported this effect in cases exposed to *x*-ray merely for diagnosis, in pneumonia for example. He believes that such symptoms are more apt to occur in patients in whom the kidneys are diseased. We have observed under *x*-ray treatment vomiting, collapse, and stupor. With radium we have not observed such marked symptoms, but believe it is wise carefully to examine patients before prolonged treatment and reduce the protein intake with particular reference to the purins. The blood should also be repeatedly examined numerically and histologically. It has been suggested that the toxic symptoms reported under the *x*-ray treatment may be due to the ozone or the oxides of nitrogen liberated by the powerful electric currents with the small wires which are commonly used. No doubt this may account for many of the milder symptoms particularly drowsiness and lessening of pain while patients are being treated by the *x*-ray.

Comparison of X-ray and Radium.—Although there are numerous physical differences between Roentgen rays and those emitted by radioactive substances in certain respects they are analogous. They produce similar chemical action on photographic paper or film, they cause fluorescence, they penetrate opaque objects, and have the property of ionizing the air and so rendering it a conductor of electricity. The similarity in the physiological action of the Roentgen rays and of radioactive substances, particularly if used by like methods, is striking. The physical and chemical properties and the production of Roentgen rays and radioactive substances and their products are discussed in other articles in this Handbook and to these reference should be made, unless the reader already has an elementary knowledge of radioactivity. In general it may be said that the local therapeutic effects of unfiltered *x*-rays produced by soft tubes may be compared with rays from radioactive substances if filtered through a very thin sheet of paper or aluminum which intercepts merely the alpha rays, that is, unscreened rays with very short exposures of a few minutes are comparable in effect to weak beta rays of radioactive substances with exposure of from fifteen minutes to an hour. Such rays have comparatively little penetration and are used in the treatment of superficial lesions of the skin and mucous membranes, for it is believed that only the rays absorbed produce physiological changes. It is, therefore, necessary in order to produce any marked effect on deeper tissues to use screens or filters to check the less penetrating rays which would otherwise be absorbed by the superficial tissues and cause marked destructive changes there before the less numerous and more penetrating rays could act on the deeper tissues. In order to obtain the most penetrating *x*-rays for the so-called "deep Roentgen therapy," the *Tiefenröntgentherapie* of the German school, it is necessary to employ a hard tube, high vacuum, and an electrical apparatus of high voltage. The rays are not all of equal penetrability and it has been found that they are more homogeneous when the softer have been "filtered out" by an aluminum screen three millimeters in thickness. When using radium it has been shown that screens or filters, lead two or three millimeters thick, brass 1.2 millimeters, or other heavy metals such as silver and gold or platinum, allow the penetrating hard beta and gamma rays to pass and intercept the alpha and soft beta rays which would otherwise be absorbed and cause destructive changes in the superficial tissue. As the amount of the more penetrating rays is only a small proportion of the total activity, less than five per cent., it is necessary in deep therapy to make the exposures correspondingly long. Hours are required, even twenty-four, forty-eight, or longer, for deep therapy with heavily screened apparatus, whereas a few minutes to an hour are used in the treatment of more superficial lesions with radium. Werner believes that the therapeutic action of *x*-rays may be increased by the injection of borocholin which is supposed, according to him, to "sensitize" the tissues. He also advocates various other forms of "combined therapy." Fluorescent dyes, colloidal metals, and other substances have been advocated to "activate" or intensify the action of radiations. They have not as yet, however, been proved to be of clinical value.

In practical radiotherapy radioactive substances will in certain cases doubtless be preferable to the use of Roentgen rays, particularly when there is necessity for the most precise localization, especially within the body or in the cavities difficult of access; also when the condition of the patient or circumstances demand portability of the therapeutic agent for convenience or ease of treatment. The disadvantages of radium are its great expense for sufficient doses necessary in some cases, also the possibility of loss of the salt by accident or theft. This may, however, be obviated by use of the emanation as above indicated, but the expense is thereby increased because of the necessity of retaining a physicist and equipping and carrying on a physical laboratory. When sufficient clinical experience has been gained in the application of the recent advances in the production of highly penetrating homogeneous *x*-rays of great volume by Coolidge and his coworkers, supplemented by careful scientific study of the physiological effects, we believe that there will be, in the majority of cases, very little difference in the therapeutic value of the *x*-ray and radioactive substances. It may be possible that similar results to those now produced by radioactive substances may be brought about in a much shorter time by the *x*-ray when the desired quantity and quality of the radiation may be measured in a rational manner so that the results obtained by one man may be compared with those of others and that there may be a repetition of results from day to day. From the preceding it will be seen that each source of radiation has certain advantages as well as disadvantages. Unless in the near future the cost of production and the selling price of radium are greatly reduced it would seem with the recent developments in the *x*-ray that the latter will become of more general use in the treatment of many diseases

* Radiations will be the term applied to rays, particles, or electrons derived from Roentgen-ray tubes or radioactive substances.

† These have been described in considerable detail by Tyzzer and Ordway in "Diseases of Occupation and Vocational Hygiene," Kober and Hanson, P. Blakiston's Son & Co., 1916.

Internal or Medical Use of Radium.—The treatment of so-called medical diseases by radioactive substances must be considered at present in the experimental stage. The indications and contradictions are not as yet clear nor has sufficient time elapsed to judge the real value of the treatment. The best sort of application in special single cases is not known.

Radium may be administered internally as a therapeutic agent by various methods. A soluble salt such as the chloride of radium may be injected into the body or taken by mouth or used for bathing. The *emanation*, the radioactive gas evolved from a solution of radium, is somewhat soluble in water and may thus be used in the same manner as the salt. In the form of gas it may be taken in by the lungs by various devices—in the small personal respirators, with mouth or nose pieces, in cabinets or in bed or in room emanatoria. In some of these, patients remain for hours; the resulting carbon dioxide and water vapor are removed by soda, lime, and sulphuric acid, oxygen is added, and the temperature is controlled by coils as in the calorimeter. The *active deposit* radium A, B, C, when deposited on salt may be administered in a manner similar to the soluble salt above indicated. The dosage of the various forms of radium taken

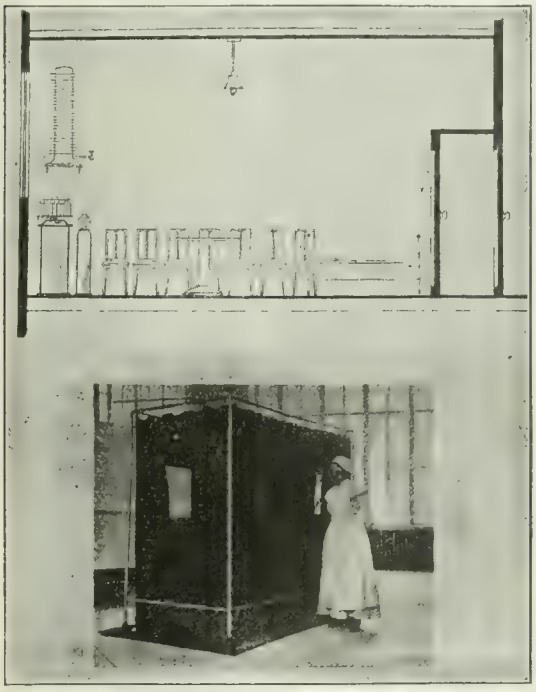

FIG. 4379.—Plan of Emanatorium; room emanatorium above, bed emanatorium below.

internally is, at present, very variable, wide range having been employed by various workers as below indicated.

Radioactive substances are employed in various ways. In the form of packs naturally active material of pitchblende residue or artificially activated material is used. It has also been given in the form of baths in water from naturally radioactive springs or in water to which has been added soluble radium salt or emanation. Indeed, it has been claimed that the beneficial effects of the waters of certain well-known springs are due to the fact that they contain radioactive substances, chiefly emanation. The emanation and soluble salt have been given by mouth and the emanation is also administered by inhalation. In the former case it is believed by von Noorden that there is greater effect upon the liver, as the emanation reaches the heart through the portal veins and leaves the body almost entirely through the lungs within a few hours. In the latter instance he considers that the emanation goes more rapidly into the general circulation. In the radioactive bath of 200 liters the natural radium content varies from 31,000 to 120,000 M.E. (Mache units) or in some instances 450,000 M.E.*

When water is artificially activated, similar amounts have been used. When radium emanation is used for drinking 1,000 M.E. a day up to 10,000 or in certain instances 90,000 M.E. a day have been given by the

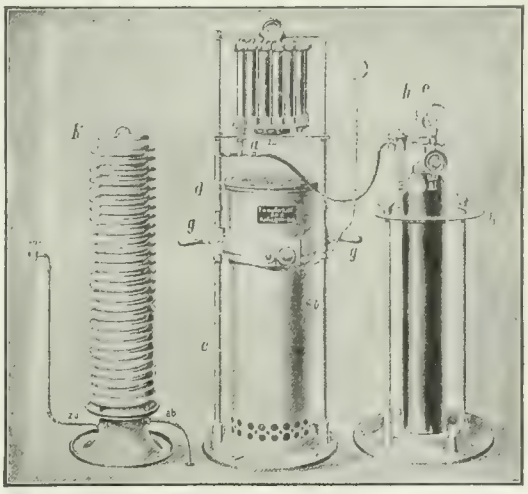

FIG. 4380.—Apparatus for Supplying Emanation to Emanatorium, Removing Carbon Dioxide and Water Vapor, and Cooling the Air and Supplying Oxygen.

German school. They usually begin with doses of 330 M.E. three times a day and for further treatment proceed to 5,000 or 10,000 M.E. three times a day and in individual cases 30,000 to 90,000 M.E. a day. The Radium Institute in London, during the year 1914, recommended the drinking of at least one quarter of a liter of water activated by emanation containing at least one millicurie per liter (a millicurie being equivalent, according to the physicist at this Institute, to 2,160,000 M.E.). This would make the dosage vary from 540,000 to 1,080,000 M.E. daily. It is believed at the Radium Institute that at least six weeks' treatment is necessary before benefit is noticed.

When a solution of the soluble salt of radium is used for drinking or by subcutaneous injection the dosage given has varied from 50 to 250 micrograms. The above indicates the very great variations in the dosage which have been employed by different observers. Similar variation is seen in the case of emanatorium treatment in which some recommend per liter of air two to four M.E., others begin with the same dose and increase to 22 M.E. and gradually to 45, in special cases to 110, eventually to 220, 440, or even 660 M.E. Recently von Noorden and Falta have given 1,200 M.E. per liter. Coutard recommends emanation from two to four milligrams of bromide of radium (without accumulation) in a room of ten cubic meters. He has the patient remain in this room for one and one-half hours. Various devices are now on the market for furnishing water containing emanation. The dose is, in many instances, small and it is important that the products of apparatus used in conjunction with radium therapy should be carefully analyzed by a competent physicist for the true radium content. A portable radium emanation activator devised by Prof. Lazarus and Dr. Saubermann has been used extensively on the con-

* One-thousandth of a milligram (a microgram) of radium solution in equilibrium is equivalent to 2,700 M.E. of emanation.

tinent, particularly in Germany and Austria, and to a lesser extent in this country.

Physiological Action of Emanation.—It has been claimed that emanation in many patients increases the gaseous exchange and the respiratory quotient. In Basedow's disease although the basal exchange is above normal it may be still further increased by emanation. Emanation is thought by some to increase sugar metabolism as well as that of albumin and purins. The uric acid output is particularly increased by emanation in cases of gout. The influence of emanation on the blood picture may be striking; at first there may be hyperleucocytosis and later a diminution in white cells. There is a relative increase in mononuclear cells. It is also claimed that in certain instances emanation acts as a diuretic, and it has been said to exert a stimulating influence on the sexual glands, particularly in cases of acquired impotency or in tabetics or in senility. Cases are cited of the return of menstruation after the menopause and also in certain instances of amenorrhea. It has also been asserted that radioactive matter modifies the phenomena of inflammation and stimulates the action of the various ferments—such as the pancreatic, peptic, and lactic acid and the autolytic ferments in the tissues.

Attention has been called to such symptoms as dizziness, pressure in the head, weakness, albuminuria, and hemorrhages following large doses and experimentally it has been found that serious complication may result in animals. With large doses also there may be marked changes in the metabolism and in the blood picture. It is, therefore, advisable to begin with small doses.

Therapeutic Results of Radioactive Substances. —*Arthritis Deformans* (Primary Chronic Articular Rheumatism).—The types with exudation are more favorable than the dry forms. His has reported cases with striking improvement bordering on cure with return of motion and great improvement in general condition. At the Radium Institute in London, Pinch reports extremely favorable results; sometimes as he said, the results are remarkable. At this Institute 250 c.c. of emanation solution of a strength not less than one millicurie per liter up to two millicuries per liter are given to patients suffering from this obstinate, painful, and crippling disease. Pinch says that it is difficult to predict with certainty the degree of improvement likely to occur in any particular case but that the cases which appear to derive most benefit are those in which the disease is of relatively short duration and the changes are periarticular in type and multiarticular in distribution. The age of the patient also exerts some influence, those under forty responding more quickly to the action of emanation. Little or no improvement can be looked for in instances when cartilaginous or osseous changes are predominant. When limitation is due to periarticular fibrous thickening, considerable increase of mobility often follows and enables patients to perform actions such as feeding themselves, brushing their hair, shaving, etc., which they may have been powerless to do for some months or even years. Muscular and articular pains are lessened or disappear, grating of the joints on movement is not so marked, muscles may regain much of their lost tone, and the patient's general health may be much improved. The treatment must, however, be persisted in quite a long time, at least six weeks, before any change is noted. It is suggested by Pinch that the action appears to be multiple and highly complex but the reinforcing of body ferments, the increase of tissue oxidation and the dissolving of uric acid are probably factors which contribute to its success. McCrudden believes that the creatinin metabolism may be influenced by radium emanation water. Dominici, in 1908, reported marked benefit in treating cases of "rheumatisme blennorrhagique" by surface applications of radium.

Acute Articular Rheumatism.—In the majority of cases treated by von Noorden it is claimed that emanatorium treatment acts as well as salicylates, the local symptoms subsiding in a few days. Salicylates were used in conjunction with emanation, however, in certain cases. The treatment was from two hours to over night and the doses 220 to 1,200 M.E. von Noorden and Falta believe emanation is specially valuable in cases which do not stand salicylates well.

Chronic Arthritis.—In arthritis secondary to acute general infections or from a focus in the tonsil, teeth, etc., results are doubtful.

Gonorrheal Arthritis.—The results are not favorable although occasionally improvement is obtained on injecting solutions of soluble radium salt in the vicinity of the joints.

Tuberculosis of Joints.—Results are not favorable.

Gout.—His reports a large series of cases of gout treated by emanation; the uric acid content of the blood is greatly lessened although there is not a complete parallel in the blood content and the clinical changes. Some cases show improvement in the general condition, subsidence of joint swelling without marked diminution of uric acid in the blood. Other cases with gouty nodes even in periods of the most frequent attacks showed no abnormal amount of uric acid in the blood. Many cases under treatment by radium emanation show disappearance of the tophi in the ear. Gudzent reported 100 cases of gout, in some of which he secured still further improvement by injection of a dilute solution of radium salt. In the beginning of treatment there may be temporarily an increase in pain as the result of reaction. Emanation may be used both by drinking and by inhalation. Radium should not replace treatment by diet and other common aids in the treatment of gout.

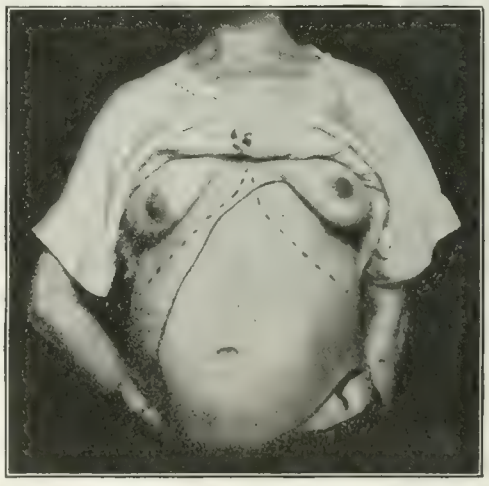

Fig. 4381.—Myelogenous Leukemia; indicating the bony landmarks, outlining the enormously enlarged spleen, and showing the emaciation of the patient. (See also Fig. 4394.)

Leukemia.—von Noorden and Falta did not obtain any favorable results by emanatorium treatment in leukemia but only produced an increase in the blood count. The writer, however, by surface applications of radium over the enlarged spleen has in a series of cases observed a most remarkable improvement and striking changes in the size of the spleen, the blood picture, and the general condition of the patient. In the course of a few weeks or in stubborn cases in three or four months after

treatment by the surface application of radium, according to the method described in this article (see Deep Therapy), a spleen which filled almost the entire abdomen extended well to the right of the median line and into the pelvis and caused marked pressure symptoms, has been reduced to normal dimensions so that it was not palpable below the costal margin. Blood with white counts of from 500,000 to 700,000 became 6,000 to 8,000. The immature forms are

Fig. 4382.—Same Patient Pictured in Fig. 4381 showing Reduction in the Size of the Spleen, and the Improvement in the General Nutrition after Two Series of Radium Treatments.

especially affected. The hemoglobin increased from 40 to 70 or even to 80 or 90 per cent. The red blood corpuscles increased from 2,000,000 and 2,500,000 to 4,000,000 and 5,000,000, indeed, the blood picture often returned to normal. A pale, emaciated, anxious individual with prominent bony framework, stooping shoulders and enormously enlarged abdomen usually loses the anxious expression, becomes plump, the abdomen returns to normal size, the color and

Fig. 4383.—Same Patient Pictured in Figs. 4381 and 4382, showing the marked Improvement in the General Nutrition and the Reduction in Size of the Spleen to Normal Limits.

strength improves so that the patient may feel entirely well. The pathological condition, however, sooner or later is apt to relapse gradually and the response is less prompt in subsequent series of radium treatments, although cases have now been followed for over two years and have been kept in good condition by occasionally repeating the radium treatment. A few cases, however, have died of intercurrent infections or have succumbed to the original disease. Although these results in the radium treatment of leukemia are most striking in the chronic myelogenous variety, in certain cases of lymphatic leukemia results are almost equally good. It must be understood, however, that the results should be

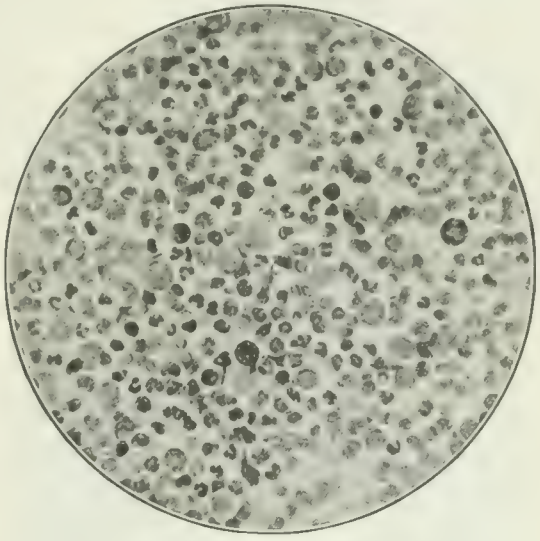

Fig. 4384.—A Blood Smear from the Patient Taken at the Time of the Photograph (Fig. 4381). White count, 500,000; enormous numbers of myelocytes and myeloblasts are shown.

regarded at the present time merely in the light of palliation and not as a cure. It is hoped, however, that future research will at least increase the duration of these remissions. It is suggested that the spleen be removed during the period of most marked improvement. It is probable that this may be done in

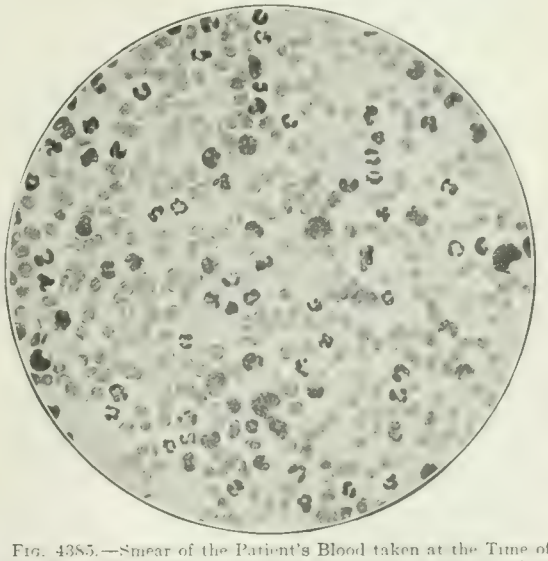

Fig. 4385.—Smear of the Patient's Blood taken at the Time of Photograph (Fig. 4382). Marked diminution in number of white cells, increased relative number of polymorphonuclear leucocytes, and diminution in myelocytes; white count 74,000.

a case now under observation. Although the treatment must not be considered at the present time as curative, from the results obtained it is the best form of treatment now at our disposal. Many of the cases which respond promptly to radium applications

over the spleen had previously proved entirely refractory to prolonged *x*-ray and to benzol treatment.

Results similar to these have been reported by various observers with the *x*-ray when used by similar methods over the spleen. In the majority of cases, however, the long bones have also been rayed. It is to be noted, however, that in the surface applications of radium above described the results were obtained without radiating the long bones, in fact, in one instance in which the long bones were radiated there was, apparently, an increase rather than a diminution in the white cells. It is also believed that the results are more prompt by the radium treatment than by *x*-ray as hitherto employed and no case has been accompanied by toxic symptoms although there

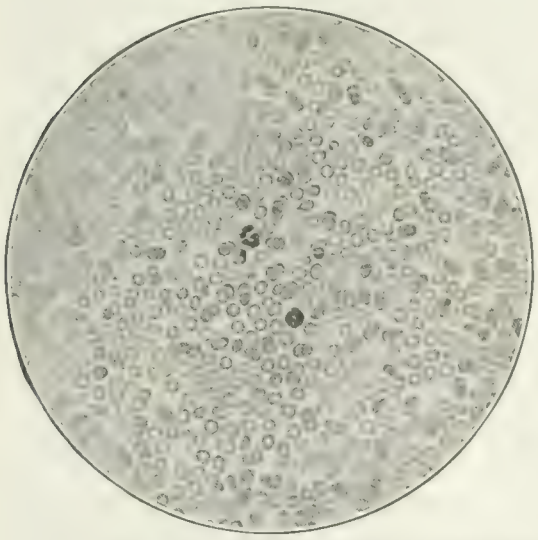

Fig. 4386.—Smear of Patient's Blood Taken at the Time of Photograph (Fig. 4383). The myelocytes have entirely disappeared; white count 5,800; some variation in size and shape of red cells persists.

is a marked increase in the endogenous purin metabolism. On a purin-free diet uric acid, urea and total nitrogen in the urine is markedly increased. It is very probable, however, that with the recent development of the *x*-ray tube by Coolidge and the resulting accurate standardization of the dosage with increase in intensity and penetrating power that results fully as good as those obtained by radium will be secured.

Miscellaneous Conditions.—In a few cases of croupous *pneumonia* it is claimed that the temperature began to fall earlier than usual and by lysis and that the dissolution of the exudate was strikingly rapid. The symptoms, such as difficulty in breathing, were markedly relieved in the emanatorium in which 100 M.E. of emanation per liter was used. In certain instances the patients remained in the emanatorium over night. In *diabetes mellitus* the effect upon the sugar metabolism is not constant but the emanation therapy is said to affect favorably diabetic neuritis. In certain cases of *neuralgia*, neuritis, and sciatica it has been claimed that the condition has been benefited. Claims have also been made for favorable therapeutic effects in the case of *arteriosclerosis*, certain kidney diseases and even in tabes dorsalis, in the latter instance more particularly in relieving the so-called lightning pains. In some cases of *syphilis* in which a positive Wassermann persisted in spite of active and prolonged treatment intravenous injection of from fifty to 250 micrograms of radium chloride solution at intervals of a few days and later once a week resulted in the reaction becoming negative in certain instances. It would seem, however, that there has been much exaggeration of the value of radium in many of these chronic conditions.

Treatment of Leukemia with Thorium X.—Although Falta did not report success in treating leukemia in the emanatorium he has treated cases with thorium X with good results. Thorium becomes transformed into mesothorium the half life period of which is five and one-half years. Mesothorium has been used in the solid form in containers in the same way that radium is used for surface applications and the results obtained are identical. Mesothorium becomes transformed into radiothorium, half the life period of which is two years, and this becomes transformed into thorium X half the activity of which is lost in 3.7 days. Thorium X gives off strong emanation similar to that given off by radium but its life is very short, being only fifty-four seconds. Its active destructive products are thorium A, B, C, D, and from the latter gamma rays are derived. Falta used a solution of thorium X either by mouth or injected subcutaneously or intravenously in saline solution. By mouth the results were less constant and less intense and he occasionally got disturbances when using 300,000 M.E. In animals Falta was able to obtain complete disappearance of leucocytes and found the fatal doses for rabbits to be 0.6 to 1 million M.E. For the treatment of leukemia 15,000 to 800,000 M.E. were injected subcutaneously and intramuscularly. There is, usually, redness and swelling at the site of injection but this disappears after a few days. In most cases of myelogenous or lymphatic leukemia the leucocytes fell to normal within a few weeks. The immature forms are especially affected and in all instances the spleen became small or disappeared. In one instance in which there were retinal changes these disappeared. The body weight was not reduced in spite of the great reduction of the pathological tissue. There was increase in the red blood corpuscles and marked improvement in the subjective findings. von Noorden and Falta regard the treatment, however, as only experimental. It is not known how long the results will last. In certain instances favorable results were obtained in cases refractory to *x*-ray. In general, however, thorium treatment seemed of value in those cases in which the *x*-ray is useful.

With small doses, that is, from 212 M.E., of thorium X an increase of red blood corpuscles was obtained with lymphosarcoma and pernicious anemia, in the latter remissions seem to have been induced in certain instances by use of thorium.

Lymph Gland Enlargement.—By similar dosage of thorium X subcutaneously and into the enlarged glands Falta, Kriser and Zehner have treated several cases of glands enlarged by tumors, tuberculosis, and other infectious granulomata. They report reduction in size of glands. Such results are, however, usually temporary but not curative.

The indications for the internal use of radium are vague and also the contraindications. Cases with severe endocarditis, pericarditis, delirium cordis, severe neurasthenia, and hysteria, especially in the menopause are given by von Noorden as contraindications to the use of radium internally. The value of the medical uses of radium has been greatly exaggerated and reports are confusing. The great variations in dosage add to this. There seems no question, however, that benefit has been derived in certain forms of gout and chronic rheumatism and neuritis. The effect upon the hematopoietic tissues either stimulative or destructive must, however, be borne in mind. Improvement has also been reported in cases of pernicious anemia, leukemia, erythrocythemia and in hypertension, in the latter the blood pressure has been reduced to normal and the subjective symptoms are said to have disappeared.

Internal therapy by radioactive substances is still too recent to express a very decisive opinion regarding its value. The duration of favorable results reported is not known in most instances. There is need of more control cases and particularly of a large number of cases worked up in detail and followed to end results before certain conclusions may be drawn.

External or Surgical Use of Radium and the Roentgen Ray.—The value of the external or surgical use of radium is much more definitely known than its medicinal use. Even the most conservative and careful clinicians who have had any extended personal experience with adequate amounts of radium or with the *x*-ray recognize their value and limitations when used externally. In a large proportion of the cases surgery is undoubtedly preferable and radiations, if employed at all, should be used not to replace but in many instances to supplement surgical procedures. We believe that many of the over enthusiastic claims, and even the exploitation, leading to much misunderstanding and confusion in the profession and among the laity have been due to the fact that the exceptional cases in which there has been great relief or even cure have been reported as if they were the rule. In describing the limitations of radiotherapy the fact must be taken into account that there are from time to time very exceptional cases particularly of malignant tumors some of which have repeatedly recurred after numerous operations, and also cases that have been entirely inoperable which have apparently yielded to radiotherapy. While the ignorant or the over enthusiastic physician has described these cases as if they were the rule yet it is by studying them most carefully and becoming acquainted with as many of the factors involved as possible that we may hope that these now exceptional and unusual cases may become more and more frequent. It is thus also that we may expect truly to advance the progress in radiotherapy. In describing conditions in which radiotherapy has been used it is difficult to follow a systematic or logical arrangement either from the point of view of pathology, etiology, or anatomy. Therefore, both anatomical and pathological arrangement will be made use of.

Methods.—It is almost impossible to give detailed rules for the application of radiations. Each source of energy for therapeutic uses, either Roentgen rays or radioactive substances, should be not only physically but physiologically standardized under the exact conditions in which it is to be employed. Such conditions include voltage, amperage, duration of exposure, amount of radioactive element, filtration, distance and individual variation of the subject of the experiment. Physical or chemical standardization for clinical purposes may be accomplished by the use of the Sabouraud pastille or its modifications, by the Kienboeck photographic scale or by the use of the ionization chambers of Duane or iontometer of Klinglfuss and Szilard. The pastilles have the advantage that the changes may be watched during the treatment but by the latter more accurate estimates are available. The great variation in the reaction of different tumors to the *x*-rays has been pointed out by Werner, who has shown that the "labilsten" growth may disappear after a deep dose of 1X to 2X, but that the radiostable tumor may resist even 25X to 30X (Kienboeck). Chilarditi says that epilation and a faint visible reaction of the first grade may be constantly induced with the dose of fifteen Holzknecht units when for filtration three millimeters of aluminum and five millimeters of leather are used. In practice, however, it has been found of the utmost importance to use the method of "physiological standardization" not only for becoming familiar with the various changes produced in animals, but in the tissues of man subjected to radiations. For example, in order to apply radium or *x*-ray intelligently for therapeutic purposes it is necessary to establish a so-called "erythema dose," that is, to determine the tolerance of the skin to the various radiations under the conditions employed.

The degree of the acute reaction following the exposure to *x*-rays is very variable depending upon several factors, namely, the intensity and quality of the radiation, the duration of the exposure, the part of the body exposed, and the individual sensitiveness or tolerance. The intensity and quality of the rays depends on the amperage, voltage, the distance from the tube and the filtration and protection. Gocht claims that there is no special idiosyncrasy to the *x*-ray as was at one time believed. The effects depend on the quality of rays absorbed by the tissue. With radioactive substances it depends also upon the quantity and quality of the radioactive substances. As the therapeutic indications and effects of the *x*-rays and radioactive substances are almost identical when employed by similar methods, these will, with certain exceptions, be considered together after briefly outlining certain technical procedures.

X-ray.—In the past various methods of production of *x*-rays have been used. Some still employ coils with the ordinary or water cooled *x*-ray tubes and obtain excellent results and others use transformers of various designs. It seems probable, however, that the new Coolidge tube will eventually replace all other methods for production of *x*-ray for therapeutic purposes. This is because this tube is the most constant source of *x*-ray. The amperage and voltage can be varied at will and it is for the first time possible to measure accurately and so duplicate conditions and allow the technique of one operator to be repeated by another. Thus in the future it is hoped that much of the mystery which has surrounded *x*-ray therapy will disappear and that there will be less multiplicity of detail in the individual operator's technique, in short, that it will no longer remain difficult to describe and to duplicate the exact conditions employed. The more recent developments of the Coolidge tube will permit the *x*-ray to approach the gamma rays of radium in penetrating power and to be of such volume as would be yielded by the most costly, even prohibitive, amount of radium element. In describing the therapeutic application of *x*-rays we shall refer merely to the use of the Coolidge tube for reasons above mentioned. In *x*-ray therapy it is the general rule always to employ a filter of at least one millimeter of aluminum when any effect is desired on pathological processes below the skin or, indeed, in all instances except those most superficial lesions in which the skin is ulcerated. When a deep effect is desired three millimeters of aluminum and in certain instances even more as a filter should be employed and certain radiotherapists use a heavy piece of sole leather in addition to protect the skin against the action of the less penetrating rays. With a tube distance of ten inches and one millimeter aluminum for filtration and a voltage of eighty kilovolts, a current of five milliamperes, exposure of seven or eight minutes may be used without producing erythema, whereas ten minutes under similar conditions may produce erythema.

Pfahler for "deep therapy" uses Coolidge tube excited by five milliamperes of continuous transformer current with a resistance of nine inch parallel spark with a focal point eight inches from the skin run for five minutes and the rays filtered through three millimeters of aluminum and one layer of sole leather. This gives approximately 20X or will double the tint B on a Sabouraud pastille placed half distance. Thus a double skin dose of filtered rays actually passes through each area of the skin. In treating cancer cases Pfahler gives a second series in two weeks, a third series three weeks later and a

fourth series four weeks later. If the growth is less rapid he repeats the treatment every three weeks or if the skin reaction is marked, at four week intervals. If the disease is of a fatal type he carries out the treatment in spite of erythema. Pfahler defines a dose as "all the skin can stand without producing dermatitis. With unfiltered rays this means tint B of the Sabouraud pastille scale or 10X of the Kienboeck scale or 5H of the Holzknecht scale." A dose can be markedly increased when filtered rays are used. This really means that five times the amount of rays reach the deeper tissues.

The patient's body other than the lesion to be treated must be protected from the effects of the *x*-ray by efficient tube holders, screens and diaphragms, and suitably arranged operating levers and dials. The dangerous results following the unguarded exposure of the operator or patient have been emphasized in the preceding paragraphs where attention has been called to a special article on this subject. Other technical details such as "cross-fire" will be referred to later.

Radium.—The strength of radium depends upon the amount of radium element present. Therefore, in reporting cases the dosage should be accurately stated in milligrams of radium or millicuries of radium emanation, per hour, per unit area. A millicurie is the quantity of emanation that furnishes the same penetrating radiation that one milligram of radium element produces. The dose employed in the so-called surgical or external use of radium usually varies from five to sixty milligrams, or even seventy-five or 100 milligrams. Burnham states that

Fig. 4387.—Apparatus Found Convenient in Routine Treatment by Radium Emanation.

Kelly now has one and one-fourth grams of radium element and in certain instances the entire amount has been used on one patient for forty-eight hours. The smaller doses are employed chiefly in superficial skin lesions, the larger for large growths or masses or for lesions deeply situated. The emanation or radioactive gas evolved from a solution of radium loses half of its activity in 3.86 days or at the rate of approximately one-sixth a day. The solution of radium, however, is replacing this loss at the same rate so that there is no real diminution in the amount available, and applicators can be thus frequently strengthened or renewed.

Applicators found useful in practical routine work are shown in Figs. 4387 and 4390. Tubes and surface applicators are used on patients according to the following general rules to which, however, there are many exceptions. These rules indicate only single applications and can give no idea of the number or of the time elapsing between them. The number of applications varies greatly with the variety and size of the lesion and the intervals are in most instances from three to six weeks, although in certain cases applications are made every day or two for a week and then if necessary repeated at the regular three to six weeks interval. Small superficial lesions may require only a single

Fig. 4388.—Various Modes of Application of Radium. *a*, Application of radium to carcinoma of larynx through tracheotomy opening; *b*, small tube (needle) of radium emanation inserted into a papilloma of the tongue. *c*, radium applied to persistent area of rodent ulcer; portions previously healed are protected by rubber-coated lead; *d*, application to sarcoma of the frontal sinus; *e*, shield and protection for treatment of verruca of nose; *f*, radium applied to senile keratosis in temple region; *g*, tube of emanation applied to small rodent ulcer with elevated edges.

application of half hour or one hour's duration. The time of application depends not only on the strength of the applicators as above indicated but also on the size and nature of the lesion, the area to be covered and the sensitiveness of the patient's skin. Certain technical details of application are illustrated in the accompanying photographs.

General Rules for the Application of Radium when Twenty-five to Sixty Milligrams of Radium Element or Its Equivalent of Emanation are Used.—**1. For Effects upon Pathological Processes beneath the Skin when the Latter is Intact.**—Surface application—screen-

ing, two to three millimeters of lead; protection, gauze, paper and rubber; exposure, four to eight hours or less.

2. *For Superficial Skin Lesions.*—Such as keratoses, small growths, etc. Screening, none or 0.1 to 0.5 millimeters of lead; protection, rubber over the lesion and adjacent normal skin carefully protected by shield of one to two millimeters of lead, gauze and rubber. Exposure, ten minutes to two hours.

3. *For Deep Skin Lesions with Ulceration.*—A. Screening, none, except rubber; protection of adjacent

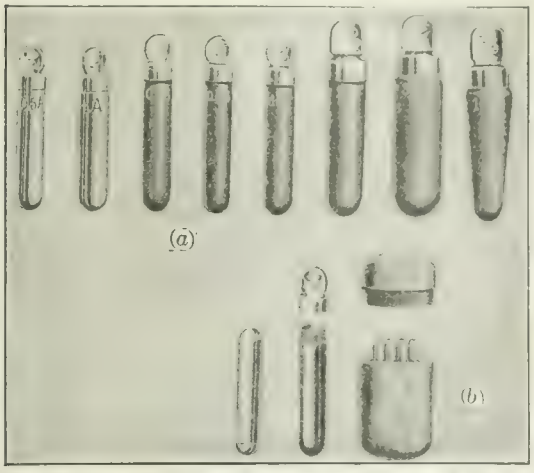

Fig. 4389.—(*a*) Tubes of Aluminum and Lead for Application of Radium. (*b*) Containers of Aluminum and Lead for Radium used in the so-called Universal Apparatus, Fig. 4390.

tissue as in No. 2. Exposure, two to four hours. B. If lesion is still deeper; screening, one to three millimeters of lead and rubber. Exposure, four to twelve hours.

4. *Lesions of Mucous Membranes when Superficial.*—Same as No. 2 except exposure of one to two hours.

5. *Lesions of Mucous Membranes when Deep and Growths Beneath the Mucous Membrane.*—Same as No. 3 except exposure twelve to twenty-four and forty-eight hours duration and in exceptional instances somewhat longer.

Fig. 4390.—The Universal Apparatus for radium Application.

6. *For Introduction of Radium within Growths.*—A. For deep effect tubes with screening of one-half to one millimeter of silver or platinum. Exposure, four to forty-eight hours depending upon size and nature of tumor. Average twelve to twenty-four hours. B. For local destructive effect unfiltered tubes, one to two hours up to twelve hours, length of time depending upon size of growth and reaction desired.

For deep effects when two to three millimeters of lead are used for filtration the skin, if intact, is protected from the action of the secondary, less penetrating rays by fifteen to twenty layers of gauze or paper. In practice all radium applicators are wrapped in a thin sheet of rubber to prevent soiling, the rubber containers being changed with each patient. In order to fasten the radium in place and to secure exact apposition which is so necessary for successful results, double coated adhesive plaster such as is used in the Wickham and Degrais clinic in Paris has recently been advocated by Tousey and is of great technical aid in radiotherapy.

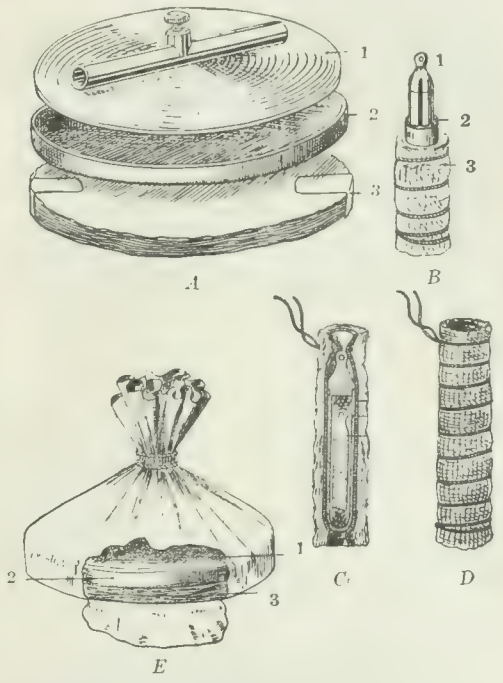

Fig. 4391.—Indicating Methods of Protecting against Secondary Radiations. *A*, a round surface applicator; 1, disk evenly covered with radium held in place by special varnish; 2, filter; 3, numerous layers of filter paper. *B*, shows glass tube containing radium; 1, tube with radium; 2, screen of lead or aluminum; 3, gauze wrapping. *C*, sectional view of apparatus *B*. *D*, surface view of same. *E*, the same apparatus as *A* protected by rubber sheeting; the gauze and filter paper are to protect from the secondary rays; the rubber covering is also used for the purpose of cleanliness. (From Dominici.)

Protection.—In treating superficial lesions, particularly small lesions of the skin, by *x*-ray or radium it is necessary to use a sheet or mask of lead one-half to one millimeter in thickness with gauze or paper beneath it or coated with rubber and cut a hole in this shield the size or in the case of radium slightly smaller than the lesion to be treated. A harness or card punch is more convenient than a knife for cutting the opening in the sheet lead. Through the opening the lesion may now be exposed to *x*-ray or radium and the adjacent healthy skin protected. Williams has used gauze masks from theatrical supply stores covered with tinfoil.

Cross-Fire.—The principle of the so-called "cross-fire" is important for successful application of radium or *x*-ray to large growths or to deeply seated lesions. The method was first described by Dominici and has since been elaborated by others, notably in the treatment of uterine fibroids by *x*-rays in the Freiburg clinic by Kroenig and Gauss. The aim is to concentrate as much of the action of the rays as possible in the deep-seated lesion with the least possible injury to the overlying skin. This may be accomplished by employing small tubes of radium scattered through-

out the tumor mass or by surface applications of heavily screened radium or *x*-ray to a large number of areas on the skin so that each area will not be exposed too long or too intensely which would be the result in applying the radium to a single area for the time necessary to produce the desired result on the underlying lesion. By this cross-fire method enormous doses, even 1,000 to 1,500 Kienboeck units may be applied to the deep lesion when not more than 20X could be safely put through one particular surface area. Pfahler uses from four to forty surface areas, a full dose through each, making a total of from eighty to 800X units.

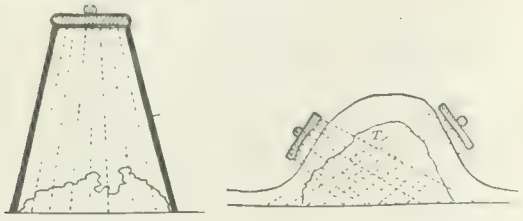

FIG. 4392.—*A* Shows Radium Applicator Raying the Tumor *B* indicates the increased effect upon growth *T* by means of cross fire.

Deep Therapy.—Cross-fire as above described in order to be successful on deep-seated lesions beneath the skin requires strong filtration of the rays. The technique of the so-called deep therapy which should be used when the greatest effect is desired on deep-lying disease processes may be illustrated by the striking result of radium when applied in the proper manner to the surface over the enlarged spleen in cases of myelogenous leukemia. For this the following details have been elaborated. The area of the enlarged spleen is carefully and plainly marked out with a red skin pencil or grease paint, the outline being indicated by percussion and palpation. Then

FIG. 4393.—Angioma of Lip, illustrating treatment by cross fire method (From Wickham & Degrais.)

the various landmarks such as the costal margins, anterior superior spine of the ilium, the symphysis pubis and the umbilicus are marked with black. The patient is photographed with isochromatic plates in an erect position in both frontal and lateral views. A series of small squares about three centimeters in diameter, when the radium applicator is two centimeters in diameter, are marked over the area of enlarged spleen. It is important not to have the successive application areas too near together or the skin between will be burned by the double dose. The squares are numbered serially. Tracings are now made on tracing cloth which serves as a chart for guidance in following the series of treatments. A swathe of thin cotton is carefully fitted to the abdomen and the outline of the enlarged spleen, bony landmarks and small squares is traced upon it. This

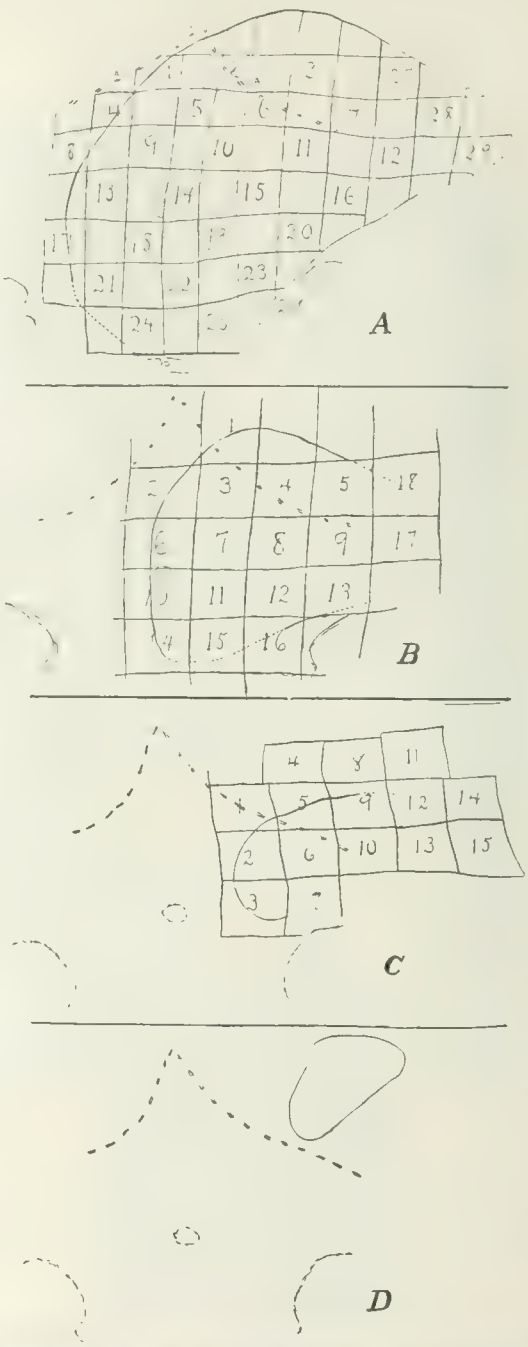

FIG. 4394.—Chart of Abdomen in the case of Myelogenous Leukemia shown in Fig. 4381, indicating the method of charting used in deep therapy. *A*, at the beginning of treatment; *B*, after the first series of radium treatments; *C*, indicating third series of radium treatments at the time of Fig. 4382; *D*, after three series of radium treatments made at the time of Fig. 4383.

swathe is left in place during the single series of treatments. The purpose of the swathe is to avoid the irritation of repeatedly applying and removing the adhesive plaster which holds the radium applicator

in place. It has been found that the area which is being or has been radiated is particularly sensitive to injury from the repeated application and removing of adhesive plaster. The added irritation may induce vesiculation or even superficial ulceration of the skin.

The general method of charting will be seen in the accompanying illustration (Fig. 4394). With the chart as a guide, the radium applicator, screened with two to three millimeters of lead and fifteen to twenty thicknesses of filter paper and wrapped in gauze is now applied to the squares in the order indicated. It is necessary also to add at least as much filtration and protection to the external side of the applicator for the patient may inadvertently rest the arm or leg on the applicator during sleep. In the second series of treatments which is usually necessary in three to six weeks, applicators are similarly applied A new swathe and tracing should be made at each series. The duration of the application in each area with fifty to sixty milligrams of radium is four to six hours. An amount of radium as small as 25 milligrams has reduced a greatly enlarged spleen to normal size and caused the characteristic improvement in the blood and general condition of the patient, but the time required is much longer and the applications must be more numerous.

The importance of the distance of the radium from the skin is well shown in the illustration of Burnham. He compares a tube one millimeter away from the skin and applied for one minute with the same tube one inch away, that is, twenty-five millimeters, which would require twenty-five times twenty-five or 625 minutes to produce the same effect. By increasing the distance, however, the difference in intensity becomes less for parts below the surface of the skin but it would be necessary to greatly increase the duration of application as above indicated or the amount of radium if radiation at a distance were employed for filtration.

For deep therapy in the natural orifices and cavities of the body radium applicators are protected by rubber covering in order to prevent the more local effect of the secondary rays as well as for keeping the applicators clean. In carcinoma of the uterus lead or silver tubes two millimeters in thickness containing radium salt or emanation, sixty to 100 milligrams or millicuries, are accurately applied and held in position by careful packing and by binders. The time of exposure is twelve to forty-eight hours or in some cases even longer. Such treatment may be applied at one sitting or intermittently within a few days. There should then be an interval of from three to four weeks during which the patient should be observed and the radiated area cared for by surgical cleanliness. Werner has injected borocholin intravenously repeatedly during the interval in the belief that the action of the *x*-rays was intensified. This has not, however, been confirmed by other workers.

With the use of more powerful Roentgen apparatus which is now being elaborated physiological standardization is deemed of utmost importance in order that the best results may be obtained and the danger to patients obviated.

In the therapeutic use of the *x*-ray the portions of the body which are not to be treated, particularly near the region to be exposed, should be carefully protected by sheets of lead at least one millimeter in thickness faced with rubber or gauze. The tubes should be encased in lead-lined boxes or special lead glass holders, and specula used for protecting the walls of natural cavities during treatment.

Therapeutic Results of the External Use of the X-ray and Radioactive Substances.—*Diseases of the Skin.*—In the field of dermatology radiotherapy has been most extensively used and is a most important therapeutic agent.

Rodent ulcers are most amenable to radiotherapy particularly the more superficial forms which have less induration and do not involve bone or cartilage. Results of radium are much better in cases which have not been previously subjected to ineffectual and misapplied doses of *x*-ray or to caustics, solid carbon dioxide, ionization, etc. Extensive rodent ulcers, involving bone and cartilage, with hard brawny edges are very intractable to radiotherapy but in a few instances in which large doses have been used and particularly when combined with very careful cleansing and dressing of the area and by allowing a sufficiently long interval to elapse between the intensive treatments the results of a few years ago have been

Fig. 4395.—Superficial Rodent Ulcer of the Face before and after Radium Treatment.

greatly improved. In some cases extensive operation, even when the entire process cannot be removed, is of value when the operative wound is left open, sometimes for many months, as advocated by Greenough, so that the first sign of recurrence may be observed and radiated. If skin flaps or other form of operation is attempted to close the wound deep recurrences are thus obscured and cannot be treated in time. The superficial lesions treated by radium require from one-half to a few hours exposure, while the deep lesions require twelve or eighteen hours or more. When the ulcers affect mucous membranes the results are less favorable.

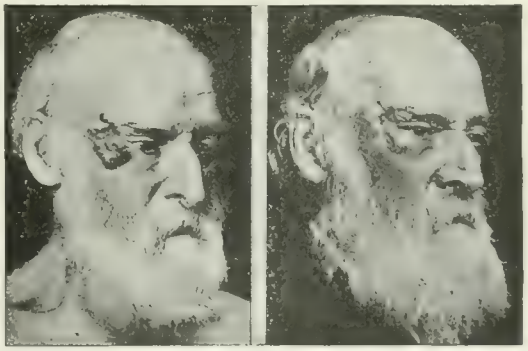

Fig. 4396.—So-called Basal Cell Carcinoma, before and after radium treatment.

When *x*-ray is employed it is advisable to give a dose sufficient to produce marked erythema and wait for some time (two or three weeks) before repeating the treatment. It is important that the effects of one series of treatments may be finished before further treatment is given, otherwise an *x*-ray ulcer may be ingrafted upon the original rodent ulcer. This is particularly apt to occur unless the operator has had experience in treating very resistant rodent ulcers and when intensive radiotherapy is necessary.

Epithelioma.—In small epitheliomata of the skin the results of radiotherapy are curative. In the fleshy (basal cell) type of carcinoma, called by the

French "carcinome bourgeonnant," the results are remarkable. Large growths "melt away" under the influence of radiations. The treatment is facilitated by careful and frequent cleansing of the lesion between the series of treatments. In the epidermoid type of carcinoma which tends to metastasize early surgery is indicated if the condition is still operable.

Epidermoid Carcinoma.—As these growths are apt to metastasize early it is unwise to attempt their treatment by radiation. There should be prompt and complete excision unless the location or stage of the disease contraindicates. In cases which are inoperable because of their extent or in those which have recurred after operation the results are rarely, if ever, curative although occasionally radiation may be of palliative value.

Roentgen ray lesions of the *skin* such as fissures, keratoses and early epithelioma are cured or greatly benefited by the application of radium. Deeper lesions, however, demand excision or amputation.

Papilloma, Verruca, and Keratoses.—When keratoses are present the results are much more rapid if the heaped up horny material is removed by salicylic acid ten to twenty per cent. in flexible collodion. The acid is thus held circumscribed and may be left in place for twenty-four hours. On removing the collodion the remaining papilloma or verruca usually responds quickly to radiotherapy in one or two treatments. Aikins recommends the application of trichloracetic acid either as pure crystals or in concentrated solution. This should be applied with some pressure by a probe, match point or glass rod. The lesion should be first wiped thoroughly dry, alcohol or ether being used. The normal skin around may be protected by vaseline. When the patient complains of stinging pain the solution of acid is rubbed off and the area treated with water until the burning has ceased.

Keloid.—In certain instances excellent results are obtained in keloids following wounds, operative or otherwise, or as the result of burns. The anesthetic effect in painful keloids may be marked. Treatment should not be too intense and must be continued over a considerable period, usually for months.

FIG. 4387.—Keloid. *a*, before radium treatment; *b*, after radium treatment of left half. Right was not exposed to radium for control. (From Wickham and Degrais.)

Lupus Vulgaris.—The results in some deep-seated cases treated by *x*-ray and radium are good. Very short exposures are employed and great care is necessary. Finsen light, however, is undoubtedly best for the routine treatment of lupus vulgaris.

Lupus Erythematosus.—The results of radiations are variable but occasionally may be satisfactory, particularly in obstinate cases.

Lichen Planus.—Patches of this condition usually yield to radiations in one or two treatments and there may be no recurrence.

Pruritus.—Short unscreened exposures may produce marked relief of itching. The results are particularly good, according to Pinch, if the condition is associated with definite lesions such as leucoplakia or hyperkeratoses, but not so hopeful if the condition is a neurosis.

Angioneurotic Edema.—Cases of this condition are reported in which considerable benefit and even cure resulted from the use of radiation.

Nevi and Angiomata.—The value of radiations in the treatment of nevi is variable. Treatment must usually be prolonged for months in the most careful manner. In superficial nevi more can be expected if blanching of the tissue is accomplished by gentle pressure. The fleshy cavernous nevi in many instances do well under radiation although if pulsating the results are more successful if the blood-vessel is previously ligated. In many cases the treatment must be extended for a long period.

Miscellaneous Diseases of the Skin.—Favorable results of radiation have also been reported in the following conditions: Sycosis, favus, hypertrichosis, alopecia areata, tinea tonsurans, hyperidrosis, seborrhea, roseacea, comedo, psoriasis and chronic eczema.

Bowen, in emphasizing the abuse of the *x*-ray in the treatment of skin diseases, would limit such use to (1) surgically inoperable epitheliomata especially those involving the orbit of the eye, (2) epitheliomata or other malignant neoplasms in cases in which the patient absolutely refuses radical surgical interference, (3) small cutaneous epitheliomata in certain selected cases in which a good cosmetic result is very important, (4) sycosis and obstinate pruritus of local or general character, (5) in a few other dermatoses such as obstinate patches of psoriasis and eczema, in mycosis fungoides and in a few rare affections. He admits, however, that the disadvantages of *x*-ray are chiefly those resulting from its improper use.

Diseases of the Eye and Ear.—Carcinoma of the eyelid, even of the epidermoid variety, usually responds in a remarkable manner to radiations and because of the possibility of exact apposition of radium it is preferable to any other form of treatment. The result of radium therapy is usually curative and the unsightly deformity and secondary conjunctivitis and its possible sequelæ are avoided. The lid remains flexible and smooth and there is practically no loss of tissue except the exact site of the growth.

Opacities of the Cornea.—Improvement has been reported in certain cases of corneal opacity but more experience is necessary before definite conclusions can be drawn.

Carcinoma or keratosis of the ear, if involving the cartilage, may prove very resistant to radium treatment and they may also be very painful. The results are variable depending upon the size and extent of the growth. In *tuberculosis* of the *ear* improvement is usual although the condition is obstinate. It has been claimed that small doses of radium have caused marked improvement in cases of *otosclerosis*, that the hearing and also such symptoms as tinnitus have improved. Other than the improvement that may follow from the encouragement that something is being done we have seen no such favorable results.

Diseases of Mouth, Nose, and Throat.—Tuberculosis and *new growths* in the mouth, nose and throat are usually resistant to radiotherapy. In certain instances *sarcoma*, even if of large size, may disappear but recurrence is usual. If operable, such cases should receive surgical treatment. Occasionally *new growths* of the *tonsils* may respond quickly to radiotherapy even when the glands of the neck are involved. Such growths have usually recurred. The results are better if the tubes of radium are inserted directly into the growth. In *tuberculosis* and *carcinoma* of the *larynx* radiotherapy may give relief but the benefit is only temporary. The exact apposition of radium is best secured as well as the safety of the patient by preliminary tracheotomy (Fig. 4388,*a*). In certain instances in which the growth is small and localized particularly in the case of *papillomata* good results have been obtained by the use of radium.

Leucoplakia of the buccal mucous membrane re-

acts variably to radium and *x*-rays. In some cases a lesion quickly disappears but it is apt to recur. In other instances it is refractory to radiation. Leucoplakia is often followed by carcinoma, particularly when the origin is apparently syphilitic.

In *carcinoma of the tongue* the results of radiotherapy are usually poor and the treatment is apt to be attended by added suffering. In certain instances, however, the burying of strong tubes of radium in the growths of the tongue have given more favorable results. In one instance a circumscribed growth of border-line malignancy with deep papillary projections in a woman considerably past middle age a tube of radium was buried in the growth (Fig. 4388,*b*) The latter completely disappeared and there was no recurrence.

In general, in diseases of the mucous membranes the results have been less favorable than similar conditions in the skin, although the uterus and vagina would seem to be exceptions. In the nasopharynx and in the *accessory sinuses* in exceptional cases remarkable results may be secured in inoperable or recurrent sarcoma. In carcinoma, however, in these regions results have been poor. In the majority of cases epithelial growths on the lip are regarded as strictly surgical and this is, doubtless, the safer procedure. The dermatologist, however, recognizes two types of epithelial lesion of the lip, the circumscribed superficial type with slight or marked keratoses readily responds to radium. The deeper type, even in the very early stages, should be treated by radical excision.

Pathological Conditions of the Neck.—In *lymphoma* and *Hodgkin's disease* the involved glands may be reduced in size by radiation and in certain instances

Fig. 4398.—Lymphosarcoma of Neck, 2 cases before and after radium treatment. (From Dominici.)

the disease seems to have been restrained. Cures are very doubtful and recurrence is usual. Kelly and Burnam, however, report sixty-five per cent. of twenty-five cases of lymphosarcoma treated by radium as apparently cured and believe that in this disease radium should be used even in the early stages in preference to surgery. In metastatic carcinoma of the cervical glands the swelling may be reduced in size, painful pressure may be relieved and the tissues become dense. Indeed, it often appears as if in certain instances the progress of the disease was checked by such radiation but owing to the great variability in the natural course of the primary disease this is doubtful. In certain instances large primary or secondary malignant growths disappear under the action of radiations and at the same time the general health of the patient rapidly fails and death may ensue. A case of enormous hemolymphangioma of the cervical and subclavicular region in an infant three months of age is reported by Dominici, Cheron, and Barbarin to have completely retrogressed in seven weeks by the introduction for twenty-four hours of a silver tube 0.5 of a millimeter in thickness containing fifty milligrams of pure sulphate of radium.

In certain instances benign tumors of the thyroid or large goiters have retrogressed to a varying degree by the action of radiations but carcinoma of the thyroid is only in rare instances favorably influenced. In cases of *exophthalmic goiter* when the thymus is involved great improvement may result after radiation. In certain instances the region of the thymus alone has been radiated. Unless the dosage is well understood, however, the danger of treating such cases must be borne in mind and this is particularly important when such good results are obtained by surgical methods.

Pathological Conditions of the Chest.—Individual cases have been cited and apparently corroborated by radiographs in which radiation has caused the disappearance of thoracic tumors especially in the case of *lymphosarcomata. Hodgkin's disease* involving the bronchial glands and lungs has not in our experience shown any permanent improvement on radiation. In *carcinoma of the esophagus* it is difficult to secure accurate apposition of radioactive substances but in the majority of cases there is marked temporary improvement. Patients who are almost in extremis from starvation may gain thirty to forty pounds. This is probably due to the repeated dilatation of the esophagus and to the anesthetic effect. Recurrences, however, are usual. It is possible that application by instruments allowing direct observation may improve results particularly in early cases.

Diseases of the Breast.—The most important disease of the breast which is subjected to radiotherapy is the *recurrent carcinoma.* It is the general opinion that all operable malignant and benign tumors of the breast should be operated upon. Therefore, recurrent or inoperable growths form a large part of those treated by radiotherapy. The minority comprise a few persons who either absolutely refuse operation or whose general condition will not permit an operation and those who are treated postoperatively in prophylaxis of recurrence. In the last class of patients it is difficult to estimate the value of such treatment until a very large number of cases has been carefully followed out and comparative series analyzed. In certain instances recurrent superficial skin nodules disappear completely. There is little doubt that the smaller and more cellular growths respond quickly to radiation but at the present time proper surgery should be the treatment of choice in all operable tumors of the breast. It is probable that radiation by the deep method for very long periods of time may delay the progress of the disease even when cure cannot be expected. The great variability in the natural history of the disease, however, renders this somewhat doubtful. When the disease is widespread with mediastinal, pleural, or pulmonary involvement or there is general carcinomatosis little can be expected from radiation.

Abdominal Conditions.—Certain abdominal tumors become smaller and may disappear on deep and intense radiation. Among this class are large retroperitoneal sarcomata, lymphomata and cases of splenomegaly. Cases are reported in which sarcomata and hypernephromata have disappeared. Details of the cases are reported by very few so that it is difficult to know the degree and duration of the clinical improvement. In cancer of the gastroenteric system there is little evidence that radiation has proved of any value. In the majority of such cases treated personally there has been a marked relief of pain and patients have even felt that it was worth

while to go considerable distances for treatment in order to secure even temporary relief, usually only a few hours or occasionally a few days duration. It is, of course, quite probable that a certain degree of relief in these cases of malignant disease was due to the encouraging fact that something was being done.

In a case of adenocarcinoma of the uterus with transplantation of the growth in the fat of the abdominal wall the large and inoperable mass entirely disappeared under two series of intensive radiation by radium. After the first series the growth became much smaller and the second series was given shortly afterward, instead of allowing the usual four to six weeks interval, at the entreaty of the patient and her husband, although it was carefully explained to them that burning of the skin would probably result. The latter occurred and it was some months before the painful burns healed. However, the tumor mass has not recurred although two years have elapsed and the patient's general health is excellent. This case is an exception and not the rule.

Certain cases of ascites from abdominal cancer have been reported as relieved but the variability of such cases naturally leaves the actual value doubtful.

A case of syphilis of the liver with extremely marked ascites for which very frequent aspiration was necessary was treated personally by radium applications to the abdomen and the ascites recurred less and less frequently.

It is probable that surgery combined with careful application of radiation would greatly improve the present results in abdominal disease.

Pelvic Diseases.—Rectum.—In carcinoma of the rectum, particularly adenocarcinoma just above the sphincter, Burnham reports that some cases are definitely curable and that in others there is marked improvement under radium treatment; deep carcinomatous ulcers of the rectum are not improved, although polypi may do well. Certain of the squamous-cell carcinomata about the anus are much improved by radiation and others are less so.

Bladder.—Chronic ulcers of the bladder may be improved by radiation, and also papillomata although in the latter fulguration is probably preferable. The papillary type of carcinoma is more favorable than the squamous-cell variety.

Prostate.—It is reported that hypertrophy of the prostate is improved in certain instances. Numerous cases have been reported by the French. In our experience, carcinoma of the prostate has not been benefited. Larger doses and better methods will, doubtless, secure more favorable results.

A great deal has been written, particularly within the last few years, concerning the value of *x*-ray and radium treatment in gynecology. Indeed, the subject has been taken up by some of the foremost gynecologists in this country and more especially in Europe. About three years ago, some of the European gynecologists made astounding statements regarding the beneficial effects of radium in cancer of the uterus; but some of these same men have recently made the most disparaging statements regarding its use. Radiotherapy undoubtedly has a large field of usefulness in gynecology. The valuable results obtained depend in a large measure upon the intensity of the radiation and the accuracy of the application to the lesion to be treated. The resistance of the pathological tissue, the length of exposures and the intervals between them is determined by the clinical judgment of the operator.

Vulva.—Most of the patients with carcinoma of the vulva have postoperative recurrences and the majority have metastases. In such cases radiotherapy has proved of little value, except in cleansing the local condition and in relieving hemorrhage. Pruritus and leucoplakia may be greatly relieved.

Vagina.—The fungating type of cancer of the vagina may yield quite readily to radiation. In the indurated type results are not so good and sufficient radiation is apt to cause a formation of fistulæ. This is not so important for they are apt to occur in the natural course of the disease whether primary or secondary. One case was treated personally with radium in which an invasive indurated recurrent carcinoma disappeared but the large vesicovaginal fistula resulting was successfully closed by a gynecologist and has remained healed for two years.

Leucorrhea may be relieved by radiation although the possibility of at least temporary amenorrhea should be remembered. Polypi of the vagina are usually cured by radiotherapy.

Uterus.—In carcinoma of the body such excellent results are obtained by proper surgical measures that only for exceptional reasons should radiotherapy be employed except in inoperable cases. Of cases of carcinoma of the cervix, however, only a very small percentage are distinctly operable when first seen by a competent physician; it is in this group of cases, therefore, that radiotherapy finds its greatest usefulness.

Although much has been written concerning radiotherapy in cancer of the uterus not a sufficient number of cases have been studied and carefully followed up for the end results to recommend any treatment except an operation in cases which are operable unless the general condition of the patient contraindicates or the family are unwilling to consent to an operation. In addition to these inoperable cases radiotherapy is used in postoperative recurrences and after operation in prophylaxis of recurrence. In the inoperable and recurrent cases of carcinoma of the cervix the results are in a large measure palliatory. One unfamiliar with the course of the disease as modified by radium treatment would be inclined to think after a few series of treatments that the condition was cured. The term "healed" applied by some observers, we believe, is misleading for the reason that under the first few series of radium treatments fungating carcinomata of the cervix may disappear and the ulceration, in the ulcerating indurated type, may become less and less and finally apparently heal, and the induration about it may be markedly lessened. Such a condition might be called healed and lead to the natural supposition that the process was cured. This, however, is not usually the case. Sooner or later, the disease extends even if it does not recur locally and the patient succumbs to the disease. Certain cases, however, distinctly inoperable at the outset even with fixation of the uterus and metastases in the vaginal wall may, after the primary improvement and local healing, be successfully operated upon. Thus, distinctly inoperable cases may exceptionally be converted into operable ones. Sometimes growths which respond promptly to the first series of radiation later become resistant to all radiation treatment. In certain instances it is desirable to combine local vaginal treatment with applications of radium and *x*-ray to the abdominal wall and back in order to increase the cross-fire effect. Relief from hemorrhage, discharge, and pain, and healing of ulceration are common in carcinomata of the uterus treated by radiations. Some cases may remain well for months or even years.

A small portion of cases of carcinoma of the uterus develop so-called toxic symptoms which include headache, vomiting, prostration, and rise in temperature. There may also be such local symptoms as pain in the back and legs, tenesmus, or frequency of micturition. These symptoms disappear in a few days.

Schauta, in his series of cases in 1913, used intense radiation and many of the patients developed extensive local necrosis. The tendency of the majority of those using radium at the present time is to use a dose of about fifty to 100 milligrams of radium element, two millimeters of lead or one to 1.5 millimeters of brass, or its equivalent in silver or platinum for filtration and a duration of exposure of twelve

hours every few days for five to eight treatments. At intervals of three to six weeks the series is repeated. Such cases rarely develop fistulæ or extensive necrosis and there is at least temporary local and general improvement. Kelly and Burnham have reported that of 199 inoperable cases treated, fifty-three were clinically cured, 108 markedly improved and thirty-seven not improved. Schmitz used fifty milligrams of radium in cases of carcinoma of the uterus for ten to twelve and occasionally twenty-four hours and repeated this after from seventy-two to ninety-six hours. After having given a dosage of from 3,000 to 4,000 milligram hours he gave the treatment weekly until he had given a total dosage of from 8,000 to 10,000 milligram hours. Bumm found all cancer cells destroyed within a distance of four centimeters but that they were viable beyond this. Cheron and Rubens-Duval made a postmortem examination of a patient dying of an intercurrent disease fifteen months after the clinical cure of carcinoma of the uterus by radium. In a complete postmortem and careful serial histological examination they were unable to find cancer cells. The schirrhous inverting type of carcinoma of the uterus seems, usually, less improved than the more fungous everting type which tends to involve the vaginal walls. During and between treatment it is important that the local condition be kept as clean as possible by a mild cleansing solution of boric acid, bicarbonate of soda or potassium permanganate.

A few cases of chorioepithelioma have been reported treated by radiation. These cases, in most instances, metastasize to the lungs early. Owing to the few cases of sarcoma of the uterus treated no conclusions can be drawn.

Of the benign tumors of the uterus, fibromata and fibromyomata have been extensively treated in this country and abroad. Although there is much skepticism regarding the results a large number of cases have now been reported in which the size of the growths have diminished or they have entirely disappeared, although it is admitted that a certain small percentage seem to be uninfluenced. In the majority of cases, however, not only does the tumor diminish in size but the symptoms of menorrhagia or metrorrhagia cease. Both intravaginal and surface applications are made and intrauterine application also when radioactive substances are used. Amenorrhea is caused in the majority of cases. Some of the foreign clinics report eighty per cent. of cures in cases of myomata treated by radium or *x*-ray. Kelly has used thirty to 724 milligrams of radium inserted into the uterus and in some cases given an additional massive treatment through the abdominal walls. The treatment requires confinement of the patient to the bed not over one or two days.

Menorrhagia and Metrorrhagia.—These conditions unassociated by the presence of tumor due to various myopathies or neuropathies or to disturbed ovarian function are in the large majority of cases very greatly benefited or cured. Burnham uses 300 milligrams of radium applied within the uterus for three hours. This usually causes complete amenorrhea. In young women the duration of application is shortened and in such instances menstruation may return.

Harris concludes "from the various and often conflicting reports as to the question of dosage in radium work and from personal observation it does not seem that any definite system or fixed basis of dosage can be given. There are, evidently, limits beyond which it is not safe to go and below which little good can be expected. The main object is the results as measured by the improvement not only of the local but the general condition of the patient. The dosage and all other factors must be managed to best secure this."

It is of the utmost importance in reporting cases treated that accurate data should be given concerning the general condition of the patient as well as the local findings and that the end results of all cases should be demanded, if necessary by secondary reports. Reports of cases without such observations and without subsequent reference to the final results are misleading and have been productive of much disappointment to both the physician and patient.

THOMAS ORDWAY.

Rag-weed.—AMBROSIA. *Ambrosia* is a genus of the Compositæ, containing about a dozen species, mostly North American. The best-known species is *A. artemisiæfolia* L., the common annual rag-weed, and one of the most abundant and troublesome of weeds. It is best known to medicine because the presence of the pollen in the nares is believed to be the principal cause or occasion of the disease hay fever. This and other species contain small amounts of amaroid and volatile oil, and have been employed, especially in domestic practice, as aromatic bitters. The idea that a preparation of rag-weed can act as a specific in hay fever has been frequently advanced, and of late many experimenters have been at work upon the problem. Although numerous reports of favorable results have been submitted, the efficacy of the treatment cannot be regarded as established.

HENRY H. RUSBY.

Railway Medicine and Surgery.—The old-time railway surgeon who cut off limbs after they had been mangled by the cars is rapidly becoming a thing of the past, as is the railway official who looked upon the Surgical Department as something to be tolerated but not encouraged. With improved technique in surgery, many limbs are now saved which would formerly have been sacrificed, while the surgeon devotes much of his energies at present to the physical examination of employees, instruction in first aid, and so on. No better evidence of this can be afforded than a glance at the programs of meetings a quarter century ago and the present time. Formerly essays on amputations bulked large in the proceedings, nowadays we find papers on the proper lighting of coaches, Wassermann test of applicants for employment, the visual qualifications, etc.

The value of a Surgical Department has always been recognized by the Claim and Legal Departments, but from the standpoint of the operating official, it not only brings in no revenue, but is a constant source of expense. Hutchison points out that one result of this slowness of American railways to recognize the importance of the Surgical Department, is that each system has built up a department which to the management seemed necessary. There has been no effort at a "standard method." However, the rapid development of State laws on Workmen's Compensation, with a National law near at hand, renders such a department necessary.

Prior to the War of the Rebellion, the mileage was mostly east of the Mississippi; skilled assistance being as a rule easily obtainable, there was little demand for systematic surgical service such as is now met with. Even at the present time, in the Eastern States where railways traverse thickly populated communities, the stations are almost in sight of each other, and cities and towns with well-appointed hospitals occur at frequent intervals. In the extreme Western States, however, perhaps several hundred miles of unsettled or sparsely inhabited territory may intervene between the locations of properly equipped hospitals. Hence during the building of the great transcontinental lines, provision had to be made for the care of employees injured during the construction of the road, all of them away from their homes and in uninhabited districts. In many instances this hospital department became

a permanent feature after the roads commenced operation.

Except for the fact that it will have a much larger proportion of emergency cases, the practice of the railway surgeon will not differ materially from that of his surgical brethren in general. The injuries with which he has to deal in large measure are very similar to the severe crushes from machinery or heavy vulnerating bodies in ordinary surgical practice. They, however, present some special features. Thus, for example, owing to the fact that the extremities often become engaged between two unyielding surfaces—the rail and the flange of the car-wheel—these railroad injuries may be extremely severe in character, with great destruction and laceration of the soft parts, and comminution of bones. Again, they are attended by a high degree of mortality, and their effect on the nervous system is overwhelming, shock being especially noticeable in this class of injuries.

The psychological element is unusually marked in such injuries, because of the contagiousness of fright and the possibility of "damages" being recovered. A striking example of this "contagion" is furnished by Schaffer of a train running in two sections. There was a collision involving the first section, there were several pregnant women on board, and none of them aborted or miscarried, in spite of sustaining severe injuries, fractures of ribs, contusions of the pregnant uterus, etc. The women in the second section were not in the collision, hence in no danger, yet as a result of the fright and anxiety about their relatives and friends in the first train, many of them aborted.

The railway surgeon often has to exert his skill under the most unfavorable circumstances and the most depressing surroundings, laboring at night with no light but the trainmen's lanterns, far from skilled assistance or even habitations, and amid rain, sleet, or snow. As a result he becomes self-reliant, and develops a routine and outfit which he learns by experience is best suited to his individual case. Here it may be noted that there is the usual variety of temperaments among railway surgeons as among other practitioners or other walks of life. Some do well when confronted with a single case or possibly two or three, but lose their heads when there is a wreck with a large number wounded, and few assistants. Others again, retain their mental poise no matter how serious the situation, and it is a striking evidence of the value of the ubiquitous "local" surgeon that many of the worst wrecks, such as the one at Homestead, Iowa, a few years ago, were handled and with remarkable results by physicians from a country community.

In addition to the crushing force, there should be taken into account the weight and force of the moving train. Of late years, owing to the introduction of cars with steel frames or built entirely of steel, the weight is greatly increased. An empty flat car with steel frame weighs 16 tons; an all-steel coal car, 22 tons; wooden freight cars, 19 tons, wooden passenger coaches 56 tons, and all-steel 69. With the increased capacity of freight cars which has grown 9 tons per car on the average in a decade, the size of locomotives has grown correspondingly, and the largest ones now measure 100 feet in length and weigh 300 tons.

The mileage of steam roads in the United States (1914) was 387,000, on which the number of passengers carried one mile was in 1912, 33,132,000,000 To operate this enormous mileage required in 1895 an army of 785,000 men; in 1901 this had grown to 1,071,000, and in 1912 to 1,716,000. In the eastern district (one-half of Illinois, and States north of the Ohio River) the number of employees per 100 miles of track was in 1912, 1,182; in the southern district, 615, and in the Western (the remainder of Illinois, Wisconsin, and the States west of the Mississippi River) 481.

When the second railway in the world was opened in 1830, from Liverpool to Manchester, Eng., the exercises were marred by the death of the Hon. Mr. Huskisson, a prominent statesman of the time; he sustained a crush of the thigh by being run over and died in a few hours. From that time the number of accidents has gone on increasing until in this country it has reached an appalling total, and this in spite of the "Safety First" movement and the Safety Appliance law. The former is discussed at length further on, the Safety Appliance law, requiring the use of automatic couplers was enacted in 1893, and went into full affect in August, 1900. In a few years this resulted in a diminution of sixty-eight per cent. in the deaths and eighty-one per cent. in the injuries.

In 1914, the total number of persons killed on the railways in this country was 9,893; of these 265 were passengers and 2,850 employees. During this time 79,388 persons were injured, 15,121 of them passengers. While in Europe there is a heavy fine for walking on the tracks, in this country trespassers made up over one-half of the total deaths—5,471. On the other hand, but a small proportion of the injured (6,354) belonged to this class, as against 51,398 employees. For the corresponding period, 409 persons were killed and 113,274 injured in industrial accidents.

To furnish relief for sick and injured employees there are four principal methods in operation: (1) The surgical service with a chief surgeon; (2) the surgical service without a chief surgeon; (3) the hospital system, and (4) the relief system.

1. A chief surgeon is appointed who selects his assistants. He acts as an intermediary between the local surgeons and the Claim, Legal, and other departments. Thus cooperation is secured, and a uniform policy is pursued. Moreover, the chief surgeon being familiar with the personnel of the profession in the territory through which his road runs, is able in case of vacancies, to appoint the best-equipped men. The mileage in rural districts far exceeds, of course, that in cities and towns, and accidents frequently occur at remote points. Consequently it is often the practice to locate at convenient points, district or division surgeons who are subordinate to the chief surgeon, and who in their turn have charge of a division or branch of the line, and of the local surgeons in their territories.

2. The local surgeons are appointed by the superintendent, general manager, or some other operating official. Local surgeons are generally stationed at division or terminal points, and along the remainder of the route—as a rule, about fifteen to twenty-five miles apart. The disadvantages of this plan of dispensing with a chief surgeon are obvious, as it lacks the opportunity of systematic supervision of the local surgeons possible under No. 1. In fact the method is so objectionable that the writer recalls but one large road which adheres to it.

3. The hospital system was first inaugurated on the Lehigh Valley, and in 1869 on the Central Pacific, at Sacramento, Cal. It is in operation on several of the large roads in the United States and Canada, and embraces the care of the employee whether sick or injured, and whether his illness occurs on duty or not. The chief surgeon is in charge, and the executive board or board of managers is composed of representatives both from the employees and from the railway company. The employee is assessed monthly according to the amount of his wages—usually from 0.25 to $2. In addition, the company either makes an annual donation or meets a deficiency should one arise. Minor ailments and injuries are attended by the local surgeons, but if the illness promises to be serious or lasting, patients are sent to the main hospital, or on the longer systems to a branch hospital which is located at some accessible point. The Northern Pacific Beneficial Association, which was founded in 1882, may be selected as a type of this plan. This body maintains four hospitals, at Brainerd, Minn., Glendive and Missoula, Mont., and Tacoma, Wash. For the year ending

June 30, 1915, the receipts were $291,484, and the expenses, $282,026. The cases treated in the hospitals were 11,441 in number, and by the surgeons along the line, 49,600. A training school for nurses is maintained at Brainerd.

4. The relief system is in operation on a number of roads, though fewer in number than the hospital system. Membership is either voluntary or compulsory. On some roads the relief system is kept up by the company, on others by the employees, and on still others by the railroads and the employees jointly. As in the hospital system the employee is assessed monthly. When sick or injured, he receives a certain sum monthly during this period of disability. Provision is also made for permanent disability and for benefits in case of death. In some associations membership lapses if the employee quits the service of the company, in others the death benefits may be retained. In others again, additional features are found in the shape of savings and building and loan departments. The scope of such a system on a large trunk line may be gleaned from the report on the one operating on the Burlington road for the year ending Dec. 31, 1914. The membership was 25,159, a decrease of 533. The average number of members disabled (for 365 days) was a fraction under twenty-nine, or 1.14 per 1,000. The death rate per 1,000 members for the year was 7.3. Applications for membership were 10,531; while the cessations were 11,064, of this number 10,849 leaving the service, 186 deaths and twenty-nine withdrawals. From 1889–1914 the net receipts from members were $10,044,395 and the company contributed $1,772,400. Since its origin to Oct. 1, 1915, $10,503,317 have been expended in disability and death benefits, and the company has contributed to this sum, $1,840,230.

Some roads with a Relief Department require the applicant to sign a "release" at the time of making an application. That is, releasing the company from damage claims arising from the injuries sustained by the employee while at work. This has been objected to on ethical and economic grounds, but its consideration is beyond the scope of this article, and reference should be had to Allport's paper, where it is exhaustively discussed from all standpoints.*

Railway employees are notorious for applying tobacco cuds, soiled waste, or dirty handkerchiefs to wounds received by them. First-aid instruction which has been in successful operation for many years in Great Britain, for a great deal of this period has been applied with equal satisfaction to this class. In this country this movement at first met with considerable opposition, but a great impetus was given by the Act of Congress of Jan. 5, 1905, incorporating the American National Red Cross. In addition to the railroads, this extends its activities to mines, factories, police and fire departments, etc. A Pullman car has been fitted up especially for the work, and travels over the various systems, occupying from a few weeks to several months, according to the mileage. Stops are made at division points or those where the shops are located and talks given to the trainmen, shopmen, and other employees. Classes can also be organized by surgeons along the line, the men being paid for their time as if they were at their regular avocation. About a dozen lectures are given of one-half hour each; these are couched in non-technical language, and illustrated by a manikin, skeleton, etc. After considering the structure and functions of the body, the treatment of accidents and injuries is taken up, followed by handling and carrying the wounded, prevention of disease, and sanitation, and ending with a general review. The balance of the time at each session is occupied by practical exercises in bandaging, application of splints, etc.

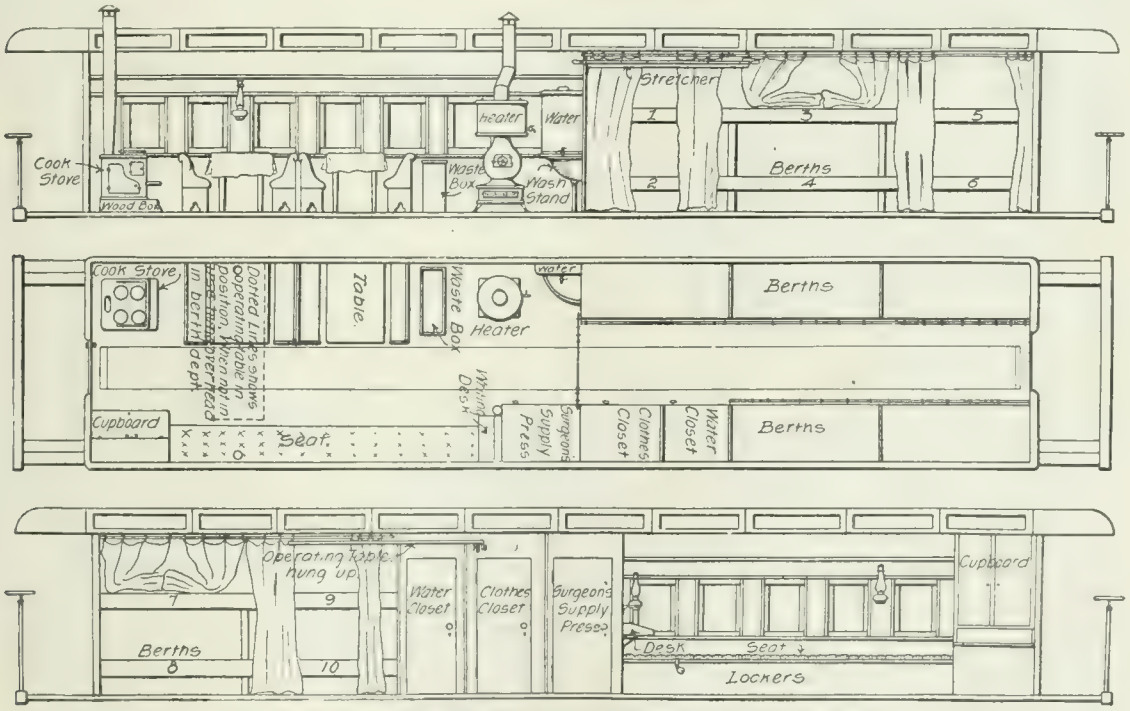

FIG. 4399.—Hospital Car Rebuilt from Old Passenger Coach. (Fairchild.)

First aid is being made compulsory by virtue of laws enacted by some of the State legislatures. Thus one in Illinois, effective July 1, 1915, provides that trains and engines are to be equipped with: "A

* Since the above was written, the U. S. Supreme Court has ruled that such "releases" are void in the eyes of the law.

standard package to contain two (2) pieces of sterile gauze, one (1) ribbon bandage, one (1) triangular cambric picture bandage in aseptic container, six (6) of these packages to make up one (1) first-aid kit." Also that: "The Chief Surgeon, one of his assistants or other capable physician shall at reasonable intervals offer first-aid instruction to the engine and trainmen in his jurisdiction."

The principal objection to the first-aid instruction in the past has been the cost of the kits recommended, sometimes amounting to $50 or $60 each. Another and potent one is the possibility of overofficiousness from the first-aid man. This latter is hard to overcome, in fact a great deal of the instructor's time is taken up warning what *not* to do. A simple outfit such as the above, however, costs but little especially in the large quantities necessary on the principal roads, and while sufficient for the purpose, can do no harm since there is little chance for mistakes.

Quite recently a movement has been started to secure, if possible, uniformity in first-aid methods, equipment, and instruction. A meeting was held in Washington on Aug. 23 and 24, 1915, attended by representatives of the Army, Navy, Public Health Service, Association of Railroad Chief Surgeons, Red Cross, some large industrial plants, etc. As a result the President of the United States appointed a Board on First-aid Standardization. The preliminary subjects for discussion are: First-aid Packages; Antiseptics for Accidental Wounds; Fixation of Injured (*a*) Upper, (*b*) Lower Limbs; Standard Stretchers, and Dressings for Large Wounds to Prevent Gauze Adhering. It may be remarked here that the whole subject of the first dressing has been markedly simplified by Grossich's tincture of iodine technique.

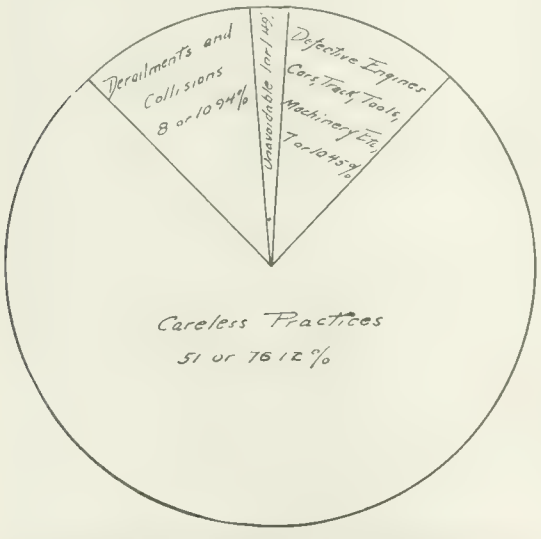

Fig. 4400.—The Causes of Accidents in Which Employes of the Chicago & Northwestern Railway were Killed while on Duty, during the Year ending Dec. 31, 1913. (Richards.)

Hospital cars for first aid on a large scale have been equipped and maintained on several roads, being kept constantly ready for use and usually attached to the wrecking train as occasion demands. They may be constructed new, but are often rebuilt from passenger coaches or even freight cars. While their arrangement differs somewhat, a general idea may be had from Fig. 4399 which shows one in use on the Chicago and North Western.

First aid deals with the employee after he is injured, and to prevent him being injured is the object of the famous "Safety First" movement, which is in line with prevention in other branches of medicine—infectious diseases, for instance. This crusade owes its inception to Mr. R. C. Richards, of the Chicago and North Western Railway. It was started in 1910, and the immediate occasion of its origin was the fact that the previous year, personal injuries increased no less than thirty-seven per cent. over the year before. As may be seen from the diagrams (Figs. 4400 and 4401), the great majority of deaths and injuries are due to "careless practices," and one of the chief aims of the Safety First movement is to stop these or at least lessen their number. Accordingly a Safety Commission was formed on every division of the road, made up of representatives of each class of labor

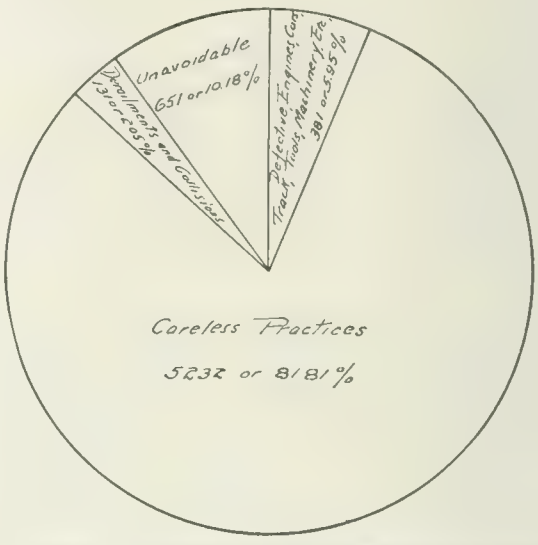

Fig. 4401.—The Causes of Accidents in Which Employes of the Chicago & Northwestern Railway were Injured while on Duty, during the Year ending Dec. 31, 1913. (Richards.)

employed on the division; similar committees were formed in the shops, roundhouses, etc., and each year about 1,500 employees serve on these committees, returning to serve as missionaries among their fellows. Any employee who in the course of his work notices any defective apparatus or object liable to cause accident, is expected to make a report of the same with a recommendation as how to overcome the danger. (In emergencies, of course, the dangerous object is repaired without waiting for the Committee). This is then referred to the Safety Committee on his division, and in 1912–13, of 10,159 recommendations made to the various committees on the North Western, no less than 9,772 were adopted.

The remarkable results of this plan are shown by the figures for the fifty-two months ending Oct. 31, 1914, as compared with the same period ending June 30, 1910:

162 fewer employees killed, a decrease of 34.3 per cent.

9,931 fewer employees injured, a decrease of 26.5 per cent.

814 fewer passengers injured, a decrease of 20.5 per cent.

200 fewer outsiders killed, a decrease of 19.1 per cent.

206 fewer outsiders injured, a decrease of 7.7 per cent.

Yet the length of the road was 500 miles greater in 1914. The movement has rapidly extended, until it is in vogue on practically every large American road, and is gaining a foothold in Europe.

In these days of compensation laws, the physical examination of employees is important. Claims

for damages are often brought to recover for conditions, especially hernia, stated to have been received while at work, though proved later to have been present when the litigant entered the employ of the company. The law of supply and demand comes into play here as in many other industries, hence we find that roads in the extreme Western States are not quite so exacting as those where plenty of help is to be had.

Defective vision and color blindness are frequent causes of rejection, both for admission to the service and for promotion. The "Soo" Line for several years has had systematic and rigid requirements of applicants for employment, for the year ending Jan. 1, 1914, of 2,040 applicants, 392 were disqualified (19.2 per cent.), 81 rejections were for defective hearing, 91 for defective vision, and 42 for color blindness. The visual requirements are so important that on some lines a car is kept constantly traveling over the road equipped for the purpose of testing the vision and hearing at stated intervals.

The causes for rejection vary, some companies reject for varicose veins, hernia, epilepsy, heart disease; others exclude applicants with hydrocele, otitis, loss of fingers, etc. The mental qualifications are generally taken into account also, and examinations, as a rule, repeated at given intervals or whenever chance is afforded for promotion. In this connection the age at which applicants enter the company's employ is becoming important since the adoption of old-age pensions on a gradually increasing number of railways. Generally speaking, the extremes of life at which applicants are received are twenty-one to forty-five years of age.

The following figures are from the pension department of the Rock Island Lines: Number retired in previous year, 44. Total number pensioned, 299 (age limit, 156; incapacitated, 143). The average years of service of the pensioners was $33\frac{3}{12}$ years, and the average age per pensioner was $68\frac{1}{12}$ years. The average duration of life after being pensioned was $2\frac{6}{12}$ years, and the percentage of death of pensioners to total number pensioned was 25.75.

The freedom of ice and drinking water from contamination, and an adequate supply of pure air and of protection against contagious diseases, are growing duties of public carriers. This is so evident that the Pullman Company, and some of the large roads have appointed Sanitary Inspectors to supervise the hygiene of the cars, stations, etc. Much confusion arises from the varying requirements of the different commonwealths; thus the public drinking cups are sometimes locked up in the passage through one State, to be taken out again when the boundary line has been reached. However, the U. S. Public Health Service is gradually assuming charge of this feature, and uniform regulations will be the result. On a few progressive roads, the cooks and waiters on the dining cars are required to be examined at regular intervals to assure their freedom from venereal and contagious disease. There is much room for improvement as regards the waiting-rooms, and especially the closets, of the stations in small towns, the toilets being proverbial for filth and uncleanliness. Oculists also tell us that the lighting of the trains, at least in the less expensive accommodations, is far from satisfactory. Ventilation is still in a chaotic condition, and it seems difficult to establish a standard which will prove agreeable to all passengers. For some years past there has been a laudable improvement in the matter of the curtains, cushions, etc. Instead of the old-fashioned dust-collecting plush, waterproof material is employed, easily cleansed and disinfected.

Concerning the transportation of consumptives, the danger of infection from this source seems but slight. Hemenway took the deaths of men over nineteen in the registration area for a decade, and then computed the percentage of deaths from consumption compared with the total deaths for various occupations. The percentage of deaths from consumption for all occupations was 14.5. That for different callings varied from 6.6 for physicians to 28.2 for "clerks," railroad employees coming second with a percentage of 7.2. He found the figures for "food manufacturers" (bakers, butchers, millers, etc.) above the average, that for traveling people decidedly below the average.

Bacteriological examinations of the air and dust from the woodwork and furnishings of cars, in many instances known to have carried tuberculous passengers, showed tubercle bacilli but one time in 195 examinations (Kinyoun). If there is any danger it must be greatest in the day coaches, for Sweet of the U. S. Public Health Service undertook an examination of this problem in the southwest, and found fifty per cent. of the tuberculous passengers in the day coaches, thirty per cent. in tourist sleepers, and the remainder in Pullman sleepers. Moreover, as Hemenway points out, each individual would have at least two and one-half times as much cubic air in the standard Pullman as in the day coach; and the relative cleanliness of the passengers is much according to the same scale. Travelers in the day coaches are much more likely to throw fruit skins on the floor or to expectorate. Again, the more passengers, the greater the chance that one will be tuberculous. Hence we must conclude that the danger of infection is greater in the day coaches, which often make short runs perhaps within the limits of a single State.

Tuberculosis is infrequent among the employees of the Santa Fe which, running to the climatic resorts of the southwest, transports a large number of tuberculous individuals annually. The percentage of tuberculous conductors is only 0.26, of brakemen, 3.08; and of all classes of employees, 1.08. The railroad authorities find but little tuberculosis outside of their clerical force (Hemenway).

Antityphoid inoculation is coming into vogue more and more, especially for the members of construction crews with scanty and impure sources for drinking water. The average unskilled laborer of the present day from the southern countries of Europe, has never been accustomed to any great degree of hygienic living, and it is difficult to train him after his arrival. However, much is being done by the various State boards of health which have jurisdiction over the camps while the roads are being constructed or repaired. Another field in which prophylaxis has worked marvels is that of antimalarial measures in the South, the morbidity and invalidism being practically wiped out, *e.g.* in the track laborers.

Societies for the interchange of views and opinions have been in existence for many years. The first composed of surgeons on the Wabash R. R. was organized in 1882; later in the same year, one was formed on the Pennsylvania Lines. A National Association was formed in 1888, in 1897 this increased its scope to include surgeons from Canada and Mexico, and the name was changed to "International." The American Academy of Railway Surgeons, organized in 1894, had a limited membership, composed principally of chief surgeons. In 1904, the two associations were amalgamated, reorganized on the delegate plan, and a flourishing body—the American Association of Railway Surgeons—was the result, with members at present in practically every state of the union. It maintains an official monthly organ, *The Railway Surgical Journal*, now in its twenty-second year, publishing, in addition to the proceedings of the national body, those of the majority of the system associations. There are numerous associations composed of the surgeons on the larger systems, among which may be mentioned the Milwaukee & St. Paul, Rock Island, North Western, Illinois Central, "Soo," Burlington, Alton, and Big Four. In 1912, the chief surgeons finding the need of meetings for the considera-

tion of administrative topics organized the Association of Railroad Chief Surgeons, which now includes representatives of 156,000 miles of road.

Lastly, a few words about the financial returns: These bear considerable resemblance to the income from insurance examinations. A few salaried positions are open to those who devote all their time to the Surgical Department. The majority of practitioners employed by the railway companies are compensated at prices somewhat below those of the fee-tables in their vicinity; on the other hand, the pay is sure and in cash. Some of the local surgeons have very few calls during the year, others, at points where there are division terminals or where the shops are located, are busy for a great deal of their time. Moreover, the position gives considerable prestige and indirectly brings in more or less practice. In many instances, the courtesies in the way of transportation extended to the surgeon and his family, even though he may do little actual work, represent quite an increment to the annual income.

Louis J. Mitchell.

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Ramsgate and Margate.—These two popular though not the most fashionable English coast resorts are situated on the Isle of Thanet, about seventy-five miles east of London. Margate lies to the north, with an eastern sea exposure, while Ramsgate, about five miles to the south of it, has a southern as well as an eastern sea front. Similar but quieter resorts in the near vicinity are Broadstairs, Westgate-on-Sea, and Birchington.

The general climatic characteristics represented by these resorts are those of a cool marine climate, with moderate or quite considerable humidity. Owing to the influence of the Gulf Stream here, as throughout all England, the mean temperature is much higher than is due to latitude. The winters are mild, the summers cool; there are no great extremes of temperature; and there is great seasonal and diurnal equability. There is only a moderate amount of sunshine, and there is always wind. Such a climatic combination is stimulating and bracing, and has been found valuable for anemia, malaria, convalescence from various diseases, dyspepsia resulting from debility, certain nervous affections, and particularly scrofula and tuberculous conditions other than pulmonary.

These resorts are available all the year, although they are naturally most frequented in the summer.

The soil is of chalk covered with a foot or two of earth, and, consequently, is dry and quickly absorbs moisture.

Ramsgate, like its neighbor Margate, presents to the sea high chalk cliffs, with an abrupt descent to the "sands," which, being thus sheltered from the winds, affords an attractive resort for the invalid and visitor, and good bathing. In general, however, here as at Margate, the winds are frequent and trying, particularly at certain seasons of the year. By the construction of terraces and crescents a certain amount of artificial shelter is obtained. Nevertheless, "even in its stillest corners the keen Thanet air is constantly moving." The southern exposure affords more sun, though the general percentage of cloudiness is 6.7. On account of its situation it is a little warmer here than at Margate.

The town contains about 27,000 inhabitants, and appears to be very healthy, as the death rate in 1891 was only 14.6, and more than one-third of the deaths occurred at over sixty years of age; the infant mortality was 118 per 1,000 births. The drainage is thorough and good, and the water supply is constant and pure. If one desired to live long this would appear to be a desirable resort, as in 1890 one-twelfth of the total number of deaths was of individuals at or upward of eighty years.

Besides the cliffs and sands there are piers for promenading; and the marine view, and the almost daily arrival of foreign fishing smacks afford a constant source of interest. There are also attractive drives in the vicinity. The temperature of the sea water is 61° F. in the summer, thus affording opportunities for bathing. Ewart ("Climates and Baths of Great Britain," 1895) says that Ramsgate has an "admirable winter climate for most invalids," and "many," he continues, "are so fortified by a winter residence as to be able to meet the spring winds without risk."

A climatic table of Ramsgate is appended; it also substantially represents that of Margate, which is only about five miles distant:

Climate of Ramsgate, Lat. 51° 19′ (from "Climates and Baths of Great Britain").

	Jan.	Mar	May.	July.	Aug.	Oct.	Nov.	Year.
Temperature:								
Average or normal.	38.8°	40.3°	52.2°	61.2°	61.4°	49.8°	45.0°	49.3°
Mean daily range.	8.9	11.1	14.2	15.2	15.4	11.8	9.7	12.0
Mean of warmest.	43.3	45.8	59.3	68.8	69.1	55.7	49.8	55.3
Mean of coldest.	34.4	34.7	45.1	53.6	53.7	43.9	40.1	43.3
Highest or maximum.	55.2	63.6	77.3	83.6	83.2	72.9	61.3	83.6
Lowest or minimum.	20.3	20.1	32.9	42.3	44.2	27.8	22.2	19.0
Humidity;								
Mean relative at 9 A.M.	89%	83%	76%	74%	74%	86%	88%	82%
Precipitation:								
Average in inches.	1.76	1.44	1.73	2.32	1.35	2.86	2.84	24.23
Days in which rain fell.	15	14	12	13	9	15	16	163
Wind:								
Prevailing.....	The prevailing wind is from the SW southwest except in April and June.							
Weather:								
Cloud at 9 A.M.	7.3	6.9	6.1	6.3	6.0	6.6	7.5	6.7

Margate (about 27,000 inhabitants) has been noted for a century for the treatment of scrofula and tuberculous diseases, especially in children, and here is situated one of the oldest and most famous seaside sanatoria for those suffering from these diseases—"The Royal Sea-Bathing Infirmary." There are also many other similar institutions. The town stands on two hills separated by a valley, and facing the north are high chalk cliffs at the base of which is a shallow beach that is quite covered at high tide. It is upon these cliffs that the new portion of the town is situated. The town also stretches some distance back from the sea over undulating ground, affording opportunities to gain a certain amount of protection from the winds. The water supply is good, and the drainage is efficiently accomplished both by natural and by artificial means.

The table shows the various meteorological data in detail. Fogs are not frequent. It is rarely uncomfortably hot or cold in summer. January is the coldest month in the year, the average temperature being 38.9° F.

Large numbers of children are sent to this resort for the effect of the sea air and sea bathing, the majority suffering from scrofula and tuberculous diseases other than pulmonary tuberculosis. The benefits obtained in these maladies in some cases are said to be extraordinary. At the Royal Sea-Bathing Infirmary the following percentages of cures are given: 1886, 23.5 per cent.; 1887, 27.84 per cent.; 1888, 38 per cent.; 1889, 46.1 per cent.; 1890, 52.35 per cent. As it requires a certain vigor of constitution to endure this climate, weakly children would probably do better in the milder climate of the Mediterranean shores.

The accommodations at Ramsgate and Margate are good and of varying price, and there are excellent facilities for all sorts of sea-baths.

Broadstairs.—Between Margate and Ramsgate a "quaint old-world town, immortalized by Chas. Dickens in 'Bleak House,' is an excellent resort for both extreme youth and extreme old age and has a climate admirably suited for the majority of invalids" It is especially favorable for children, and it has been observed that young people brought up at Broadstairs bid fair to acquire a stamina such as will serve them well later in life and last them even into old age." The bathing here can be enjoyed well on into the Autumn.

For a more extended description of this region and its climate the reader is referred to the article of Ewart in "Climates and Baths of Great Britain," and "Health Resorts of the British Islands" by Neville Wood, M. D., 1912. EDWARD O. OTIS.

Ranula.—Ranula (*rana*, a frog) designates a cystic tumor beneath the tongue, which is due to occlusion of the duct of the sublingual or submaxillary salivary gland, or of a mucous gland of the floor of the mouth. The origin of the term is not clear; it cannot be from the ranine artery or vein, for after an investigation of anatomical sources Virchow ("Die Krankhaften Geschwülste," 1863, Band i., 274) concluded that the term "ranine" was applied to these vessels at a later period.

Ranula may be congenital or acquired. Congenital ranula may be due to prenatal inflammation involving the floor of the mouth: it requires no special description. Ranula of this type may, however, be responsible for considerable deformity of the lower jaw by causing the latter to project to such an extent that the teeth do not meet. Acquired ranula results from occlusion of the duct of one of the regional glands in the sublingual space by the same causes that occlude one of the biliary ducts or the ureter—a stone within the duct (acute ranula), or compression from without (usually cicatricial, the result of inflammation).

Acute ranula usually occurs during mastication. A person at table is suddenly seized with acute tension pain from the impaction of a salivary calculus in one of the ducts with damming back of the now-retained saliva into the duct and gland. Relief is obtained when the obstructing calculus drops back into the distended duct, escapes into the mouth, or is removed. Garretson compared the result of sudden occlusion of one of the ducts to the belly of a frog, thereby, perhaps, explaining the use of the term.

The tumor itself projects more or less into the mouth cavity and presents a bluish-red, velvety appearance; it is cystic to the feel. The bluish appearance is caused by the submucous veins spread over its surface. The cyst is unilocular; the mucosa slides freely over it; it is semitranslucent, and the contents are viscid and tenacious.

When the cyst is of sufficient size it interferes with chewing, talking, swallowing, and—though rarely—breathing. Malignant degeneration is unknown and sloughing rarely occurs.

Sublingual ranula is the commonest variety. It occupies the floor of the mouth and results from occlusion of one of the ducts of the salivary gland, or, if small, of a regional mucous gland. Ablation may be performed through the mouth.

Submaxillary ranula results from occlusion of Wharton's duct. It forms a swelling beneath the body of the mandible and requires an external (submandibular) incision for its removal.

Incisive ranula appears beneath the frenum of the tongue.

Ranula of Nuhn and Blandin's apical gland of the tongue is a rare variety, since this gland is present in but twenty-three per cent. of individuals. Such a ranula is found under the tip of the tongue.

Ranula parotidea is a variety described by Bruns ("Handbuch der prakt. Chirurgie," 1859, Abth. II, Band i., 1041), and is due to occlusion of the duct of Steno.

Ranula pancreatica was encountered by Virchow, who described two essentially different forms.

DIAGNOSIS.—In the diagnosis of sublingual ranula—the usual form—dermoid cyst must be taken into consideration; and of special importance is it to remember that in rare cases an undescended thyroid gland is present in this situation (sublingual thyroid). Ranula does not resemble the solid tumors of this region in any particular.

TREATMENT.—Since the lining of a ranula consists of actively secreting cells, just as in the case of a sebaceous cyst, simple incision releases the contents temporarily, but as soon as the incision into the cyst has healed the products of secretion rapidly re-accumulate, so that permanent cure cannot result by this method alone. It is necessary to ablate the cyst *in toto*. Where this is not possible the anterior wall can be cut away broadly with scissors and the remaining membrane treated with caustics and tamponade.

MORRIS BOOTH MILLER.

Rape, Medicolegal Aspects of.—Rape may be defined as the carnal knowledge of a female, forcibly and against her will, or without her consent. The attempt has been made to draw a distinction between the expressions "without her consent" and "against her will," but the better opinion is that they are synonymous. It is a felony in all the United States, the punishment ranging from fine and imprisonment for a term of years to life imprisonment or death. The severest punishment is imposed in some of the southern states.

The crime is distinguished from seduction by the fact that it is committed by force and without the female's consent, or upon a female incapable of consenting, and also that it may be committed on a married woman. Any male person of sufficient mental capacity to be criminally responsible may commit rape, provided he has sufficient physical capacity to perform the act of sexual intercourse. It cannot be committed by an impotent person, or by a husband upon his wife. At common law a male under fourteen years of age was conclusively presumed to be incapable of committing rape. This is still the case in some of the United States, but in others want of age is only *prima facie* evidence of physical incapacity and may be rebutted. But while they cannot be guilty as principals in the first degree, an impotent person, a woman, or a boy under fourteen may be guilty as principal in the second degree.

Rape may be committed on a female who is an idiot or insane, or drugged, intoxicated, or asleep. Want of chastity is no defense unless so provided by statute, though it may be shown as bearing on the question of consent. Some statutes punishing carnal knowledge of a woman between certain ages, either with or without her consent, expressly provide that the woman shall have been previously chaste or of good repute. In Nebraska prior unchastity is a good defense where the female is over fifteen and under eighteen but not where she is under fifteen. A Tennessee statute prohibits carnal knowledge of a female between the ages of twelve and eighteen who is not and has not been a bawd, or lewd, or kept female. In Michigan a conviction may be had under such a statute if the woman had reformed and was chaste at the time of the act.

Penetration is essential to constitute the crime of rape; but the slightest penetration is sufficient; it need not be perfect; the entering of the vulva is sufficient, and the vagina need not be entered or the hymen ruptured. Emission need not now be proved. There must be force, threats, and fear of bodily harm, or, in some jurisdictions and in certain circumstances, fraud inducing consent. Consent, however reluctant, or if accompanied by only verbal protests and refusals, at any time during intercourse, prevents the act from being rape. If a woman offers herself on conditions precedent and the man succeeds in the act without complying and without her consent, it has been held to be rape. In the absence of statute, the age of consent is ten; but most States have enacted statutes fixing the age at ten, twelve, fourteen, fifteen, sixteen, and eighteen. Carnal knowledge of a woman under the age of consent is rape, and her consent is immaterial; and it is no defense that the man was informed and believed the female was above the age. It has been held that if the woman is caused to become intoxicated so that she is unable to resist, it is without her consent and is rape. But in New York this is not rape, there punishable with ten years' imprisonment, but is a crime under another statute, punishable with five years' imprisonment. Carnal knowledge of a woman asleep is rape, unless she is awakened by the act and makes no resistance.

There must be resistance before the act constitutes rape, and this must be shown beyond reasonable doubt. The woman's general statement that she resisted is not enough. The rule generally laid down is that the amount of resistance necessary will depend on the circumstances, such as the relative strength of the parties, the age and condition of the woman, the uselessness of resistance, and the degree of force manifested.

As a general rule the obtaining of a woman's consent by fraud or surprise does not constitute rape. If a physician falsely represents to the woman that the act is necessary as a part of the treatment, and she believes him and consents, it is not rape. But if she is induced by fraud to consent when she does not understand the nature of the act, it is rape. A physician made an examination of a girl nineteen years old in her mother's presence and said that she was suffering from a womb disease. He then took her into a private room, where, under the pretense of making a further examination, he succeeded in having connection with her without her making any outcry. He was held guilty of rape. In the absence of statute, the fraudulent impersonation of the woman's husband does not make the act rape. A Texas statute, however, provides that this is rape.

Physicians will be allowed to testify to the physical condition of the woman upon medical and surgical examination after the time the crime was alleged to have been committed. The probative value of this examination depends upon its remoteness. Testimony as to the condition of the sexual organs four to six days after the alleged rape has been held not too remote. Testimony as to an examination of an unmarried woman more than four weeks after, when the physician found her hymen ruptured or penetrated and that she was pregnant, has been held admissible. And evidence of rupture of a young girl's hymen on examination five or six months after has been admitted. Even evidence of the result of an examination of a girl about a year and a half after has been held admissible, although not of much force. Where the examination is made at a long distant time and it is possible that acts of intercourse with others may have taken place, it is too remote and the result will usually not be admitted in evidence.

Articles of clothing taken from the accused may be admitted against him.

Evidence as to the condition of the woman's clothing shortly after the alleged rape, as to whether it was torn, disarranged, or bloody, is admissible; and clothing may, when properly identified, be exhibited to the jury.

Evidence of the accused's condition at the time of the alleged crime is admissible. Where material, his size and strength may be shown, and such evidence may also be material to show whether he could have committed the act.

Evidence to show that the female became infected with a venereal disease may be given, and it may then be shown that the accused had the same disease.

Penetration may be proved either by direct or circumstantial evidence. The prosecuting witness may be asked if the intercourse caused her pain. A young girl, prosecuting for rape, testified that she never had intercourse before, that the penetration did not hurt her, either at the time or next day, and that no blood flowed. It was held error to refuse to allow the defendant to show that the natural result of intercourse with a girl of the prosecutrix's age would be pain, the flow of blood, and soreness.

Finally, Sir Matthew Hale's statements as to the crime of rape have been repeatedly approved by the courts. He said that "it must be remembered, that it is an accusation easily to be made and hard to be proved, and harder to be defended by the party accused, though never so innocent;" and that we should "be the more cautious upon trials of offenses of this nature, wherein the court and jury may with so much ease be imposed upon without great care and vigilance; the heinousness of the offense many times transporting the judge and jury with so much indignation that they are overhastily carried to the conviction of the person accused thereof by the confident testimony, sometimes of malicious and false witnesses."

In a large majority of all cases of alleged assault the allegation is accidentally or maliciously false. Amos was doubtless correct in his estimate that there are twelve false charges to every true one. The estimate is true also of cases in which a child is the principal witness. Even young children are taught by designing women to tell the story of an assault; but they are often taught to use language most unnatural to their age, and the absolute precision of their statements is often a ground for suspicion. The motives for such deception need not be discussed. The chief of them is revenge, and this is often for the most trivial offense, an unpaid debt, a fancied slight or insult, or a cessation of improper relations with the mother. In such cases the report of the examiner should prevent the case from coming to trial.

It is the duty of the physician to make an impartial examination and to submit the facts just as he finds them. The examiner, however, would often err if he confined his opinion too rigidly to the physical condition of the victim. He can often further the ends of justice by carefully interrogating her apart from her friends and the officers in charge of the case. For his own protection, however, he should never examine her alone in a closed room. The examination should be made at the earliest possible moment after the assault, but in the case of an adult woman only with

her consent. A complete record should be kept of the examination, including the name, residence, age, and apparent age of the subject, the exact time and place at which the assault is alleged to have been committed, and the place and exact time at which the examination is made. The injuries, if any, should be described with minuteness. The most trivial circumstances often prove of value in the hearing of the case, but particularly the time at which the crime is said to have been committed and the time which was permitted to elapse before complaint was made. An excellent form for this record is given in the "Medical Jurisprudence" of Witthaus and Becker.

The principal facts to be established by the physician's examination are: (1) Marks of violence on the woman's genitals; (2) marks of violence on her person or on that of the accused; (3) stains of blood or semen on the person or clothing of either, and (4) the presence of venereal disease, gonorrhea, syphilis, or chancroid in one or both. It is better to make the examination of the defendant with his consent and under full knowledge of its purpose, for it may otherwise be excluded as being in the nature of an involuntary confession. For the same reason the consent must be obtained without threat or promise.

The examiner is generally expected to testify that he has found, or that he has not found, evidence of the penetration of some blunt instrument. It is sufficient that the penetration has been only slight, as a separation of the labia. A recent rent of the hymen is one of the most positive signs that force has been employed and that penetration has been effected, but it is not essential. The fact that the hymen is intact is of little value as negative evidence, for its firmness must be taken into account. Repeated intercourse is sometimes possible without its rupture. And, on the other hand, the membrane may be torn in many ways other than by sexual intercourse. It is probably congenitally absent in rare instances. The vaginal wall may also be torn. Comparatively few examinations are made early enough to discover a recent bleeding rent of the hymen, and after the third day it is extremely difficult to determine the recentness of an injury. More than one examination should generally be made, and the statements made at each should be carefully compared. In many cases the injury is limited to one or more abrasions just within the labia minora. The examiner should see that this corresponds to a possible injury by sexual contact, and that it is not an excoriation such as might be made with the finger-nail. He cannot, of course, testify as to the manner in which the injury was inflicted, but he may state that the injury corresponds exactly to an injury inflicted in a forcible effort at sexual intercourse.

Complete penetration of the vagina of a young child by an adult male penis is impossible without the most extensive laceration, and this is generally prevented by the outcry. When there has been recent complete defloration, complete penetration of a virgin, there are generally well-marked signs of violence. The hymen is lacerated and the external genitalia are inflamed to a variable degree. There may be only slight redness, heat, and sensitiveness, or the swelling and tenderness may be so great as to render a thorough examination almost impossible. The woman walks with difficulty, and separation of the thighs causes intense pain. In the course of from forty-eight to seventy-two hours these conditions may subside or they may become more marked as suppuration develops in the lacerations. Other evidences of a struggle are generally revealed in cases of extreme injury, especially contusions, abrasions, and lacerations of the thighs.

JOHN SIMPSON.

Rat-bite Fever.—*Definition.*—Rat-bite fever (*Rattenbiss-Krankheit, Sudoke,* Japanese) is a disease occurring as the result of the bite of a rat. Subsequent to the traumatic incident, there is an incubation period of variable extent, following which there is noted a single or a succession of paroxysms characterized by chills, fever, and sweats. The paroxysms follow each other at regularly recurrent intervals separated by a free period; each relapse is usually associated with the occurrence of a localized or a diffuse erythematous rash. The disease is signalized by severe nervous phenomena, progressive emaciation, and weakness. The course is variable, often prolonged; fatal cases are not at all infrequent.

HISTORY.—Until recently but little attention was devoted to this malady, sporadic references appearing in the literature of several nations. Only the Japanese have attempted systematically to collect their clinical material, Miyake, in particular having studied and published a splendid account of the incidence and course of this strange malady. With the birth of interest in the subject, several commendatory articles have appeared in the British literature (Horder), American literature (Proescher), and German literature (Hata). All in all far less than a hundred cases have been described, though this number hardly represents the frequency of the disease, since as a clinical entity we are just beginning to be intimately acquainted with it.

ETIOLOGY.—Apparently, no country or nation is exempt from the disease, for the etiological factor, the common house rat, is ubiquitous and his bite is equally morbid throughout the world. Such nations as Japan and America with large areas of sparsely settled country and wooden structures, by encouraging the increase of rats, encourage the number of cases of rat-bite fever. For the same reason, farmers, agriculturalists, and seamen are predisposed persons.

The age of afflicted people varies, no age being exempt, and those persons of most active occupation most often being the ones bitten. Older children, with their predatory habits are most frequently the victims, more especially the males.

In regard to predisposition, no factor seems to play a rôle. The constitution of the person bitten does not affect the incidence of the malady.

The animal inflicting the wound is usually described as a large black or brown rat. It should be noted at this point parenthetically, that a disease, practically identical with rat-bite fever in its clinical course and symptoms, has been observed to follow upon the bite of a ferret, cat, squirrel, and other animals.

It has never been determined whether the condition of the animal at the time of the infliction of the wound plays a rôle. The animal is often described as infuriated, and battling for his life, but just as severe a course has been seen to follow the bite of a perfectly peaceful beast.

Not every rat-bite is followed by the appearance of this disease, and, strangely, the observation has been made that of more than one person bitten at the same time only one may become sick, the others escaping without morbid consequences.

The location of the wound which is followed by the appearance of symptoms is variable, hands and arms being most common, face and head next in frequency. Any exposed part of the body may become the original focus of infection.

PATHOLOGICAL ANATOMY.—Usually, the site of the bite heals without incidence. Upon the occurrence of the first or successive paroxysms, the wound becomes red and inflamed looking; vesicle formation often progressing to ulceration and sloughing may occur. Suppurative inflammation or a distinct phlegmon is practically unknown.

Only twice has an autopsy been performed in fatal cases. Except for an increase of cerebrospinal fluid, no definite postmortem changes were found. In

a recent case of Schottmüller's, acute ulcerative endocarditis was noted.

The white blood corpuscle count at the height of the fever shows a well-marked leucocytosis varying from 16,000 to 21,500, with a relative increase of polymorphonuclear leucocytes to eighty-seven per cent. Occasional eosinophilia is noted. Progressive anemia is the rule.

Results of Examinations of Pathological Tissues.—While the bite of the rat is the traumatic origin of the malady, it is generally recognized from the nature and course of the symptoms that a living parasite is actually inoculated into the patient at the time of the injury. What the real causative factor of the infection is, remains inconclusively decided. Several recent contributions seem to offer definite proof of the existence of an offending organism, yet no two discoveries appear to agree in their conclusions.

Ogata[2] in 1908 reported finding in smears of the blood, excised lymph nodes, and the local lesion a variety of protozoa classed by him among the sporozoa. Ogata succeeded not only in inoculating animals and in reproducing the disease, but also in transmitting the disease from animal to animal.

Middleton[3] in 1910 reported finding a diplococcus in blood culture and smears.

In a careful study of a case, Proescher[4] 1912, noted small peculiar formations in the red blood cells, two to six microns in size. Cultures were negative as well as experiments in animal transmission.

In 1914 Schottmüller[5] reported two cases, one of typical rat-bite fever and one of a disease clinically identical with rat-bite fever, but caused by the bite of an African squirrel. From the first of these cases, he recovered, in seven successive blood cultures a Gram-positive bacterium, streptothrix in character, which grew profusely though slowly on Loeffler's serum agar medium and in milk. This organism he called *Streptothrix muris ratti* and regarded as the direct etiological factor in producing the disease. In the second case, he recovered in the pus withdrawn from the pustules near the local lesion a similar though smaller bacterium, Gram negative in staining characteristics. This latter organism he was unable to cultivate. The blood cultures were sterile, though the same organism was seen in smears of the blood. A monkey inoculated with blood from this case died in a few days with symptoms of the disease.

During the present year two further communications have appeared upon the subject.

Blake[6] reports an instance of the disease of marked severity and ending fatally after four weeks. From this case in blood culture during life and from the organs after death he demonstrated a bacterium similar to the one recovered by Schottmüller, growing slowly but profusely in media containing serum or blood, negative to the Gram stain and having many of the characteristics of a streptothrix. The organism was only very slightly pathogenic for rabbits. This organism was agglutinated by the serum of the patient in dilutions up to 1:320.

Apparently further to confuse the subject, Futaki, Takaki, Taniguchi, and Osumi[7] in a joint article very recently published, describe and illustrate a spirochete which they demonstrated in the blood, skin, and glands of two typical cases which came under their observation. The organism is a typical spirochete, a little larger than the *Sp. pallida* and but slightly smaller than *Sp. duttoni* and *Sp. obermeieri*. They were able successfully to reproduce the disease in monkeys, guinea-pigs, and white rats.

In the light of the above-mentioned reports, it is impossible to choose rationally the cause of this disease. The nature of the symptoms, recalling so distinctly relapsing fever of the Asiatics, and the prompt response to salvarsan, bespeak a spirochetal origin of the disease. But the finding of bacteria by three several authors, and of protozoa-like bodies by another, calls for guarded reserve until further scientific observations elucidate the problem. Judging from the success of many authors in reproducing the disease in animals, namely in rabbits, there seems little doubt of the parasitic origin of this unusual but most interesting malady. Yet the author[8] himself in a very accurately studied and closely observed typical though mild case, was unable to demonstrate to his satisfaction anything that could be considered etiological.

Symptomatology.—The following is a general description of the disease as it occurs in the average case.

The infliction of the wound is followed by an incubation period averaging twelve days. During this period the bite heals without incident. The first paroxysm is ushered in by a chill or repeated chills, malaise and prostration. The site of the wound begins to swell and becomes indurated and bluish red. The lymphatics stand out reddened like thin red streaks leading to the nearest regional lymph nodes; these latter are swollen and tender though discreet.

Promptly following the chill the temperature rises, reaching usually between 103° and 105° F.; the pulse becomes rapid and small. Marked sweating, occurring throughout the paroxysm, marks the remittent drops of temperature.

During the course of the paroxysm, usually one or two days after the initial chill, a bluish-red raised exanthem appears, beginning usually about the wound, and, in the majority of instances also becoming universal and appearing over the whole of the surface of the body.

Nervous phenomena are a prominent feature of the paroxysm. Prostration is marked; the reflexes are increased; hyperesthesia or paresthesia, pareses, dysphagia may be prominent. Nephritis usually makes its appearance at this time.

The paroxysm lasts usually four to five days, coming to an end abruptly, and being terminated by profuse and drenching sweats.

Usually there now ensues an interval of three to five days, during which the patient is free from active symptoms, though feeling the languor, weakness, and exhaustion expected after a severe paroxysm.

There may now follow an alternation of paroxysms and free intervals. There may be only one paroxysm, or there may be as many as twenty-six. As a rule, each succeeding relapse is weaker in its intensity than its predecessor, the disease appearing gradually to abate in its strength and the free intervals become longer in duration.

The fatal cases are severe from the onset; they run a short, and stormy course; nephritis is the usual cause of death. The moderately severe cases drag along week after week, the progressive exhaustion and emaciation being the commonest feature. The mild cases cease after one or two paroxysms, leaving the patient but little the worse for his experience.

A few of the features of the clinical course of the disease may now be discussed in more detail.

The incubation period averages twelve days. The severer cases have a shorter period before the onset of active symptoms; this may be shortened even to two or three days; in the milder cases it may extend for over three or four weeks. Fulminating cases are known to have occurred in which the incubation period was a matter of hours.

The type of fever is never regularly quite the same. Four types are described.

A. *Afebrile Type.*—This is a rare form, lasting only a few days; the symptoms are mild, neither rash nor nerve symptoms appear.

B. *Type with Continuous Temperature.*—This is really a form with only one paroxysm. The attack may be mild and disappear in a few days, or it may be severe and protracted. This latter is the variety that is most often fatal.

C. *Type with Intermittent Temperature.*—This is the common variety. Its duration averages four weeks; it may be prolonged up to six months.

D. *Miscellaneous Types.*—These include cases with purely local phenomena, fulminating cases, etc.

The exanthem varies in different instances, being sometimes a small localized rash in the neighborhood of the initial lesion, at other times appearing generally diffused over the entire body. The rash consists of large raised erythematous or urticarial macules varying in size from that of a dime to that of the palm of a hand; they are bluish red in color. Occasionally vesicles or pustules are observed interspersed with the erythematous spots.

Gastrointestinal symptoms are of little importance, except a peculiar form of dysphagia which is described in numerous cases, as occurring at the onset of every paroxysm. It is associated with salivation, huskiness of the voice or aphonia.

Of cardiac symptoms, acute endocarditis with distinct endocardial vegetations has been noted by Blake.[6] Myocarditis occurs frequently as an evidence of the severe intoxication and prostration.

The nervous symptoms of the disease play a prominent rôle throughout its course. Hyperesthesia and anesthesia are frequently mentioned. Stiffness of the joints and localized neuritides and pareses often occur. A lasting atrophy may remain as a permanent testimonial of the vicious character of the pathological changes in the nerves and nerve centers.

Marked cerebral irritability, rigidity of the neck, delirium, stupor, or coma may occur.

Duration.—The duration of the disease varies with the number of recurrent paroxysms, from a few days to six months. In a case cited by Frugoni[1] the course was protracted for over two and a half years, though there were long intervals of good health between the later attacks.

Course and Prognosis.—In general, the disease is a mild one; the succeeding paroxysms become fainter and fainter in their violence, and the free intervals more prolonged. However, about ten per cent. of the cases terminate fatally. These cases run usually a short but violent course with acute nephritis and marked nervous phenomena playing the chief rôle.

Treatment.—Locally, Miyake strongly recommends early and thorough cauterization of the wound, claiming in this way to have prevented several cases of infection following the rat bite. Carbolic acid and permanganate of potassium are particularly recommended.

Generally, except for supportive and symptomatic treatment, no therapy had been suggested until the advent of salvarsan. In the last few years several cases are reported as being cured by the intravenous use of salvarsan or the intramuscular use of neosalvarsan. The paroxysms are said to end abruptly and all symptoms rapidly disappear after the institution of this therapy. Mercury by deep injection is warmly spoken of as an adjuvant to this treatment.

Burrill B. Crohn.

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4. Proescher: Internat. Clin., Series IV, xxi., p. 27.
5. Schattmüller: Dermat. Wchnschr., 1914, lviii., Supl. 77.
6. Blake: Jour. Exp. Med., 1916, xxiii., 39.
7. Futake, Takake, Taniguchi, and Osumi: Jour. Exp. Med., 1916, xxiii., 249.
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Rat Fleas.—The two most important fleas infesting rats are *Ceratophyllus fasciatus* and *Xenopsylla cheopis;* the latter being the common carrier of the plague. A. S. P.

Ravenden Springs.—Randolph County, Arkansas. Post-Office.—Ravenden Springs. Hotel Southern, and numerous smaller hotels and inns.

Access.—Via the Frisco Railroad to Ravenden Station, thence five miles by automobiles or hacks to springs. Tourists from the East or Southwest come via St. Louis, Iron Mountain and Southern Railway to Hoxie where connections are made with trains on the Frisco for Ravenden.

This resort is located in the northern part of Arkansas near the White River Mountains, the range in which the Eureka Springs have their origin. The elevation is 1,200 feet. The geological formation is the same as that at Eureka, but the mountains are not so high or so rugged. The surrounding scenery is, however, exceedingly fine, and many features of interest are pointed out to visitors. The climate is most salubrious. The place takes its name from the "Raven's Den," a small cave with a circular opening a few feet from the top of the highest mountain. In this cave it is said that many of the feathered denizens of the forest, particularly the raven, or black crow, made their homes and hatched their young for a long period of time. Fish and game are abundant, and it is stated that many deer are killed in the vicinity during the winter months. The following analysis of the water was made by Messrs. Wright & Merril, analytical chemists of St. Louis:

One United States Gallon Contains

Solids.	Grains.
Lithium carbonate	1.26
Calcium carbonate	4.61
Magnesium carbonate	4.48
Calcium chloride	1.24
Magnesium chloride	2.99
Sodium chloride	2.19
Alumina	2.36
Silica	0.83
Iodine, iron, and calcium sulphate	Trace.
Organic matter	1.86
Total	21.82

Gases.	Cubic inches.
Carbonic acid	21.5
Atmospheric air	13.3
Temperature of water	59° F.

Emma E. Walker.

Rawley Springs.—Rockingham County, Virginia. Post-Office.—Rawley Springs. Hotel.

Access.—Via Baltimore and Ohio Railroad to Harrisonburg, thence by automobile eleven and one-half miles west over a macadamized turnpike to springs.

This is one of the famous old Virginia mountain resorts, and it unites many of the best features of a summer resting-place. The elevation is 2,000 feet above the sea-level, and the climate peculiarly dry and equable. The surrounding scenery is wild and rugged, but at the same time picturesquely attractive. The hotel at the springs is a comfortable and handsomely furnished building containing seventy-seven rooms, with a dining-room capacity of one hundred and fifty guests. It is well supplied with modern comforts and conveniences and facilities for amusement. A new hotel is to be built for the coming season. The springs here are three in number. The water of each fountain seems to possess the same general characteristics. It is without odor, and possesses a strongly marked chalybeate taste. It exhibits a faintly acid odor from the presence of carbonic-acid gas. This disappears as the paper saturated with it dries. The water is perfectly clear and transparent as it flows from the earth, but on exposure to the air it soon begins to deposit a rust-colored precipitate of the

oxide of iron. According to the analysis of water from Main Fountain by Professor J. W. Mallet of the University of Virginia.

One Imperial Gallon Contains:

	Grains.
Iron protoxide	1.3214
Manganese protoxide	0.0122
Alumina	0.0514
Magnesia	0.3874
Lime	0.3536
Lithia (detected by spectroscope)	Trace.
Soda	0.3068
Potash	0.0721
Ammonia	Trace.
Sulphuric acid	0.5208
Chlorine	0.0315
Silicic acid	0.8613
Carbonic acid (combined)	1.5624
Organic matter (in humoid acid)	0.3531

These gases are dissolved as follows:

Carbonic acid 7.24 cubic inches per Imperial gallon.
Oxygen..... 20.7 cubic inches per Imperial gallon.
Nitrogen..... 4.18 cubic inches per Imperial gallon.

The temperature of the water which is reported as remaining unaffected by the season was as follows:

Main fountain	51.8° F.
Smaller fountain	54.5° F.
Upper spring	51.8° F.

The qualities of the water are improved by the presence of carbonic acid. It is a very useful, lightly carbonated, chalybeate water, ranking high both as a tonic and alterative. The iron in the water of the main fountain exists exclusively in the form of ferrous carbonate. The iron is held in perfect solution by the great excess of carbonic acid. A larger part of the alkalis also exists as carbonates. The water is grateful to the most delicate stomach. It is beneficial in a variety of conditions: anemia, neuralgia, dyspepsia, in convalescence, in diseases of the liver, in genito-urinary disorders, in nervous debility, and in gout and rheumatic affections. The water has an extensive sale. Emma E. Walker.

Rawlins Sulphur Springs.—Carbon County, Wyoming. Post-Office.—Rawlins. Hotels.

Access.—Via Union Pacific Railroad, thence two miles to springs.

These springs are pleasantly located about two miles from the enterprising town of Rawlins. The situation is on an elevated plateau, at an altitude of 6,400 feet above the sea-level. The surrounding country is rugged and mountainous. The following analysis was made in 1894 by E. E. Slosson, of the School of Mines of the University of Wyoming, at Laramie:

One United States Gallon Contains.

Solids.	Grains.
Potassium chloride	1.40
Sodium chloride	12.18
Sodium sulphate	854.0
Magnesium sulphate	18.23
Calcium sulphate	19.28
Calcium carbonate	7.41
Silica	8.23
Carbonic acid	0.82
Total	76.09
Temperature of water at spring	48° F.

The water is said to be highly sulphureted as it flows. The above analysis having been made at a distance from the springs, this gas was lost by volatilization. Therapeutically, the water has been fully tested in only one affection, viz., so-called rheumatism. In this affection it is stated to be very efficacious, both when taken internally and when used in the form of hot baths. The water, as shown by the analysis, should possess very good diuretic and laxative properties. A first-class hotel and bath-house are much needed to put the resort on a good footing. The natural advantages of the place appear to offer excellent inducements for the establishment of a sanatorium.

Emma E. Walker.

Rawson, Sir William.—See *Adams, Sir William.*

Raynaud's Disease.—Laveran was the first to apply to this disease the name of its discoverer. To the literature of the condition Raynaud made three contributions: his thesis in 1862, his article on "Gangrene," 1872, and his "New Researches," 1874. His attention was first attracted to the subject by a case of spontaneous symmetrical gangrene which came under his observation in 1861. As the result of personal observation and a searching of medical literature he brought together twenty-five cases (Monro) upon which he based his thesis. After a study of the varied phenomena of these cases, he elaborated his theory of spasm of the arterioles and venules in the affected parts, and suggested that, therapeutically, electricity might be of value. He believed symmetry of the lesions and absence of demonstrable changes in the vessels to be two essential features in the disease. He also thought that the larger arteries might be affected by the spasm to such an extent that the radial pulse might be temporarily lost.

In the "New Researches" he describes a contraction of the arteries of the fundus oculi observed in two cases. He also elucidates more fully the theory of abnormal irritability of the vasomotor centers with consequent vascular spasm of a reflex nature.

It has long been known that under the influence of cold the fingers may undergo a change of color, becoming white and even blue. The former condition has been designated the "dead finger" (*digitus mortuus*); Raynaud called it "local syncope," and other names, such as "local anemia" (Hardy), or "regional ischemia" (Weiss) have been used to describe it. Raynaud applied the term "local asphyxia" to the affected part when it manifested a blue appearance; Weiss suggested the term "regional cyanosis" and Barlow that of "local cyanosis" as more appropriate than Raynaud's appellation. The same condition was called by Boiseau "uterine cyanosis" because of its relation to the suppression of the menses. Monro thinks that, on etymological grounds, Sir George Johnson's criticism of Raynaud's use of these terms was correct, viz., that "local syncope" should be called "local asphyxia" and "local asphyxia" should be termed "local apnea," but that the attempt to put this into practice would cause much confusion. Symmetrical gangrene is the culmination, and one of the most distinctive features, of Raynaud's disease. Raynaud's clinical tripod, then, is local syncope, local asphyxia, and symmetrical gangrene. Writers have multiplied terms in their endeavor to describe the various phases of this syndrome, but the clarity of our conception of the subject will be greatly enhanced by utterly disregarding the same.

Symmetrical gangrene is a rare condition, but "Raynaud's phenomena" (Hutchinson), local syncope and local asphyxia or either, may occur for years, finally disappearing without any gangrenous manifestation. The occurrence of local syncope or "dead finger" is seen in healthy, anemic, or neuropathic persons or in those with kidney disease unassociated with any further symptoms. (Oppenheim). An illustration of this is Mrs. M., now under my observation. When nine years of age, were she to write, knit, sew, or do any work requiring the dexterous use of the fingers, the first phalanx of the fingers of the right hand would become white, cold, and numb, eventually assuming a purple of bluish aspect; she could not again use them until the attack had passed

and feeling had returned. This condition continued until her fifteenth year when it ceased and did not again show itself until a few months ago.

Raynaud's disease usually develops before the thirtieth year. Children, even infants, may be subject to it, but I have known it to occur after the seventieth year as well. Females are more susceptible to it than males. According to Monro the ratio, as found in the medical wards of the Glasgow Royal Infirmary, has been about one in three thousand cases, but this proportion he regards as an underestimate—*i.e.* if the disease be considered purely as a neurosis, and not in its relation to other diseases of which it was an incident only. In my own experience "Raynaud's phenomena" constitute a not very infrequent condition.

Raynaud's disease may occur as a pure neurosis or it may be associated with about fifty morbid conditions such as hysteria, insanity, epilepsy, tabes dorsalis, disseminated sclerosis, parturient period, syringomyelia, myelitis, neurasthenia, spinal tumors, chorea, Graves' disease, lead poisoning, syphilis, phthisis (in about 10 per cent. of them this condition), infectious fevers, Bright's disease, chlorosis, anemia, diabetes insipidus, and a congenitally small aorta; it sometimes appears also in connection with certain dermatoneuroses, as urticaria, scleroderma, and erythromelalgia. Heredity is present in about eight per cent. of the cases (Monro). The most important causative agent is cold. Emotional influences, malaria, diseases of the female generative organs, and the breaking off of the morphine and chloral habits are all important etiological factors.

Local syncope comes first in the trinity of symptoms which characterize Raynaud's disease. It may exist alone or it may be associated with local asphyxia, a very frequent combination; or, as is more usual, all three symptoms—local syncope, local asphyxia, and gangrene—are present. Numbness and stiffness in the digit affected may usher in an attack, or there may have been in the extremity or parts involved, for days or even weeks previous, severe pain which is intensified as the attack develops.

The seizures are paroxysmal. The parts involved become pale or even corpse-like; they do not bleed when pricked, are cold, and movement is difficult. This latter, Raynaud suggests, is due to a defect of afferent impulses and not to muscular weakness. The nose, cheeks, chin, and ears are but seldom invaded. The case of Mr. G., well illustrates this phase. In September, 1902, he noticed that the first phalanx of the thumb, first and second phalanges of the index, and first phalanx of the ring finger became cold and white when exposed to the air or on touching something cold. The local syncope was at first attended by pain in the thumb and index-finger, and there were also isolated white spots distributed over the unaffected surface of the ring finger. Occasionally, should the hand become very cold, local asphyxia would occur on its dorsal surface. Sometimes, as the local syncope disappeared, local asphyxia would take its place. The involvement of the thumb here observed is very exceptional; it is usually unaffected.

Local syncope may be unilateral or bilateral. The upper extremities are more frequently involved than the lower. The syncope may attack one finger or all, or it may attack the different phalanges in an irregular manner. There is no regularity in the frequency of the seizures; they may occur once or many times daily, or there may be intervals of uncertain length. They may occur for weeks, months, or years and then cease, either absolutely or for an indefinite period. In my case of Mrs. M., already referred to, there was an interval of twenty-seven years.

The part affected is cold to the touch, tactile sense is impaired, and the various forms of sensibility are irregularly and unequally involved. Temperature sense and pain sense may be lost, or that of temperature may be present and those of touch and pain lost. Local syncope may disappear without leaving any trace or causing any pain. Frequently there occurs a decided reaction accompanied by pain and by annoying paresthesias.

Local asphyxia constitutes the second stage of this symptom-complex. Usually it is preceded by local syncope, but not invariably so. As already stated, local syncope may disappear, leaving no trace and causing but slight discomfort, or it may be followed by a blue, bluish-black, bluish-white, purple, violet or reddish discoloration of the skin affecting, sometimes symmetrically, sometimes unilaterally, the hands, fingers, feet, and toes. A livid marbling of the adjacent parts may be associated with this characteristic discoloration.

Local cyanosis differs from local syncope in not being confined chiefly to the limbs, but in attacking as well the ears, face, lips, chin, tongue, and trunk. Raynaud describes a lividity of the breasts, a painful neurosis which merits the appellation of local asphyxia of the mammæ. The extreme sluggishness of the circulation in the cyanotic area is shown by the slow disappearance of the white spot made by pressure.

The manner in which the parts are involved is most irregular, there being no definite order of sequence. The lower extremities are less frequently attacked than the upper. Sometimes an edematous condition develops in the asphyxiated parts and instead of a blue or black discoloration of the skin, with a lowered temperature, the affected area assumes a bright red hue, is hot, and becomes covered with perspiration. The edema pits upon pressure and may precede or even take the place of the cyanosis. One part may be cyanotic and swollen, while at the same time another may be only swollen. The edema is not confined to the extremities, as the ears, the face, and the tongue may also be affected (Monro).

Local asphyxia may or may not be attended by pain; often this is absent unless the cyanotic part is handled. The pain at times becomes neuralgic in character, or it may be continuous, and it varies from a slight discomfort to an intense agony. A patient of my own complained of irregular attacks of numbness for two years before the onset of the disease. In this case the pain was most agonizing from the very inception of the local syncope, which was in a few hours followed by local asphyxia, the appearance of the latter in no way mitigating the suffering.

There may be loss of motion, temperature sense, and tactile sense. Electrical sensibility may also be affected. Monro has collated some interesting cases showing that vasomotor instability is certainly a marked feature of this condition. Calmette could readily induce an attack in the susceptible parts by putting cold water on any portion of the body. Raynaud, by using electricity on one hand, caused the disappearance of cyanosis from both, while Israel Sohn, by applying friction to the upper limbs, caused the disappearance of local asphyxia from all four extremities.

The character of the onset in local asphyxia is most erratic. Discoloration may precede or follow the pain, or the two may be associated. The development of the cyanosis may be very sudden; it may take the place of, precede, or follow the local syncope; its duration may be a few minutes, hours, or days; there is no regularity in the occurrence of the attacks. The pulse may be normal or absent. There is no fever, but occasionally there are depression, headache, insomnia, aphasia, convulsions, and even unconsciousness.

Patients who have long been subject to local asphyxia may suffer from changes in the skin called "tachetic" patches; these purple areas are very persistent, are unaffected by pressure, and are probably due to extravasated blood pigment in the deep

layers of the skin (Monro). Local asphyxia, once having been developed, is very likely to recur; this liability is not, however, so great as in syncope. The Scotch verdict, "not proven" should be applied to those cases which are reported as cured.

The idea that a disturbed innervation might bear a causative relation to gangrene was entertained long before Raynaud wrote his now celebrated thesis. His contributions gave to the medical profession a new clinical concept, a disease with certain definite characteristics, viz., a local syncope, local asphyxia, and symmetrical gangrene, a distinct morbid entity. For more than twenty years medical men regarded this disease as an idiopathic affection dependent upon a vasomotor disturbance. Although the clinical entity described by Raynaud is generally accepted, it is now believed to be, in the majority of cases, merely a symptom (symptom-complex) occurring in a great variety of diseases.

Symmetrical gangrene is the last and most important of this trinity of symptoms. Gangrene is usually associated with local asphyxia; in a very few instances local syncope and gangrene are combined; often the three classical symptoms are all present, while in about two per cent. of the cases gangrene occurs alone.

Raynaud emphasized its symmetrical nature, but it may occur unilaterally as well.

The parts most likely to be affected are the extremities and ears; the thumbs suffer less frequently than the fingers. The tip of the nose, the cheeks, lips, and chin may be affected. Desquamation of the epithelium may be the only evidence of the necrosis. Unfortunately this is but infrequent. The nails may fall off, but usually reappear. Raynaud describes a peculiar type of blister, a large bulla, of a deep brown color when dry, due to gangrene of the papillary layer of the derma. Necrosis may attack one or more of the phalanges of the digits, or a portion of the foot, or even the entire foot. In one of my cases both legs were gangrenous.

The attack may be so severe that spontaneous amputation of the extremities may occur. Recovery is slow, usually extending over months. If the gangrenous process is limited to small necrotic areas, the only evidence of its existence, discoverable after recovery, will be the presence of a slight scar or scars, and the number of these is an index of the number of previous attacks. The gangrene is dry and the parts become mummified. It is usually accompanied by pain which, in grave cases, is most agonizing. The general health may suffer seriously through insomnia, pain, and suppurative processes. Fortunately, "Raynaud's phenomena" often occur for years without the presence of gangrene; indeed it may never supervene, but its appearance is always a matter of grave importance.

Oppenheim regards trophic disturbances of the joints characterized by an acute synovitis and associated with swelling of the neighboring soft parts as of rare occurrence. Griffith has called attention to changes in the bones as shown by shortening and attenuation of the phalanges. Other writers likewise have observed this trophic involvement of the osseous system. Clark says that a causal relation exists between cardiovascular disease and Raynaud's disease in about twelve per cent. of the cases. Occasionally there occur transient disorders of vision, of hearing, and of taste. Preston has called attention to the relation of paroxysmal hemoglobinuria to Raynaud's disease, while Cassirer has pointed out the similarity existing between them.

The prognosis of Raynaud's disease, considered as a pure neurosis, is, if children are excluded, always good. When associated with other morbid conditions it is that of the underlying disease. For example, a patient of my own died during a very severe attack of Raynaud's disease, gangrene and mummification being very pronounced, but death was evidently the result of a chronic Bright's disease, from which she had suffered for years.

Diagnosis is easy when the three typical stages are present. The occurrence of local syncope and local asphyxia, either separate or associated, constitutes what is known as "Raynaud's phenomena," but the additional element of gangrene is necessary to justify a diagnosis of Raynaud's disease. Painful felons may occur in the intervals between the attacks (Mills). The age, the sensory, motor, and trophic symptoms, together with the symmetry of evolution, will usually enable one to form a correct conclusion. Gangrene due to old age, ergot, and trauma is wanting absolutely in etiological and clinical characteristics.

There is a consensus of opinion among authors that local syncope and local asphyxia are of vasomotor origin. Local syncope is undoubtedly due to spasm of the arterioles; authorities are at variance as to whether the venules do or do not participate in this spasm. Local asphyxia is due to an isolated spasm of the smallest venules which impedes the outflow of the venous blood from the capillaries, thus producing stasis (Weiss). The seat of these disturbances is situated in the vasomotor center of the medulla oblongata, which regulates blood pressure through the innervation of the muscle fibers of the blood-vessels; and this center, like any other, may be irritated reflexly or directly, and in each case, varying with the intensity of the irritation, will there be an increased tonus of the vasomotor constrictors and a spasm of the vessels will result (Burdach).

Oppenheim believes that nothing is certainly known as to the cause of Raynaud's disease but that it is most probably a vascular spasm involving both arteries and veins. According to him, "the most probable explanation is that various processes (organic diseases or conditions of infection or intoxication) localized at certain parts of the spinal cord (posterior and lateral gray matter(?)) may give rise to the syndrome and that typical cases in which the condition appears independently are due to slight reparable changes."

The explanation of the occurrence of the gangrene is more plausible on the supposition of the existence of trophic nerves and a consequent perversion of trophic influence, than it is under Raynaud's theory of insufficient nutrition due to the occurrence of local syncope and local asphyxia.

We now come to the important question: Is Raynaud's disease to be regarded in all cases as merely a symptom-complex of other morbid conditions, or may it occur at times as an uncomplicated neurosis? There can be no doubt that the proper conception would be to class it under both heads, with which the present tendency is in accord. In a majority of instances it is to be regarded purely as a symptom, while in rare and exceptional cases it is, without doubt, a genuine neurosis.

Raynaud's disease offers an excellent example of pernicious habit on the part of the vasomotor system. The therapeutic problem is how to overcome its morbid paroxysmal manifestations, and, above all, to prevent by proper hygiene and appropriate treatment the tendency to recurrence. If the attack is severe and occurs in winter, and especially if the patient is debilitated and advanced in years, a change to a warm climate is advisable. The effort should always be made, during the interval between the attacks, to build up the general and nervous strength, for by this alone can the paroxysmal tendencies be retarded and possibly overcome. Everything that favors a seizure, especially undue exposure to cold, must be carefully avoided. Appropriate clothing suitable to the season, should be worn, constriction of the circulation guarded against, and the water used in washing ought to be at blood heat.

If the attack is at all pronounced, it would be best for the patient to remain indoors in a uniform tem-

perature. A mixed diet is the most suitable. Great caution should be employed in the use of stimulants, as the liability on the part of the neurotic to acquire a taste for alcoholics must never be lost sight of. If the patient has been at all subject to malarial influences quinine is the remedy *par excellence;* in any event it is a drug of unquestioned value. Opium has been greatly lauded; its chief efficacy, however, lies in its power to alleviate pain, to promote sleep, and thus to conserve the strength of the patient. Should the severity of the symptoms demand morphine, it ought never to be given hypodermically at the seat of pain, as the resulting irritation may cause gangrene. Nitrite of amyl and nitroglycerin should be given a trial. The use of thyroid extract is highly spoken of by Short. Sommer believes that thymus extract should be tried in all cases of vascular or metabolic disorders. Caffee advocates treatment by the hyperemic method. Noesske suggests incising the finger ends and applying suction. Schreiber says he has obtained benefit from this procedure in the acute asphyxia of injuries, etc., but not in the chronic asphyxia of Raynaud's disease.

When this syndrome occurs in the course of constitutional lues, as occasionally happens, the intensive treatment for syphilis by intravenous injections of salvarsan and in the intervals between the latter, injections of mercury intramuscularly, should be administered. Iron, arsenic, nux vomica, strychnine, malt, cod-liver oil, are all useful agents and potential aids in the process of upbuilding.

Spinal galvanization is perhaps one of the most efficient remedies. The negative pole should remain stationary over the sacrum, while the positive is slowly moved up and down the entire length of the spine, care being taken not to interrupt the current. The current strength should not exceed fifteen milliampères; séances should be daily, lasting not over five minutes; if the room is suitably warm, it would be advantageous to vary the spinal treatment by applying the positive electrode directly over the affected area. Galvanization of the cervical sympathetic is recommended. Since high-frequency currents influence favorably the metabolism of the blood-vessels, a current of 500 milliamperes by the autocondensation method should be employed for fifteen minutes on alternate days.

Massage, general and local, has in certain cases proved very efficacious, but great care must be exercised in its application, as the devitalized skin is liable to ulcerate if roughly handled. Should the immediate area affected be too sensitive to allow of its use, the adjacent parts may be treated. Warm fomentations have been found useful. It is of first importance that the extremities affected be kept carefully wrapped in flannel. I have known this simple precaution to be of more value than all medication. Cases where suggestion has been reported as beneficial are psychic in character and should not be regarded as a manifestation of the Raynaud syndrome.

The treatment of the gangrene is a purely surgical matter. Sufficient time, however, should be allowed for the demarcation line clearly to show itself, as the actual gangrene may include but a small part of the affected extremities.

Much will depend upon the tact and resourcefulness of the physician, and with all his remedies he must not forget the therapeutic value of hope.

C. Eugene Riggs.

Reamy, Thaddeus Asbury.—Born in Frederick County, Virginia, April 28, 1829. He studied medicine in the Starling Medical College, and received the degree of Doctor of Medicine from that institution in 1854. During the Civil War he was surgeon of one of the Ohio regiments. He afterward settled in Zanesville, the town in which he had spent his early life, and he carried on a general practice there until 1870, when he removed to Cincinnati. From that time onward he devoted himself chiefly to obstetrics and gynecology. From 1867 to 1871 he was Professor of Diseases of Women and Children in the Starling Medical College; during the following twenty years he was Professor of Obstetrics, etc., in the Medical College of Ohio at Cincinnati; and afterward Professor of Clinical Gynecology in the same institution. He died March 11, 1909.

Of his contributions to medical literature the following deserve to receive special mention: "Metastasis of Mumps to the Testicle treated by Cold;" "Puerperal Eclampsia," 1868; "Cancer of the Uterus," 1876; "Lacerations of Perineum," 1877; and "Medical Education." Reamy also devised a modification of the obstetrical forceps, and invented a dilator of the cervix uteri, an intrauterine medicator, a uterine cervical syringe, and other useful instruments employed in gynecic surgery. A. H. B.

von Recklinghausen, Friedrich Daniel.—Born at Guetersloh, Germany, on Dec. 2, 1833. He studied medicine at the Universities of Bonn, Würzburg, and Berlin, and received the degree of Doctor of Medicine from the latter institution in 1855. The title of his graduation thesis was: "De pyæmiæ theoriis." After he had received his degree he

Fig. 4402.—Friedrich Daniel von Recklinghausen.

pursued the further study of pathological anatomy under Virchow for a period of three years. Then, after spending a few months in visiting Vienna, Rome, and Paris, he settled down once more in Berlin, for the following six years (1858–64), as an assistant in the Pathological Institute. In 1865 he was chosen full Professor of Pathological Anatomy in the University of Königsberg; but at the end of six months he accepted a call to fill the same chair in the more important University of Würzburg. Finally, in 1872 he was made full Professor of Pathological Anatomy in the newly established University of Strassburg. He died, August 25, 1910.

Among the discoveries made by von Recklinghausen there are several which deserve to receive special mention. These are the demonstration of the wandering cells of connective tissue—organisms which are identical with lymph corpuscles and with the white corpuscles of the blood; the discovery of the usefulness of what is termed the "moist chamber" in microscopic investigations of this nature; and the demonstration of the changes in form and the amœboid movements of living pus cells—a discovery which served as the basis for the now accepted doctrine of inflammation. von Recklinghausen was also the first one to point out the relationship which exists between the lymph vessels and ordinary connective

tissue, and to demonstrate the existence of stomata in those particular lymph vessels which ramify, in the form of a network, throughout the superficial part of the peritoneum—stomata through which any fluid that may be lodged in the peritoneal cavity may find a way out.

The titles of von Recklinghausen's more important published writings are the following: "Die Lymphgefässe und ihre Beziehung zum Bindegewebe," Berlin, 1861; "Ueber die multiplen Fibrome der Haut und ihre Beziehung zu den multiplen Neuromen," Berlin, 1882; "Handbuch der allgemeinen Pathologie des Kreislaufs und der Ernährung," Stuttgart, 1883; and "Untersuchungen ueber die Spina bifida," Berlin, 1886. A. H. B.

Recklinghausen's Disease, or multiple neurofibromatosis, is clinically indistinguishable from molluscum fibrosum. It is considered by the majority of dermatologists, as merely a synonym of that disease. Pathologically it differs somewhat from fibroma, as there exists in neurofibromata a proliferation of the connective-tissue sheaths of the nerves, while in fibroma molluscum there is a hyperplasia of the connective tissue, mostly of the fibrous type, without nerve-tissue involvement. According to von Recklinghausen, the tumors originate from the interior of the nerve filaments in the subcutaneous tissue, and spreading upward involve the vessels, the muscles, and the follicles, dividing into fine bundles as they extend toward the epidermis. The course, prognosis, and treatment of the affection are identical with those of molluscum fibrosum (*q.v.*).

Paul E. Bechet.

Rectum and Anus, Diseases of the.—Examination and Diagnosis.—With all the methods now available, there is no reason why an accurate diagnosis should not be made in every case of rectal disease where the lesion is confined to the caudad extremity of the hindgut. Furthermore, there is no excuse for making a diagnosis without an examination, because many apparent lesions are secondary to others more important, and if slipshod methods are allowed, the physician is liable to errors—more or less grave—sacrificing the health, the comfort, or even the life of the patient. As a concrete instance we may state that a large percentage of all cases of cancer seen by the surgeon have been previously treated or operated on for hemorrhoids without the cancer being found. There is no excuse for this, as in the majority of instances a simple digital examination would have revealed the presence of a growth, and its benignancy or malignancy could be easily settled.

It is not sufficient to confine oneself to a local examination. Bleeding from the bowel may be secondary to cirrhosis of the liver, to cardiac insufficiency, to pressure from the uterus, or to a tumor of the uterus pressing on the bowel. Diarrhea may be the result of a goiter, pancreatic insufficiency, or nephritis. Prolapse of the bowel or hemorrhoids may be the result of tabes, and the physician or surgeon cannot hope to make a correct diagnosis unless he gives the patient a thorough and systematic examination. One may say that as long as a diagnosis of hemorrhoids is made, it is not always necessary to find out the exact cause; but one must admit it would be disastrous to operate on hemorrhoids when the true cause was cancer or cirrhosis of the liver. In the latter instance the patient's safety lies in the free bleeding from the hemorrhoids.

The history is important, and will often enable one to make a diagnosis; but one must not consider the diagnosis proved on the history alone. Only after a complete examination may the surgeon reach a conclusion.

One point in particular to be observed in rectal conditions is the functional action of the bowels, whether they are regular or irregular, whether the stools are hard or soft, if there is more or less frequent desire to defecate without success, if there is a feeling of unfinished stool or otherwise, if there is mucus, blood, or pus with the feces, and if so, if it is mixed or coated on the mass.

It is pain that usually drives the patient to consult the physician. Because of the abundant nerve supply and the association of the nerve supply with other more important organs, any pathological condition of the anus causes acute aching, and so incapacitates the

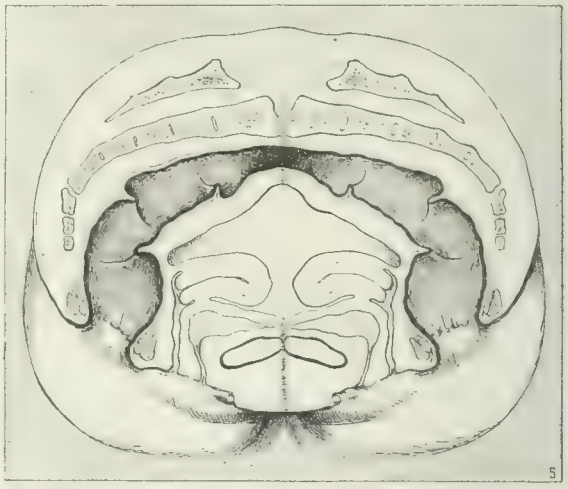

Fig. 4403.—Diagram of the Rectum and Anus for the History Sheet. (Tuttle.)

individual that he readily seeks medical assistance. And as pain is the expression of so many pathological conditions around the anus, and there are so many varieties, the proper interpretation of the character of the pain is what is important. A throbbing pain is suggestive of an abscess; a dull aching pain after exercise or mental worry, shooting toward the prostate, would suggest hemorrhoids or congestion; pain in the back may be due to a prolapse, an impaction, or a malignant growth; a burning pain suggests an acid condition of the stools or an ulceration; pain shooting down the back of the leg from the lumbar region may mean cancer or merely ulceration.

The other points to be observed are protrusion, discharge, character of the feces, hemorrhage, itching. Many of these symptoms are considered entities when in reality they are manifestations of disease in some more remote region. A retroverted uterus may account for constipation or diarrhea. If in doubt, one should always make a chemical or microscopical examination of the stools. The Abderhalden reaction or the *x*-ray will often supply the missing link in the chain of evidence, but these should be considered merely as adjuvants and not in themselves sufficient to base a diagnosis on.

When the *x*-ray is employed it must be thorough, and one must not depend on an examination of the colon or the stomach alone, because many errors will follow if such casual methods are adopted. Let us cite some instances. Mr. X. gave evidence of colonic trouble, indigestion, and other symptoms which made the examining surgeon suspicious of a growth in the colon. The colon was examined and nothing found. A diagnosis of autointoxication was then made. The author saw the patient two years later, had a general *x*-ray examination made, and a carcinoma of the stomach was revealed. If this examination had been complete in the first instance,

the patient's life would undoubtedly have been saved; but it was too late then to do anything radical.

In another case a patient giving symptoms of ulceration or malignant growth of the stomach was very carefully *x*-rayed, but this investigation was limited to the stomach. I think I counted twenty-four plates made within a short space of time. Six months later, the case was brought to me and a thorough examination revealed an adenocarcinoma of the ileocecal valve. I could enumerate other cases; but these instances are sufficient to impress on the physician the necessity of thoroughness in this as in other methods of diagnosis.

Under local examination are included inspection, palpation, digital examination, and the introduction of the entire hand under anesthesia, known as the Simon examination.

The position of the patient for a local examination will depend on the preference of the surgeon, the custom of the country, and the instruments that are used at the time. In England they prefer the right Sims; here we prefer the left Sims. This is merely a matter of convenience as the posture of the patient has to be changed frequently during the examination.

For *inspection* we usually place the patient in the Sims position, note the condition of the skin, the tonicity of the muscles, the presence or absence of an opening. At this inspection very often the presence of a fissure, external hemorrhoids, pediculi, pinworms, tonicity of the muscle, inflammation, abscess, or formation of thrombotic hemorrhoids can be noted.

Fig. 4404.—Method of Digital Examination of the Rectum.

By *palpation* a great deal can be learned; it is possible to follow a fistula without the aid of a probe, outline an abscess, note painful points which may later direct us to the location of an internal opening of a fistula, a fissure, or the presence of a tumor in the lower bowel. Palpation gives us a pretty good idea as to the condition of the muscle, and the condition of the muscle often leads to important discoveries. For instance, in tabes, the muscle loses its tone. More than once the author has been put on the right track of a diagnosis by observing the condition of the perineal muscles.

Digital Examination.—Anyone trained in this method of examination can almost immediately discover the least abnormality; even abrasions of the mucous membrane can be readily detected by the trained finger. Just as much can be accomplished by gentleness as by rough methods, and one should always put himself, mentally, in the patient's place, when making such examination. It is possible even in the presence of an ulcer to make a digital examination and not hurt the patient, always pressing gently away from the sensitive area. The entire hand can be introduced into the rectum for the purpose of diagnosis when the circumference of the hand does not exceed nine inches. Of course, this is always accomplished under general anesthesia. In the female no examination is complete that does not embrace a vaginal exploration by the usual methods.

Fig. 4405.—Proctoscope.

Instrumental Examination.—There are several instruments that are used in making an anal or rectal examination, but the most important, and one that has assisted to advance this line of work, is the electrically lighted tube known as the anoscope, proctoscope, or sigmoidoscope, when used in this locality. Fig. 4405 furnishes a very good idea of the proctoscope used by the writer. The proctoscopes vary in diameter and length. At the present time almost every surgeon and physician possesses a set of proctoscopes; but few have sufficient experience with them to interpret what they see. To one accustomed to the use of this instrument everything within view is an open book. The smallest pin-point ulcer or growth is easily seen and its benignancy or malignancy readily determined.

It is scarcely ever necessary to remove a piece of tissue for diagnostic purposes; it is a procedure fraught with the greatest danger and one that we sanction only under exceptional circumstances.

The method of passing the proctoscope is important. It is never necessary to hurt the patient when passing this instrument, except where there is some ulceration of the anus, and even then, by cocainizing the fissure first, the proctoscope can be passed without causing pain.

There are four positions which the patient assumes for the purpose of proctoscopy. As the occasion demands, the patient can be examined in the Sims, knee-chest, Haines, or exaggerated lithotomy position. We prefer the knee-chest but occasionally use the lithotomy position, as it has some advantages in certain cases.

Having assumed that position found by both patient and examiner to be most advantageous, and which may be obligatory because of some infirmity of the patient (as for instance a man with a stiff knee or hip cannot assume the knee-chest position), the instrument is held so that the handle of the obturator rests against the ball of the thumb to prevent slipping while

the instrument is being passed, and the tip of the instrument and the left index-finger are lubricated. The left index-finger is then introduced into the rectum, the patient is asked to bear down, and the proctoscope is gently passed. (See Fig. 4406.) The tip of the obturator should always press against the introduced index-finger. The instrument having passed beyond the internal sphincter, the obturator is withdrawn, and the light connected with the rheostat. From now on the instrument is passed by sight, and it is not at all necessary to damage the mucous membrane by pressure of the instrument; one should see clearly ahead and know exactly where the instrument is going. If the bowel is prolapsed the tube of a rubber inflater is attached to an opening in the instrument especially devised for the purpose.

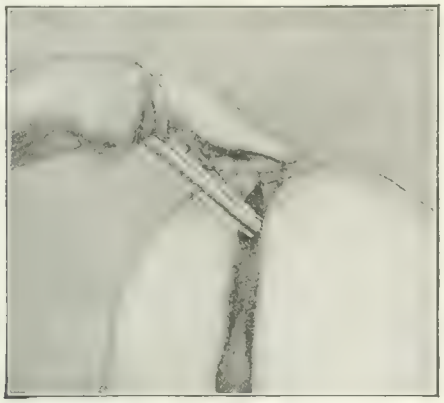

Fig. 4406.—Method of Passing the Proctoscope.

When the rectosigmoidal juncture is reached, some difficulty may be experienced in passing the tube from the rectum into the sigmoid, as very often the sigmoid turns directly to the right or to the left, and the opening is obscured by a valve. It is at this juncture that mistakes are liable to occur, and the uninitiated will imagine there is some contraction of the bowel at this point. By carefully moving the instrument from one side to the other and instructing the patient to take a deep breath, the opening will come into view, and the instrument can be passed, with little difficulty, up into the apex of the sigmoid.

After the proctoscope has reached the apex of the sigmoid, the patient is turned on his back, and, with the right hand holding the tube in position, the left hand is passed over the abdomen; the tube can readily be felt through the abdominal wall. This point is usually one and one-half to two inches above the umbilicus, more often to the right. The left hand now gradually moves the instrument from side to side. This gives one the radius of movement of the sigmoid; and, by this method, the fixity or mobility of the sigmoid can be determined. The length of the sigmoid can also be judged in this way.

The patient is now returned to the knee-chest posture if he can take that position, and the instrument is gradually withdrawn; and, in so doing one is able again to survey the ground passed over when the instrument was introduced. By this method it is impossible to overlook any lesion. When finally the instrument reaches the internal sphincter, one carefully observes the condition of the rectum at its juncture with the anus. The instrument is now withdrawn outside of the internal muscle and held in this position for a few seconds while the examiner observes the condition of the internal muscle; then gradually further withdrawn, the anal canal inspected, and also the condition of the papillæ and the crypts of Morgagni. Before the tube finally passes the external sphincter, the obturator is introduced, with the object of preventing the external muscle from closing down on the sharp edge of the tube.

Hemorrhoids.—For the sake of convenience hemorrhoids are divided into two great classes, external and internal. The external hemorrhoids are again subdivided into thrombotic, venous, and rhagades, or skin tabs. The latter are usually the result of the former. Internal hemorrhoids are classified as nevoid, or venous, and capillary.

Thrombotic hemorrhoids ordinarily result from the rupture of a vein or thrombosis of some of the veins surrounding the anus. They usually occur after violent exercise or motoring, following a diarrhea, or after a strain of any kind. They are of a purplish-

Fig. 4407.—Thrombotic Hemorrhoid. (Lynch.)

blue color, and the onset is marked by an acute stabbing pain with a pear-shaped swelling. They vary in size between an orange seed and a peach stone. If allowed to run their course, they will gradually subside by canalization, but this is a very slow and tolerably painful process, and as a blood clot is a good medium in which to grow bacteria, and an abscess may supervene, it is wiser to remove them under a one per cent. solution of novocain when they first appear. This can be done without any pain or inconvenience to the patient. By applying pressure for twelve hours, all evidence of the tumor will then have disappeared and no further discomfort will be felt.

Venous external hemorrhoids are usually associated with a very tight external sphincter muscle and can be treated satisfactorily by the application of an astringent ointment, such as the official tannic acid ointment applied twice daily, or the following modification:

R. Unct. acidi tannici	ʒiii.
Ungt. stramonii	ʒiii.
Ungt. belladonnæ	ʒi.

M. Sig. Apply twice daily.

Skin tabs are the result of a thrombotic hemorrhoid, inflammation, pruritus, syphilis, or gonorrhea. They usually cause distress on account of the difficulty of keeping the parts clean, and the consequent irritation and erosion. Such hemorrhoids may be perforated by little fistulous openings, the result of previous subcutaneous or cutaneous abscesses. In the early stage some simple local remedy, such as hot applications, keeping the parts thoroughly cleansed and dry, obviates any further trouble. When they are well developed, they should be removed under novocain. This is very simple and can be accomplished in the office or at the patient's home.

Internal hemorrhoids are due to some obstruction to the return of the circulation. The causes of this

obstruction are numerous. We cite one cause, cirrhosis of the liver, since this is the one condition when bleeding hemorrhoids should not be removed, *as this is a safety valve and the bleeding is salutary.*

There is an impression among medical men that hemorrhoids can be diagnosed by the introduction of the finger. This is a fallacy that it is difficult to eradicate. After hemorrhoids have existed for a long time and thrombosis has taken place with con-

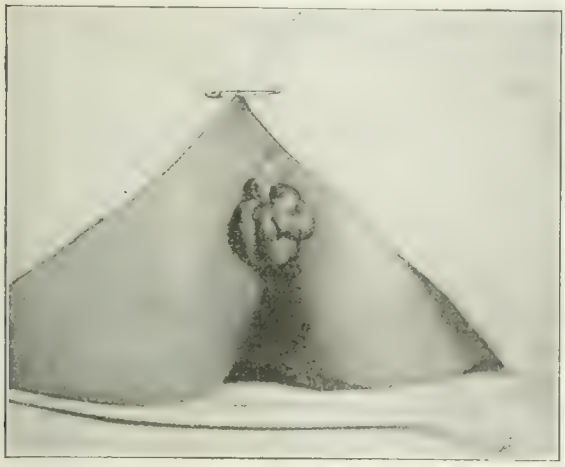

FIG. 4408. Prolapsed Internal Hemorrhoids Showing Hypertrophied and Inflamed Papilla. (Lynch.)

nective-tissue formation, hemorrhoids can be felt; but, except in this very late stage, the only method of diagnosing hemorrhoids is by seeing them.

It seems proper, at this stage, to sound a note of warning against the common practice of taking it for granted that, because a patient states that he has hemorrhoids and has passed blood, this is so. Bleeding from the rectum may mean cancer, tuberculosis, stricture, dysentery, or one of several other

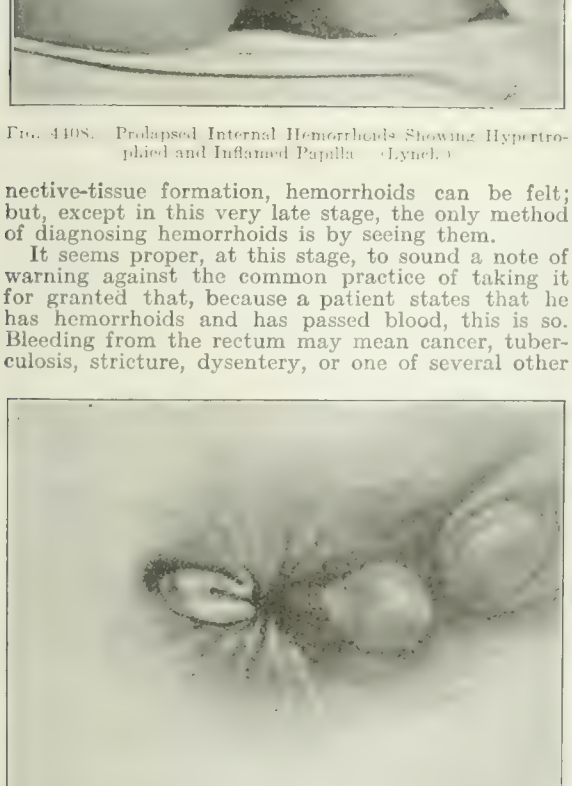

FIG. 4409.—Prolapsed and Bleeding Internal Hemorrhoid Complicated with a Fissure.

diseases. It is therefore imperative that the physician should investigate and see for himself; not alone be satisfied with seeing the hemorrhoids, he must go further and make sure that the hemorrhoids are not of secondary importance to some more serious condition. Anything short of this is criminal negligence, and this can be upheld in a court of law if pressed by the patient or his relatives.

There is one class of internal hemorrhoids that merits a word or two before proceeding to the treatment. That is the so-called raspberry, ulcerated, internal hemorrhoids (as shown in Fig. 4409) which bleed easily and frequently. This type of hemorrhoid is so gradual in its onset, and the bleeding so insidious, that the patient becomes markedly anemic and is usually found consulting a medical man for shortness of breath under the impression that he is suffering from some pulmonary or cardiac disease. His blood is examined and a secondary anemia is found. "What is the cause of this secondary anemia?" puzzles the medical man. As the patient has not mentioned the hemorrhoids, the physician often has difficulty in finding the cause of the trouble. These patients have a hemoglobin index varying between seventy and thirty, are fatigued by any form of exertion, and incapable of performing even the ordinary duties of life. It is in this class of cases that the most brilliant results accrue from treatment; the patient picks up, within a few months, is restored to vigorous health, and is mentally and physically rejuvenated.

Treatment.—The treatment of hemorrhoids was old when Hippocrates was born. Many of the methods then in vogue are still practised, but more humanely than in the olden days. The application of the hot cautery without an anesthetic is not an operation one would adopt as a pastime. Even under novocain the pain following the operation is severe.

The various methods of treatment may properly be divided into medical and surgical. The medical treatment is directed toward the regulation of the bowels, constipation being the frequent cause of hemorrhoids, putting the patient on a suitable diet in order to relieve the liver congestion if such exists, and the application of astringent ointments. Adrenalin ointment or any one of the following will be found satisfactory.

℞. Ungt. acidi tannici ..... ʒiv
Ungt. stramonii ..... ʒiii.
Ungt. belladonnæ ..... ʒi
M. Sig. Apply once or twice daily. Put up in collapsible tubes with tip.

℞. Ichthyol. ..... gr. xxv.
Argyrol. ʒi
Anesthesin. ʒiv.
Vaseline ʒi.
M. Sig. Apply as often as necessary.

℞. Tinct. belladonnæ,
Tinct. nucis vomicæ ..... āā ʒiv.
Aq. destillat. ..... ʒxv
M. Fiat mist. Sig. Two or three tablespoonfuls injected into the rectum every morning and night. (Bodenhammer.)

℞. Olei ricini vel olivæ ʒj
Infus. semin. lini tepidæ ʒviij.
M. pro enemate. (Bodenhammer.)

℞. Potassii bitartratis... ʒj
Ol. limonis..... gr. xv.
Sacchari albi ʒij
Aq. bullientis Oij.
Misce. (Bodenhammer.)

℞. Sulphuris loti,
Magnesiæ calcin.,
Sacchari lact. āā ʒj.
M. Fiat pulvis. (Bodenhammer.)

℞. Liq. plumbi acetat., ʒi
Tinct. opii ʒij
Spir. camphoræ ʒiij.
Aq. rosæ ʒviij.
M. Fiat lotio. (Bodenhammer.)

℞. Bismuthi trinitratis, ʒij.
Glycerini ʒj
Ungt. aq. rosæ
M. Fiat unguentum. (Bodenhammer.)

℞. Pulv. carb. plumbi ʒiv
Ol. olivæ q. s.
Morph. sulph. gr. xv.
Ungt. stramonii ʒj.
M. Fiat unguentum. (Bodenhammer.)

℞. Extr. belladonnæ . . ℥j.
Liqr. plumb. subacetat. dilut . ℥ss.
Morph sulph. . . gr. x.
Ungt. aq. rosæ. . ℥j.
M. Fiat unguentum. (Bodenhammer.)

℞. Extr. aloes. . . . . gr. xxx.
Extr. nucis vomicæ . . . . . gr. xx.
Extr. hyoscyami. . . . . gr. xv.
Sulph. ferri . . . . . gr. x
Ol. caryophylli . . . . . gr. v.
M. et divide in pilulas xxx. One pill daily at dinner or at bed time.

℞. Extr. nucis vomicæ . . . gr. x.
Aq. menth. piperitæ . . . . . ℥vj.
Mucil. acaciæ,
Syrupi limonis. . . . . āā ℥j
M. Fiat mist. Sig. A tablespoonful may be taken three times daily. (Bodenhammer.)

℞. Pulv. aloes socotrinæ,
Pulv. seminum amsi . . āā ℥j.
Spir. vini gallici . . . . . ℥ij.
Fiat tinctura. Sig. One or two tablespoonfuls two or three times daily. (Bodenhammer.)

The question is frequently asked whether horseback riding will create hemorrhoids. This might be answered by stating that we do not believe that horseback riding *per se* has anything to do with the onset of hemorrhoids. We have no doubt that this form of exercise is apt to aggravate them, however. After they are cured, there is no reason why riding in the saddle may not be resumed.

Ligation.—This operation is of great antiquity, antedating as it does about 400 years the birth of Christ. It has survived all others and has stood the test of time with very little, if any, change. One must naturally feel that an operation that has survived so many centuries must have great merit. As practised by Hippocrates it was as follows: The hemorrhoid was transfixed by a needle threaded with a woolen thread, and afterward tied at both sides of the pedicle. This, he asserted, was a sure and certain method of curing hemorrhoids. There is very little change in this operation to-day; we use sterile catgut or linen thread instead of woolen thread, which we assume was a trick not known to Hippocrates, although, he may have been a very clean man and his results quite brilliant. This operation, however, has its shortcomings and, in the hands of the most expert and experienced is not entirely free from danger, as illustrated by a case that came under the observation of J. B. Murphy of Chicago. In this case, which he saw at autopsy, multiple abscesses of the portal circulation had followed the operation. There are several other methods of applying the ligature, simply tying the pedicle with a single suture, subcutaneous ligation, and so on.

Clamp and Cautery Operation—This, like the ligature operation, has been handed down to us from antiquity. While not strictly surgical it is exceedingly safe and followed by fewer complications than perhaps any other of the many operations that are constantly used in the eradication of hemorrhoids.

Technique.—The tumor is brought into sight with a pair of hemorrhoidal forceps. If the case is one of combined hemorrhoids, *i.e.* external and internal, the the operator cuts through the skin until the mucous membrane is reached. The object of this is to avoid burning the skin, a burn of the skin being exceedingly painful. The clamp is fitted into the groove made by cutting the skin, the screw on the clamp is applied until the hemorrhoid is held as in a vice, and the hemorrhoid is then cut with a pair of scissors, not too close to the clamp and always leaving a good pedicle. This is essential if we are to avoid after-complications. The stump is thoroughly seared with a cautery which has been brought to a dull red heat, so that the tissues are dehydrated. If this is properly accomplished no trouble should follow. The clamp must be gradually removed; but, before doing so, some bicarbonate of soda should be dusted on to the stump, thus minimizing the after-pain. The other hemorrhoids are treated in a similar manner.

After-treatment.—The after-treatment that we have adopted following the two methods described, is to confine the bowels for forty-eight hours by an occasional hypodermic of morphine. This answers two purposes, prevents pain as well as tying up the bowels. After forty-eight hours, the patient is given an injection of a two per cent. solution of hydrogen peroxide, in order to break up and remove hard fecal matter that has accumulated during the previous forty-eight hours, so that when a cathartic is given, the patient has a comparatively easy movement. After the bowels have moved, the rectum is irrigated with a very warm normal salt solution, and some soothing ointment applied. I usually prefer the solution of balsam of Peru and castor oil. During convalescence, the bowels should be kept open and the rectum irrigated after each movement until at least the second week. The surgeon should pass his finger, covered with a finger cot, into the rectum to stretch the anus, and by this method prevent subsequent contraction.

Injection Treatment.—Mr. William Colles of Dublin was the first to practise this method of treating hemorrhoids. A number of formulas are used, all having as their basis carbolic acid. We prefer the following:

℞. Ac. carbolici (Calvert's) . . . . . ℥ij.
Ac. salicylici. . . . . ℥ss.
Sodii biboratis . . . . . ℥j.
Glycerini (sterile) . . . . . q. s. ad ℥j.
M. (Tuttle.)

The amount of fluid to be injected will depend to a great extent on the size of the tumor. It is impossible to lay down any hard and fast rule for the guidance of the surgeon in this form of treatment. One can say, in the average case, five minims should be injected; but some cases require ten, some less than five; common sense and judgment must be used. No special instrument is necessary for injection; an ordinary hypodermic syringe with a fine needle, through which the fluid can easily flow, will do.

The hemorrhoid, having been thoroughly cleansed with alcohol sixty per cent., is brought into view and one finger passed into the rectum. The needle is then passed into the hemorrhoid, but not through to the other side. A drop or two is deposited here and there as the needle is withdrawn, and, before it is finally withdrawn, a swab saturated with alcohol is placed over the needle to prevent the leakage of carbolic acid, which might be followed by ulceration of the mucous membrane. Only one hemorrhoid should be injected at a sitting. The patient should be instructed to remain perfectly quiet for twenty-four hours after the treatment and if by any chance the injected hemorrhoid should prolapse, he should call on the surgeon at once, so that it can be immediately replaced, or if the surgeon cannot be reached, the patient should make an effort to replace it himself; and he should be instructed to return for another injection in five days. This process is kept up until there is a complete obliteration of the veins in the hemorrhoid. If the case is examined some months after the operation, the hemorrhoids will be found to resemble a fibrous tumor.

Fissure.—A fissure is a solution of continuity of the mucous membrane, due to traumatism from a hard fecal passage. It may result from the tearing of one of the crypts of Morgagni. It is usually single, and, when multiple, is supposed to be of specific origin. It is situated in the posterior commissure in men, very frequently in the anterior commissure in women. The reason for this is quite evident; the support and resistance is greater anteriorly than posteriorly in men, while the opposite prevails in women. This is

especially so in women who have a congenitally weak perineal body, and such women will often state that they have considerable difficulty in expelling a stool, as it presses toward the vagina and there becomes packed. This is the reason why women so frequently suffer from a fissure in this region. There is no disease in the whole realm of surgery, of apparently minor importance, that causes so much discomfort mentally and physically, that so upsets gastrointestinal digestion, and that so frequently brings the patient to the verge of insanity. It causes constipation because of the dread of having a movement, and the increased constipation makes it more difficult for the patient to move the bowels. A vicious circle is established, a toxemia results, and we have known of more than one occasion on which a diagnosis of tuberculosis or malignancy was made because of the rapid loss of flesh, due to this apparently insignificant lesion.

In some cases, the pain is referred to the prostate in men, to the bladder or ovary in women. Each movement is followed by an intense burning pain, sometimes radiating down the back of the leg and not infrequently mistaken for sciatica. The pain may be referred to the lumbar region on account of the close association in the origin of the ileolumbar and sciatic nerves. In this disease the patient notices a little blood on the paper after each movement, though this is not always the case. The pain in fissure may last half an hour or so at a time, or it may be constantly present. There is a close association between the urethra and the rectum as one branch of the long pudendal nerve supplies the internal sphincter, another branch the compressor muscles of the urethra; hence difficulty is occasionally experienced in passing water. This also explains why eighty per cent. of patients have to be catheterized from twenty-four to forty-eight hours after a rectal operation.

In the female, bearing-down pains with backache and neuralgia are not infrequently associated with rectal fissure.

A diagnosis is easily made by asking the patient to bear down, and by gently pressing the buttocks apart, the fissure comes into view. It is then quite evident, even from a superficial examination, as there is usually associated with a fissure what is known as a sentinel pile, a little teat-like projection which is extremely sensitive.

The *treatment* of fissure may be medical or surgical, depending on its duration and depth. As the bowels are usually constipated, this should receive early consideration. It is not sufficient to order a cathartic without supplementing it with some local injection, because there is severe pain following a movement of hard fecal matter. This can be almost entirely obviated by injecting a two per cent. solution of peroxide or warm olive oil. Opium suppositories are sometimes necessary to allay the pain that follows a movement.

The *local treatment*, which is very often curative, consists in keeping the parts thoroughly cleansed and resting the muscle as much as possible. This is best accomplished by instructing the patient to lie down after a bowel movement, and by the application of moist heat. The best local applications are pure ichthyol, one per cent. solution of nitrate of silver, or tincture of iodine. When the fissure is very painful and the muscle is in a state of spasm, local treatment should be preceded by an injection, underneath the fissure, of one per cent. solution of novocain.

The *operative measures* are: incision, excision, and dilatation. When the fissure is old and the edges indurated, excision is the safest and best operation. This can be accomplished under local or general anesthesia. The shortest, easiest method is to infiltrate the base of the fissure with a one per cent. solution of novocain or hemesia, or a combination of the two. After the infiltration, the muscle is incised, and the wound is packed with gauze. In excision, the fissure with the sentinel pile is removed *in toto*. Dilatation is uncertain and attended with some risk, and more can be accomplished under novocain than by a single dilatation under gas.

Abscesses.—Abscesses around the rectum are superficial or deep. A superficial abscess may result from traumatism, thrombosis with infection, ulceration within the rectum, or a hematogenous infection. The same etiology stands for a deep abscess, except that deep abscesses, especially the superior pelvirectal abscesses, may result from prostatic infection. An abscess is very frequently preceded by a fissure, especially those abscesses that occur in the triangular space back of the rectum, and the ischiorectal abscesses. An abscess occurring as the result of a fissure may first infiltrate the triangular space and afterward work its way under the mucous membrane, reaching an enormous size and closely simulating a tumor of the rectum.

The *symptoms* are usually those of discomfort when sitting, walking, or rising. As the pus accumulates, there is a feeling of weight in the rectum, with a bearing-down pain and a constant desire to move the bowels. Deep abscesses, especially, may be preceded by chills, fever, and headache.

The *treatment* of all abscesses is the same, no matter in what part of the body they are situated. There is no such thing as medical treatment for them, surgery is the only measure which affords relief. It is a waste of time and exceedingly dangerous to wait for an abscess to ripen. This idea, indeed, is archaic and exists as a relic of medieval times. The moment there is any evidence of infection, an incision should be made, whether pus is present or not. By so doing, we limit the destruction of tissue, give the patient instantaneous relief, and put him in the best possible position to resist the infection. I have never seen an ischiorectal abscess, no matter how extensive, that could not be cured by a large incision and proper after-care. Proper after-care means packing for the first forty-eight hours, afterward washing out with salt solution or boric acid, keeping the two edges apart with gauze, and carefully watching developments. More harm can result from overtreatment than from lack of treatment. I have seen cases where drainage tubes and packings have resulted in a fistula. It is impossible for a wound to heal if it is tightly packed every day, and if this sort of treatment is kept up until the two edges come together, a fistula is the natural result.

In case of an ischiorectal abscess it is not good policy to search for an opening into the rectum; there is nearly always an opening—but it may be so small as to baffle discovery, and in the presence of a severe infection, it is dangerous to invade healthy tissue. However, the patient should invariably be informed that a secondary operation may be necessary later on. Usually, a small fistula will be found running into the rectum which can be easily opened up under novocain anesthesia, without running any risk of incontinence, as might occur if opened at the first sitting.

Fistula.—A fistula is always the result of an abscess. The rule laid down by Salmon is very helpful in indicating whether a fistula is simple or complicated and in locating the internal opening. Mr. Salmon's rule is as follows: If the external opening of a fistula is within an inch and a half of the anus and anterior to a line drawn from one tuberosity to the other, the fistulous tract is generally straight and the external opening will usually be found just inside the external sphincter. If the external opening is posterior to this line, the internal opening is commonly found in the posterior commissure and between the two muscles. There are exceptions to this rule, but they only prove the rule.

Treatment.—There is no medical treatment that the writer knows that can accomplish a cure once a fistula is established. Beck's paste, if this may be considered

a medical treatment, is occasionally helpful, especially in the blind external type; but while I have tried it faithfully I have never succeeded in curing a complete fistula by this method. However, cases have been recorded by other men so the treatment is mentioned for what it is worth.

There are various methods of surgical treatment, some more radical than others, all evidently accomplishing the same result. They are excision, incision by the cautery or knife, the application of a mucous flap after excision, and the elastic ligature. I have been practising the method of excision, and find it very satisfactory in certain types. It is applicable only to old-standing cases and those where the suppuration is reduced to a minimum. The elastic ligature accomplishes the same result. Great care should be exercised when operating on a fistula not to damage the muscle, seriously and whenever possible the fistula should be removed without cutting it.

Operation alone does not always mean a cure, for the after-treatment is of the greatest importance. Most men know how to operate on a fistula; few know how to care for it afterward. The secret of success is watchful supervision with as little meddling as possible. The overzealous surgeon can do more harm than good, and one who constantly packs, is sure to get a bad result. The trained eye and the trained finger can accomplish more than anything else. The fistula should be examined from time to time, and if it needs stimulation, balsam of Peru in castor oil, ten per cent., is the most efficacious application. By occasionally passing the finger, one can ascertain almost instantaneously whether proper union is developing or not.

Besides the simple fistulæ we have those that are complex or complicated. A small percentage are of tuberculous origin.

In all cases where there is any suspicion of tuberculosis, the fistula should be opened only by means of the cautery. If there is any delay in healing, an application of radium for twenty minutes will hasten repair of the wound. We have seen such cases heal within forty-eight hours after one application of radium. The surgical treatment of a tuberculous fistula, almost always results in the improvement of the general condition of the patient.

Rectovaginal fistula is a most distressing complication of infection of the glands of Bartholin, commonly known as vulvovaginal abscesses. These fistulæ very frequently result in stricture, and it may be necessary to perform a colostomy before we effect a cure. Rectovesical fistulæ do not occur very often; when they do, they are usually the result of a diverticulitis or a malignant growth. The most suitable treatment is colostomy and subsequent excision of the fistula between the bladder and the bowel..

Pruritus Ani.—Pruritus ani is a painful itching about the anus, due to an infection or an irritation of some kind. Murray claims, in a large number of cases, the infection is due to the *Streptococcus fæcalis*. Pruritus ani is divided into two classes: coccigenous and poikilogenous.

Coccigenous Pruritus Ani.—To determine the presence of infection, the parts are scrubbed with soap and sterile water, then washed with a saline solution; a sterile swab is used to scrape the superficial areas of the fistula. The material thus obtained is placed on some agar and afterward put in the thermostat for twenty-four hours. Irrespective of the germ found, an autogenous vaccine should be made from it and huge doses administered to the patient. The first dose, as advised by Murray is 130,000,000 dead bacteria, increasing gradually to as many as 2,000,000,000 at a single dose. The injection should be repeated every five or six days until all evidence of itching has disappeared.

Poikilogenous Pruritus Ani.—Almost every disease has been suggested as a factor, but congestion is always present. We find a large percentage of cases due to cryptitis or papillitis. There is no question but that the presence of thread worms can cause the most intense itching and should always be considered when this distressing disease occurs in children. Proctitis, internal hemorrhoids, or local irritation should be looked for in making a diagnosis.

The most satisfactory *treatment* we have found is as follows: The patient is instructed to keep the parts scrupulously clean. After the bowels have moved, the rectum should be washed out with a few ounces of a solution of boric acid 5 per cent. and physiological salt solution 0.9 per cent., or a 20 per cent. solution of witch hazel. Protection must be made against discharge of any kind, or from the rubbing of clothing. Painting the parts with tincture of iodine once in three or four days is advised, or nitrate of silver 1 per cent. solution, fluid extract of hydrastis 20 per cent. Ointment should never be used when the moisture is excessive and there is maceration of the skin, as it aggravates the condition. The following ointments have been found efficacious:

℞. Carbolic acid ..... gr. iii.
Calomel ..... ʒi.
Tar ..... ʒiv.
Menthol ..... gr. xx.
Zinc oxide ..... ʒii.
Lanolin ..... ʒii.
M. Make an ointment. Sig. Apply at bedtime.

℞. Carbolic acid ..... ʒii.
Salicylic acid ..... ʒv.
Sodium biborate ..... ʒi.
Glycerin ..... ʒi.
M. Sig. Paint on the parts with a camel's hair brush.

When the pruritus ani has existed for a long time, and all other forms of treatment have failed, the operation as devised by the author gives most satisfactory results. "The patient is placed upon his left side, with knees and thighs flexed. A point is chosen about one and one-fourth inches from the anus. At this

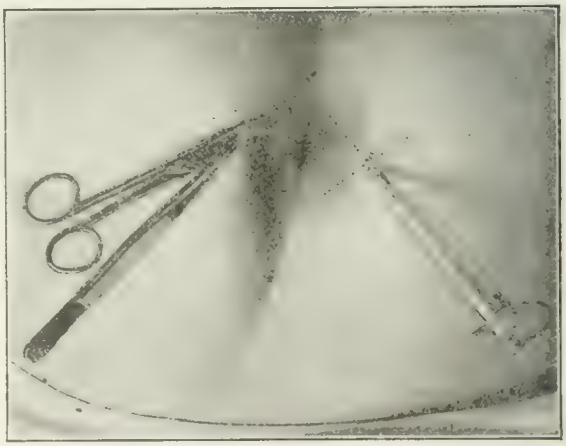

Fig. 4410. Lynch's Operation for Pruritus Ani.

point a one per cent. solution of novocain or a one-fifth of one per cent. solution of cocaine is injected or, what we have more recently used, a two per cent. solution of hemesia. An area extending to the posterior midline is anesthetized. At the point above mentioned a small curved incision is made, about one-half inch long, and extending just through the skin. Through this incision blunt-pointed dissecting scissors, curved on the flat, are introduced as in Fig. 4410. With this instrument a blunt subcutaneous dissection is carried out

working to the anus mesially and to the raphe anteriorly and posteriorly. When completed, there is an area of skin, extending from the anterior raphe to the posterior commissure and involving all the skin within a radius of one-half inch from the anus, which has been deprived of its sensory nerves. Any bleeding may be controlled by pressure. When the bleeding has stopped, a small piece of rubber tissue is introduced into the incision and permitted to remain twelve to twenty-four hours. Sometimes, in addition, a horsehair stitch is taken through the incision, but this is not usually necessary. As a rule, at the end of forty-eight hours, the wound is entirely healed. Either at the same sitting, or at some subsequent time, the same procedure is followed on the other side. The results of this operation have always been satisfactory. Though there may be a recurrence, this is not likely to take place for two or three years, and two or three years of relief is certainly a boon. The itching, of course, ceases immediately and, perianal sensation being lost, the irritation soon lessens. With proper treatment all local conditions should promptly clear up." (Lynch, "Diseases of the Rectum and Colon.")

FIG. 4411.—Exposure of the Anal Canal through Humphrey's Speculum; shepherd's-crook probe introduced into a cryptic pocket leading down into the hypertrophied medial fold. *B*, shepherd's-crook flexible probe. (Tuttle.)

CRYPTITIS AND PAPILLITIS.—In the anus there are a number of little pockets supported on either side by pillars; from the pillars develop sensory bodies; these bodies are known as papillæ. The diagnosis is made by symptoms and by direct investigation of the crypts by means of a probe bent to resemble a shepherd's crook. Fig. 4411 shows the method of investigating these little tracts. The treatment consists in removing the crypt and stretching the anus.

Inflammation of the papillæ is occasionally associated with inflammation of the crypts. The papillæ are frequently associated with hemorrhoids and sometimes attain enormous proportions. They are often the cause of pruritus or itching and give the patient the impression of passing worms. When discovered, they should be snipped off under novocain.

ULCERATION OF THE RECTUM.—Ulceration of the rectum may be due to a number of causes, as, for instance, a simple follicular infection may result in a pin-point ulceration. Among the causes we might mention are follicular, gonorrheal, syphilitic, and dysenteric; in fact, any infection of the rectum, from any cause, may result in ulceration. It is important to distinguish between the different ulcerated lesions, as the success of the treatment, to a great extent, depends upon a proper diagnosis. A tuberculous ulceration is usually irregular in outline, has an undermined border, with the base worm-eaten and covered by pus. The syphilitic ulcer is clean cut. A dysenteric ulcer is ordinarily elevated and the circumference of the base is about one-half the circumference of the outlet.

The treatment depends on the cause; but on general principles, the rectum should be irrigated two or three times a day with warm salt solution, peroxide of hydrogen two per cent., or a weak solution of iodine.

Tuberculous infection of the rectum has been treated most successfully by making an artificial anus and putting the parts at rest, and then proceeding with local treatment. Syphilis should be treated in the usual manner; salvarsan gives the most satisfactory results. Dysentery is treated with increasing doses of emetine, beginning with a half a grain once a day and gradually increasing until the dose has reached its maximum of two and one-half grains daily. A patient suffering from this disease should be treated once a month for six months, otherwise the disease will recur. Great care should be taken to keep the mouth in good condition, as it has been found recently that the gums very often harbor the ameba. The emetine treatment should, therefore, be supplemented by the local application of ipecac to the gums.

STRICTURE.—Stricture of the rectum may be due to a simple infection or to innumerable other causes, such as syphilis, tuberculosis, gonorrhea, or some one of the numerous bacteria that inhabit the intestinal tract. Infection of the glands of Bartholin, with extension of the infection to the rectum, is a frequent cause of the cicatricial contraction. Amebic dysentery must also be considered as an etiological factor. Neoplasms or abscesses cause narrowing of the bowel which may be mistaken for a true, benign stricture but such mistakes do not frequently occur and should not occur, if one realizes that stricture is ordinarily the result of a long-standing infection, the symptoms extending over a period of several years, whereas a malignant growth is usually limited to one or two years, and, in the case of sarcoma, to not over six months.

The *symptoms* of stricture are gradually increasing constipation with colicky pains, followed by periods of diarrhea alternating with constipation; a little mucus mixed with blood or pus finds its way into the rectum and causes an intense desire to move the bowels.

The *treatment* will depend, to a great extent, on the cause and on the location. Strictures situated near the anus may be treated by gradual dilatation, local applications, excision, incision, or almost any method. When the stricture is more extensive, the problem of treatment becomes a much more serious affair. We should say, as a general rule, forcible dilatation is a very unsafe method of treatment, even in the hands of the most skilful. We have obtained the best results by making an artificial anus, putting the parts at rest, and dilating the stricture from above and below. Excision of the stricture should never be practised until all the infection has been removed; and surgical intervention, having for its object the

removal of the stricture, should be considered only as a last resort.

Prolapse of the Rectum.—Prolapse of the rectum is commonly spoken of as complete or incomplete. One should be able to distinguish between the two almost immediately by the fact that the sulci run all around the bowel in a complete prolapse, and longitudinally in an incomplete one. The incomplete prolapse is usually found in children and in old people. Occasionally it follows the continuous use of saline cathartics. By asking the patient to strain, or by giving an enema, the prolapse can be brought into view. A proctoscopic examination should never be neglected, as a simple polypus may be the cause of the prolapse, and when this is removed the prolapse gradually improves. Indeed this is sometimes all

Fig. 4112.—Complete Prolapse of Rectum, Vagina, and Uterus. (Lynch.)

that is necessary to effect a cure. Tabes dorsalis is almost invariably complicated by prolapse. It is important, therefore, that this cause should not be overlooked, as radical measures under these circumstances are out of the question, and even if undertaken, would be of only temporary relief.

Treatment.—In young children, it should be seen to that the child has an easy movement without straining, and in some cases it may be necessary to administer a cathartic or enema. Whenever possible, the child should move his bowels flat on his back, and this can be accomplished by the use of a bedpan.

Surgical treatment sometimes becomes necessary on account of the chronicity of the trouble. When this is indicated, there are many simple operations which are very effective. Clamping the prolapse and burning it off by means of the cautery the same way in which we treat hemorrhoids; ligation, with or without cutting; or some modification of the Whitehead operation. In children, replacing after a movement and then spreading the buttocks with adhesive plaster is sometimes sufficient to effect a cure. A method which has been in vogue for many years, and which has sometimes been exceedingly effectual, is the application of the actual cautery to the mucous membrane or touching the mucous membrane with fuming nitrous acid. With the latter we have had no personal experience.

Complete prolapse is usually due to a recurrence of the ligamental supports of the rectum, or an unusually deep culdesac. In the latter case it would come under the heading of true hernia. This cause is comparatively rare.

Many operations have been devised for the cure of prolapse, but only those with which the writer has had experience and which he considers best will be given. In prolapse of the first degree the operation of the writer has proved satisfactory.

"The patient having been prepared in the usual manner, the parts are painted with tincture of iodine and the patient put in an exaggerated lithotomy position well over the edge of the table. A vertical incision is made from about one-fourth inch back of the posterior commissure to the coccyx. The parallel fibers of the external sphincter are incised, and the incision continued through the levator ani muscle and fascia. After the levator muscle is divided, it is held apart by means of two retractors. The rectum is now brought out through the incision and scraped with a dull curette. Six longitudinal sutures are inserted and tied. By this means the posterior wall of the bowel is folded on itself. Three transverse sutures are now inserted and brought out on either side of the sacrum and coccyx and tied over a piece of gauze. The levator ani muscle is brought together by two or three plain catgut sutures, care being taken not to tie the sutures too tight, but just sufficiently to bring the muscle fibers in apposition. The fascia of the levator is closed by interrupted chromic catgut sutures, and the skin by means of a continuous suture." (Lynch, in Johnson's "Operative Therapeusis," vol. iv.)

The Quenu-Moschcowitz operation is as follows: "Pagenstecher or silk sutures are passed circularly around the cul-de-sac of Douglas and tied. The lowermost suture is placed about an inch above the inferior extremity of the cul-de-sac; similar sutures, six to eight in number, are passed at intervals until practically the entire pouch of Douglas is obliterated." (Lynch: "Diseases of the Rectum and Colon.")

Where the prolapse is very pronounced, some modification of the Mikulicz operation may be used. The patient being in the lithotomy position, with hips well elevated, the prolapse is dragged down as far as possible with traction forceps. It is then clamped by two vulsella and held in this position by assistants. The elevated position of the hips allows any coil of small intestines to slip out of the peritoneal pouch and so escape the danger of being wounded. After the intestine is dragged down, it is surgically cleansed and dried by sterile gauze. Sterilized gauze is now used to pack the gut in order to avoid soiling the wound. After these preparations, an incision is made through the mucous membrane about an inch from the skin, upon the interior surface of the gut. Dissection is carefully carried through the entire thickness of the intestine, all bleeding being checked as it occurs, until the peritoneal cavity is opened. Here Cunningham uses a clamp, which is an improvement on Mikulicz's method. When this is done, the serous membrane of the intussuscepted portion of the gut is brought into view. This membrane is cut through and its upper edge sutured to the peritoneal edge of the wound in the anterior layer of the prolapse. Thus, step by step, the peritoneal pouch is closed. This having been accomplished, the entire thickness of the intussuscepted gut is cut through, little by little, and its muscular and mucous layers are sutured by chromicized catgut to the mucous membrane surrounding the margin of the anus at the side of the original incision. In this manner the entire prolapse is excised, and end-to-end union of the gut is accomplished.

The ends of the sutures in the muscular and mucous layers are left long, in order to steady the parts

and prevent their retraction while the operation on the other portion of the circumference is being made. All bleeding points are caught, and either twisted or ligated during the operation.

It should be noted that if, after completing the excision, the edges of the mucous membrane are not in accurate apposition, a continuous suture should be applied halfway around the gut, and tied, and the other half afterward treated in the same manner (a complete suture is apt to cause contraction). The long end of the sutures should then be cut off and the wound dusted with boric acid or thymol iodide.

The operation being thus completed, the gauze is removed, a Lynch tube introduced, and the buttocks strapped with adhesive plaster to prevent the tube from coming out. The perineum in then repaired and the patient returned to bed.

Neuralgia of the Rectum.—Since the advent of more exact methods of diagnosis, the cases of true neuralgia, like neurasthenia, have become fewer. In one case that came under the writer's observation, where a diagnosis of neuralgia had previously been made, he discovered a foreign body in the cul-de-sac, the removal of which caused entire disappearance of the neuralgic pains. But one should carefully exclude foreign bodies, hemorrhoids, fissure, cryptitis, papillitis, congestion of the posterior urethra, and every and all morbid conditions that may account for pain and discomfort, before making a diagnosis of neuralgia of the rectum. Many authentic cases, however, have been treated from time to time. Parmentier and Farland report two such cases one in a man of thirty-six, the other in a woman of forty-six. Both cases were preceded by acute inflammation of the colon. In the case of the woman the exacerbations always followed eating. In both cases the application of very warm douches accomplished a cure.

The writer remembers one patient in particular, a neurotic woman, who had suffered for years from severe pains in the rectum. These pains were worse during the menstrual period. She was entirely relieved by the application of warm, alkaline douches. Tuttle has reported a number of cases of urethral and bladder infections which caused rectal symptoms, and one should always be on the lookout for peripheral manifestations in the rectum. Prolapse of the ovary has been known to cause neuralgic pains in the rectum.

Besides the neuralgic or sensitive rectum, there is also another condition, quite the opposite, in which there is a marked decrease in the normal sensibility. Under such circumstances, we should always be very thorough before making a diagnosis lest we overlook such a profound cause as tabes dorsalis. When there is a marked insensibility without any apparent cause, painting with tincture of iodine helps restore normal tone and sensibility to the part. Cold water injections have occasionally been found very useful.

The Sigmoid.—This and the cecum are two of the most variable organs in the body. The sigmoid may be very small or it may be exceedingly large. When redundant, it causes constipation. On account of its proximity to the tubes, ovaries, and uterus in the female, it is often secondarily involved. When we consider the large percentage of women who suffer from affections of the genital organs, it is surprising that the sigmoid is not more frequently diseased. One case came under the observation of one of our colleagues, where a large diverticulum of the sigmoid became adherent to a fibroid. In another case, the apex of the sigmoid was adherent to the fimbriate extremity of the tube, and both were closely adherent to the bladder. When the sigmoid is redundant, one can see how kinking and angulation are much more apt to occur than when it is short and less mobile. In the former case intussusception not infrequently follows straining and the use of cathartics.

One case of adenoma came under our observation in which there was complete intussusception of the sigmoid, the adenomatous tumor appearing outside of the anus. Complete recovery followed operation.

Volvulus of the sigmoid is comparatively frequent and is usually the result of overdevelopment of the organ, occurring in cases where the sigmoid is long.

While diverticula may occur in any part of the intestinal tract, the sigmoid is more frequently affected than is any other organ. The diverticula are usually multiple, though a single diverticulum has been reported. I have already mentioned one case in the practice of a colleague. They occur in the rectum, but they are exceedingly rare. These diverticula are often concealed and may be overlooked at operation on account of the frequency with which diverticula are associated with fatty sigmoid. The fat acts in two ways, by causing the weakening of the musculature, and by providing a series of spots of lowered resistance to pressure from within, especially opposite the appendices epiploicæ where the majority of diverticula occur. These pockets, like the appendix, as long as they drain, do not cause any serious trouble, but when, from some reason or other, fecal matter finds its way into the pockets, an ulceration results. If the organisms which cause the inflammation are of low activity, then we have a subacute inflammation with a proliferation rather than a destruction of tissue. Under such circumstances, a large tumor mass is formed which is frequently mistaken for cancer. On the other hand, if the organisms are very active, we have an acute inflammation with gangrene of the sac. We may have a chronic proliferative inflammation with adhesions to adjacent organs. The bladder in such cases is the organ most frequently affected. In one case which came under the observation of the writer, the small intestine was adherent to a diverticulum, resulting in acute intestinal obstruction. A chronic inflammatory process may involve the mesentery, giving rise to sigmoid mesenteritis, which may result in shortening of the mesentery and kinking of the bowel. The conditions which are most likely to be mistaken for diverticulitis are sigmoiditis due to inflammation of some neighboring organ, or to ulceration within the bowel, appendicitis with left-sided symptoms, inflammation of the pelvic organs, hyperplastic tuberculosis.

The treatment is entirely surgical and depends to a great extent on whether the process is an acute or a chronic one. Usually in a chronic inflammation some other neighboring organ becomes involved, this being most frequently the bladder. An acute process should be treated as any other acute condition in the abdomen, such as appendicitis. Where a large tumor has developed, it should be treated on the same principle as a malignant tumor.

Benign Tumors.—"Benign tumors are new growths whose cells are arranged in the same systematic order as the tissues from which they are derived, with no special function, and with a tendency to grow away from the parent tissue. Different types of these tumors are found in the rectum and sigmoid according to the tissue from which they are derived. Some are very rare, others comparatively frequent. All tumors are potential cancers, and as it is difficult to state how long the cell composing a benign tumor will refrain from anarchy in growth, their prompt removal when discovered is the surest means of avoiding future trouble. Besides, no matter how innocent a tumor is when situated in the gastrointestinal tract, it is a constant source of danger to its host by its tendency to cause either intestinal obstruction, intussusception, volvulus, obstruction to the circulation of the bowel, disturbance of nutrition, diarrhea, or constipation." (Lynch, *loc. cit.*)

Adenoma.—The adenoma is the most common type of the benign tumors, and they may be single or

multiple. When single they usually have a long pedicle; when multiple, they are sessile. The single adenoma is found both in adults and in young children, and may exist for a long time in the latter, before attracting the attention of the parents. The first symptom to attract attention, is the passage of blood and mucus and a frequent desire to go to the toilet, with a feeling as if there were something more to come away. When they occur in adults, the diagnosis is easily made because of the constant desire to move the bowels; and, in some cases, the very persistent and imperative necessity of emptying the bowels so incapacitates the patient that he is often afraid to go any distance from a toilet. At other times the digestion is so upset that patients are often treated for intestinal indigestion and have stomach symptoms, as in one case referred to the writer. In this particular instance, the diagnosis was exceedingly difficult because the pedicle was at least six inches long, and when the proctoscope was passed the tumor would disappear way up in the region of the sigmoid, so that it was only by persistently examining this patient that the diagnosis was finally made. On the occasion when the tumor at last came into view it was held by a forceps until a snare was brought, by which the tumor was removed. After the operation, the patient gained in weight and all his symptoms disappeared.

The earliest symptom in children is fretfulness which is often mistaken for intestinal colic. I have removed as many as six polypi in one child. Anemia may be a marked symptom, especially in children where the parents are not observing, and the constant loss of blood results in secondary anemia.

On the other hand, the multiple polypi are a much more serious menace to life, as a comparatively large percentage eventually undergo carcinomatous degeneration. Forty-one such cases were collected by the writer with the following results: ten were pedunculated, two sessile, ten pedunculated and sessile, nineteen not classified. The symptom in these cases is usually constipation alternating with diarrhea, the passage of mucus, blood, and pus.

The treatment of the pedunculated adenomata is simple and consists in removing the tumor by means of a snare. Where the tumors are multiple, they usually involve the entire colon up to the ileocecal valve. Under such circumstances, I have found the best treatment is to put the bowel absolutely at rest. This can be accomplished by a cecostomy or an ileostomy. I have tried this treatment in three cases with the entire disappearance of the tumor and, in one case, a gain of thirty pounds. After the ileostomy or cecostomy has been made, the bowel is washed out with astringents.

Fibroma.—The fibromata are usually pedunculated and when occurring in the lower part of the rectum, are commonly due to hemorrhoids, which have undergone fibrous degeneration; occasionally to other conditions. When seen they should be removed either by tying off with a ligature, or by a snare.

Myoma.—This may occur in the buttocks or in the bowel wall. When myomata occur in the bowel wall, they usually grow in toward the lumen. The symptoms are those of pressure or obstruction, as a rule, and the treatment consists in the removal of the growth as soon as possible.

Papilloma.—These tumors occur most frequently around the margin of the anus, and there they are known as warts.

Condylomata Acuminata.—These occur in the papillary layer of the skin and are usually associated with moisture and filth. The treatment is exceedingly important as simply cutting them off is not safe; when this is done, they almost invariably recur. They should first be removed with the scissors and then the stump thoroughly cauterized by means of a platinum wire. If this method is followed, recurrence does not take place. It is necessary to instruct the patient to keep the parts clean and dry.

Villous Tumors.—The villous tumors closely resemble the ordinary adenomata, except that there is less glandular and more connective tissue and they reach an enormous size. They are usually attached by a broad pedicle to the bowel and quite a percentage undergo carcinomatous degeneration. The symptoms are the passage of large quantities of mucus and blood, and a frequent desire to move the bowels. The removal of the mucous membrane which forms the base of the tumor is necessary in order to prevent a further recurrence. The author has preformed the operation two or three times under local anesthesia, but does not recommend this method except in selected cases. Ordinarily, it is better to give the patient a general anesthetic, for in so doing, the tumor can be more thoroughly removed and there is less likelihood of hemorrhage.

Dermoid Cysts.—Dermoid cysts may occur back of the rectum or at the margin of the anus, and give the same symptoms as any other tumor. Occasionally they rupture into the bowel, and are discovered only at that time.

Lipoma.—These tumors may occur at any portion of the gastrointestinal tract. They occur sometimes at the margin of the anus.

Postanal Dimple.—Postanal dimple (Fig. 4413) is due to an imperfect approximation of the lateral halves of the buttocks during uterine life. It

Fig. 4413.—Postanal Dimple. (Lynch.)

is usually situated at the crease of the buttocks, and occurs more frequently in hairy people. It may be mistaken for an ordinary fistula, a dermoid cyst, or a sequel of syphilis. A proper appreciation of the fact that these skin fistulæ are lined with epithelium and contain hair follicles is important, because, if the entire tract is not dissected out, it is sure to recur; when simply opened up it almost invariably reforms.

Cancer.—Next to the stomach, the caudal extremity of the human alimentary canal is the most frequent seat of malignant disease. The termination of the hindgut, which has a blind caudad extremity, forms the rectum, whereas an inflection of the ectoblast forms the anus. Dividing these structures there is a membrane which later breaks down, giving outlet.

This is analogous to the condition at the cephalad end. In the ectoblastic part there is a very abundant lymphatic and nerve supply which gradually de-

creases cephalad so that two to three inches from the anus there is at birth practically no sensation. These two factors have great prognostic and diagnostic value. Malignant growths are lethal in direct proportion to their nearness to the ectoblastic tissue and this is significantly true at both extremities of the alimentary canal.

As pain is the normal protection of the tissues from injury throughout the body, so in the anus malignancy, or its forerunner, is more quickly recognized by subjective sensations than similar conditions cephalad to the anus. This is what should be expected, for the loss of pain sense is compensated for by proportionate diminution of the lymph supply and of the consequent malignancy.

Now, it is a singular fact that cancer occurs most frequently in those sections of the alimentary canal that are subject to chronic insult and irritation; note cancer of the pylorus and cancer of the rectum. This being the case, chronic constipation must have an important bearing on the development of rectal carcinoma. The same may be said of ulcerative or infectious conditions. The majority of rectal cancers occur at the peritoneal reflection.

The earliest sign of cancer is constipation. This occurs irrespective of the size of the growth or of its encroachment upon the gut lumen. It is equally true of laterally implanted growths, as of the annular types. It is next to impossible, by either catharsis or enemata, to empty the bowel of the fecal mass which accumulates in the dilated pouch just oral to the growth. It is common to associate diarrhea with a new growth, but, of course, diarrhea is not evidence of the absence of constipation, for the most persistent diarrheas are those associated with constipation. The frequent and imperative desire to defecate is not properly a diarrhea, but a mere subjective reflex without objective basis.

The presence of mucus and blood in the stools is so common a condition that it attracts little or no attention on the part of the patient. Next to constipation it is the earliest symptom and may even exist before constipation, as any slight irritation of the bowel causes an outpouring of mucous.

The usual history given by a cancer patient is as follows: He will state that up to a certain date he was well, then a change took place, the exact nature of which it is usually difficult for him to describe. This condition was followed by gradually increasing constipation or diarrhea. Subsequently, he had an imperative desire to move the bowels, with a feeling of unfinished stool. This occurred perhaps once or twice a day at first. The movements were explosive; he may have noticed a little blood, or passed clotted blood mixed with mucus and feces. Then he was aware of an uncomfortable feeling in the pelvis; knew there was something wrong without being able to define it. As time went by, the desire to go to the toilet became more imperative and more frequent; he had to go several times during the day and the first thing in the morning. A little later on, he suffered from indigestion, sleeplessness, and had to empty his bowels several times during the night. There may or may not have been a loss of weight; as a general rule the appetite was variable; occasionally nausea was present. This is the history of the average patient. We have seen cases where the only symptom was the passage of a little blood during or after a movement. Sometimes it is noticed on the paper, at other times in the toilet. We have seen a good many cases where the first symptom was a very severe hemorrhage, followed later by a quiescent period and then the usual symptoms. The history, no matter how carefully taken, is not of great value in the majority of cases, because there are few patients so observing as to be able to furnish reliable data of their condition. As a general rule, when the symptoms are so pronounced as to attract the attention of the patient the growth is well developed, not necessarily inoperable, but well advanced.

If, whenever *any* of the above mentioned symptoms come to our notice, we make a protoscopic examination, cancer will be discovered in a large proportion of cases. By waiting until *all* these symptoms are present, the cancer will be well advanced before discovered. If we made this examination regularly, regardless of symptoms, cancer of the rectum would be discovered in its incipiency. Early diagnosis is impossible at present because of the lack of a regular, systematic examination of the bowels. I would therefore urge that every patient suffering from constipation, diarrhea, blood, pus, or mucus in the stools, especially hemorrhoidal cases, should be protoscoped before measures for relief are instituted. I have purposely omitted other diagnostic adjuvants, such as the Abderhalden reaction, blood reaction, and many others that are useful in cancer in other parts of the intestinal tract, but are superfluous in cancer of the rectum.

The following table gives the results in our operated cases to date:

	Operations.	Recoveries.	Deaths.
Adenocarcinoma	144	106	37
Epithelioma	5	5	
Sarcoma	7	7	
Colloid carcinoma	2	2	
Scirrhous carcinoma	2	2	
Malignant papilloma	6	6	
Malignant condyloma	1	1	
Malignant stricture	1	1	
Totals	168	130 (77%)	37 (22%)

Of the 130 recoveries, we have reports from 58 to date; 39 were well without evidence of recurrence after three years, and 19 reported recurrences.

Combined Operation.—The abdomen is opened by a median incision, and, if the subject is unusually stout, this incision is continued to the left of the umbilicus until there is sufficient room in the abdomen to do the work without the undue interference that results from a small incision. The patient is then put in the Trendelenburg position. It is most important that all the small bowels should be removed from the pelvis and walled off, so that when the patient is returned to the prone position, the small bowels do not fall back into the pelvis in any way. This being accomplished, a self-retaining retractor is secured in place. The sigmoid is brought out of the wound and, in so doing, tension is put on the sigmoidal vessels. This is important, as indicating the blood-vessels which are to be tied. The right leaf of the mesenteric peritoneum is slit, and scissors curved on the flat passed through the opening. This instrument can be passed for a considerable distance. By gently opening the blade the peritoneum is separated from the fat and blood-vessels, and the peritoneum is cut with a knife, using the scissors as a director. The left leaf is treated in the same manner as far as the culdesac. Here a transverse incision connects the two longitudinal incisions. The sigmoidal arteries are ligated close to the root of the mesentery. A little below the sigmoidal vessels, as the bowel passes over the promontory of the sacrum, the superior hemorrhoidal artery can be found, and it also is ligated. These two arteries having been ligated, the bowel can be dissected out from between the two leaves of the mesentery, carrying with it all fat and glands. This dissection is continued to the levator ani by means of a periosteal elevator or scissors. The bowel is separated in front from the vagina in the female and from the prostate and urethra in the male. The lateral ligaments should be doubly clamped, otherwise severe bleeding may result from cutting the middle hemorrhoidal arteries.

From now on there is some difference in technique,

depending to a great extent on whether the surgeon proposes to eradicate the lower segment and leave the patient with an artificial anus, or whether he intends to remove the lower segment and bring the sigmoid down to take its place.

If the first is to be carried out, the bowel is double clamped and divided below the peritoneal reflection. This division is always to be accomplished with the cautery or with a Pryor clamp. After the bowel has been divided, the lower segment is invaginated and closed by a purse-string suture. The upper segment is treated in the same way, covered over with a cloth and brought outside of the abdominal wall. The operator now proceeds to close the peritoneal floor, and, for this purpose, the peritoneum that has been dissected from the mesenteric leaves is used. The peritoneum is closed so that no raw surfaces are left. The abdomen is closed in the usual manner except that the peritoneum is stitched to the oral end of the bowel, and the fascia is closed by interrupted sutures; also the skin. A Paul's tube is inserted into the lumen of the oral end.

The surgeon can now return the patient to bed and divide the operation into two stages, removing the caudad end at a subsequent operation, or the patient can be put in the lithotomy position and the caudad removed at the same sitting.

Removal of the Rectum.—The technique of this portion of the operation is very simple, because it is not necessary to save any of the structures. A wide incision is made around the anus, about an inch from the opening, and, by this incision, all the glands and skin are removed. The dissection is continued up to the levator muscle. Here, an opening is made posteriorly in the muscle, and the surgeon passes the left index-finger through the opening, bringing it forward on the left side close to the gut where the levator ani is attached. Using the finger as a director, the operator separates the levator ani muscle from the bowel. Then this same finger is passed over on the right side, where the same procedure is carried out. After this, the entire lower bowel is removed. A drainage tube is passed into the cavity, and around this is packed some gauze. The levator muscle and its fascia are brought together by interrupted sutures and the skin is treated in the same manner. The posterior incision should now be prolonged to the side of the coccyx as far as the sacrum, and the wound closed, leaving an opening sufficiently large to allow removal of the gauze and the drainage tube. By continuing the incision posteriorly, we reach the most dependent portion of this large cavity and, in this way, establish efficient drainage.

In the second procedure, the operator dissects the bowel free from its mesentery and from the vagina in the female or the prostate in the male; and, posteriorly, as far as the levator muscle. One of two methods can be followed: The assistant makes an incision between the rectum and the coccyx, continuing the incision if necessary to the sacrococcygeal joint, afterward separating the levator muscle. Through this opening the forceps is passed and a piece of gauze or tape tied around the bowel above and the ends of the tape placed between the jaws of the clamp which has been passed up from below. The clamp is now withdrawn and with it the bowel which is brought out through the posterior incision. The operator closes the peritoneal floor and afterward the abdominal cavity. In the other procedure the bowel is packed down into the pelvis and the new diaphragm made about an inch above the old one, and the abdomen closed. The patient is then placed in the Trendelenburg position and the anus closed by means of a purse-string suture. The mucous membrane is dissected free from the skin, as in a Whitehead operation, and the sphincter muscle slit posteriorly, the levator muscle separated from the bowel, and the tumor with the lower bowel brought through this opening until healthy bowel is reached. Here the bowel is double clamped and cut through by means of a cautery, care being taken to tie the blood-vessels at the mesenteric border. The levator muscle is attached to the gut with two or three interrupted sutures, and over this the fascia is sutured snugly around the bowel. The two ends of the divided sphincter should be brought together with catgut sutures and afterward the skin with silkworm-gut sutures. The next step consists in sewing the mucous membrane to the skin and around the anus. When this is completed, a drainage tube is placed in the rectum. Into the cavity back of the rectum, a small drainage tube is passed and some fluffed gauze packed into the cavity to prevent oozing. The posterior incision should be continued back to the site of the coccyx so that drainage may be established at the dependent point.

JEROME M. LYNCH.

Red Bugs.—Chiggers. Immature mites of the family *Thrombiidæ* which attack the skin. They may be prevented by sprinkling the underclothing with powdered sulphur or naphthalene. See *Arachnida.* A. S. P.

Redia.—A larval stage in the development of flukes. Ripe eggs pass out with the feces. These hatch into ciliated larvæ which swim about in the water and bore their way into a pond snail. Here the larva is completely reorganized into a bladder-like sporocyst, which has rediæ developed inside it. The rediæ in turn give rise to tailed cercariæ which break out of the snail, swim to grass or other vegetation where they become encysted and await a chance to infect a vertebrate. They mature in this vertebrate host. See *Trematoda.* A. S. P.

Redlands and Riverside.—These two places may be taken as representing the climate of the eastern foothills of Southern California, where are to be found many resorts favorable for a winter or an all-the-year-round residence.

Redlands (1,350 feet), in San Bernardino County, lies in the East San Bernardino valley, and is surrounded by mountains from 5,000 to 12,000 feet high on the north, east, and south, and lies open to the sea on the west, from which it is distant about eighty miles. The city is beautifully situated and substantially built, and contains over 10,000 inhabitants. It is a favorite place of winter residence for Eastern people, and in attractiveness of situation and the character of its inhabitants and residences is comparable to Pasadena. Parks, many churches, a fine public library, excellent schools, clubs, golf links, good hotels, are all to be found here. The soil is porous and rich, and especially favorable for the cultivation of the orange, which is the principal fruit grown here. The water-supply is a fine one, and affords irrigation for the orange groves. There is a sewer and storm-water system, and the sanitary condition appears to be of the best.

Redlands has good railroad connections and electric roads; and from it one can easily reach the various attractive mountain resorts on the one side and those of the coast on the other.

One rarely meets with a more attractive town, even in Southern California, than Redlands, exhibiting as it does so many of the natural attractions peculiar to all this region. Wherever there is irrigation, flowers of endless variety abound, and the most luxuriant vegetation flourishes. The dust of the streets is laid by the crude petroleum, so abundant in Southern California. By this process an almost perfectly dustless road is obtained, and remains so for many weeks from a single application of the oil.

The characteristics of the climate of Redlands, as, indeed, of all this eastern foothill region, are equability, comparative dryness, abundant sunshine, and a small rainfall occurring mostly in the winter and spring. Early morning fogs, so-called "high fogs," may also be considered a climatic characteristic, for they are not of infrequent occurrence here, as elsewhere in Southern California.

The average rainfall is 15.59 inches, of which 7.45 inches falls in the spring and 6.55 in the winter. The mean annual relative humidity as given by Bridge ("The Climate of Southern California," Transactions of the American Climatological Association, 1901) is 64.4 per cent. The average mean winter temperature as given by the same authority is 54.7°; for summer, 75.3°; spring, 63°; autumn, 66° F. (Solly). Sanborn ("The Climate of the Eastern Foothills," by Dr. C. A. Sanborn, Redlands, Cal., Transactions of the American Climatological Association, 1902) gives for Redlands the following extremes of temperature from an average of three years for the three months exhibiting the greatest extremes of heat and cold:

January	Mean maximum temperature	62 degrees.
	Mean minimum temperature	40 degrees.
February	Mean maximum temperature.. about	69 degrees.
	Mean minimum temperature.....	42 degrees.
July	Mean maximum temperature...about	95 degrees.
	Mean minimum temperature	59 degrees.
August	Mean maximum temperature...about	91 degrees.
	Mean minimum temperature.....	58 degrees.

The average mean relative humidity of Redlands for these months is given by the same authority as 55.7 per cent.

In the summer the temperature occasionally goes above 100° F. in the middle of the day, but with the dry atmosphere this is not so uncomfortable as might be supposed. The difference between the day and night temperatures is great, something like 20° to 30°. Similarly, there is a great difference between the night humidity and the day humidity. "This means to an invalid," as Solly remarks ("Medical Climatology"), "a climate possessing, in the course of the day, perhaps six hours of moderate dryness, and eighteen hours of positive dampness."

These two characteristics of the fall in temperature and increase in dampness at night probably account for the apparent chariness with which the residents open and keep open their windows, and the fear they have of sitting out of doors at night. As paradoxical as it may seem, one can evidently sit out of doors more evenings in the year in New England than in Southern California; or else the New Englander is more venturesome and hardened in enduring the evening air than is the Californian of the South.

Freezing weather is very rare.

The mountains to the north of this valley shut off the winds from the desert, but the sea breeze blows daily, beginning usually about ten o'clock in the forenoon, and lasts until sunset. There are said to be over 300 sunshiny days in the year at Redlands. At San Bernardino, about eight miles to the northwest, the total number of clear days, as given by Dr. A. K. Johnson, a volunteer observer (period not given), is 235; fair days, 95; cloudy, 35; rainy, 33½. According to Sanborn (*loc. cit.*) "patients with pulmonary lesions, not far advanced, do well in this climate (Redlands and vicinity), especially in that part of the valley where orange growing and the consequent dampness from irrigation do not prevail." Sanborn also refers to the irritation of the respiratory tract brought about by the extensive use of commercial fertilizers. He has noticed a prevalence of tonsillitis and pharyngitis occurring at the time of using this material. "Nervousness" is said to be increasing here as well as in other portions of Southern California, and it is attributed by Sanborn to various causes, climatic and others, such as eye strain from a succession of bright days, and nostalgia.

Five miles from Redlands, on the line of the Southern Pacific Railroad, is the *Loma Linda Sanatorium* (about 1,200 feet), beautifully situated on the hillside about 200 feet above the surrounding country. It is approached through a stately avenue of pepper trees, and is surrounded by orange groves and beautiful gardens. The view from the sanatorium is extensive and grand, the lofty "Arrowhead" and its hot springs lying directly in front. The buildings of this institution are well equipped, containing operating-rooms, etc., and excellent accommodations are offered to the nervous and other invalids, as well as to those who only desire to rest under such favorable conditions of situation and climate. The tuberculous are not received here.

Riverside (elevation 850 feet) is a city of 15,212 inhabitants, about sixteen miles by rail southwest from Redlands. It is the most famous orange-growing district in Southern California, and is well supplied with water for irrigation and domestic purposes from a number of artesian wells near the mountains. The drainage is good, and the city affords every opportunity for comfortable living, either for the transient or for the permanent resident. There are attractive parks, in one of which is the curious "cacti garden." There are also beautiful estates, many churches, fine school buildings, a Carnegie library, a government Indian school, a State horticultural experiment station, a city hospital, miles of pleasant roads through the orange groves, and avenues shaded by the eucalyptus, the pepper, and the palm, among them the famous Magnolia Avenue.

The vegetation, as at Redlands, is most luxuriant, and besides the orange, the pomegranate, olive, persimmon, fig, and other fruits are found here. Flowers abound in a wild profusion, and this whole area seems like one vast park or garden.

The accommodations are good. Besides the lovely drives and walks, there are opportunities for golf, polo, and tennis.

The climate is similar to that of Redlands. The average yearly rainfall for fourteen years was ten inches, February and March being the rainiest months (Solly, "Medical Climatology"). The relative humidity for the year 1888 was 65.5 per cent. The mean monthly temperature for the seasons, covering a period of twelve years is as follows: Spring, 60°; summer, 74°; autumn, 74°; winter, 51° F.* The mean for July is 76°; maximum, 106°; mean for August, 76°; maximum, 104°; mean for January, 50°; minimum, 29°. The average variation between the day and night temperatures, as given by Sawyer ("A Study of Riverside Climate," etc., Southern California *Practitioner*, 1887), for January is 20°, and for July, 34.° "The ordinary wet season at Riverside," says the same author, "is much drier, has less rain, and a larger proportion of dry, clear sunshiny days than the average summer in New York, Boston, or Chicago." The amount of sunshine is great, and, according to Sawyer, there were 280 absolutely clear days from July, 1885, to July, 1886.

Thirty-five miles southeast of Colton, which is eight miles north of Riverside, is the little town of Hemet, the starting-point for the carriage ride to the health resort of *Idyllwild*. This is a journey of twenty miles, the last ten of which are up a steep mountain road. Idyllwild has an elevation of 5,250 feet, and is situated in the Strawberry Valley, in a large forest tract of 1,500 acres, which is again bounded by extensive government forest reservations. The valley is well timbered, the pine, cedar, and live oak predominating. The climate possesses the characteristics of the high altitudes in a comparatively warm latitude, the atmosphere being dry and pure; and the temperature warm but not hot in summer, and in winter cool, but

* Quoted by Solly from a meteorological record issued by the Riverside Board of Trade.

not generally going below the freezing-point. As is generally true of this whole region, the majority of the days are sunny.

The Idyllwild hotel, formerly a sanatorium occupies a well-protected situation, and besides a large, well-appointed central building containing fifty-one rooms, there are several cottages of three and six rooms, tents, etc. There are appliances for furnishing steam heat and electricity, an ice plant, and a steam laundry. The sanitary conditions are well looked after. The water comes from a pure mountain spring, and there is a well-constructed sewer system. The plumbing is modern and good. EDWARD O. OTIS.

Reductases.—Enzymes capable of inducing reduction are designated reductases. See *Enzymes*.
F. P. U.

Reduction-division.—See *Maturation*.

Reduviidæ.—The assassin-bugs, a family of true bugs, *Hemiptera*. These insects are capable of inflicting painful bites. A. S. P.

Reduvius.—A genus of hemipterous insects. *R. personatus* is the "masked bed-bug hunter," which often frequents buildings. Its bites are very painful. A. S. P.

Reed, Walter.—Born in Gloucester county, Va., in 1851. He was a graduate of the Medical Department of the University of Virginia, and of Bellevue Hospital Medical College in 1875. He was appointed an Assistant Surgeon in the Army the year of his graduation, and at the time of his death was first on the list of majors in the Medical Department of the Army. In 1893 he was appointed Curator of the Army Medical Museum in Washington. During the Spanish-American war in 1898, he was a member of the board to investigate typhoid fever in the army. In 1900 he was sent to Havana and was placed at the head of the commission appointed to determine, if possible, the cause of yellow fever and the means by which it is spread. Starting from Finlay's theory of the agency of the mosquito in the dissemination of the disease, the commission, by a series of painstaking experiments, demonstrated most conclusively the causal relation of *Stegomyia fasciata* to yellow fever epidemics, and disproved the theory that the disease could be conveyed in fomites, or that it was contagious in the ordinary acceptation of the term. Sanitary measures based upon the conclusions of Major Reed's commission have made possible the freedom of the tropics from this disease.

Upon his return from Cuba Major Reed was stationed at the Army Medical Museum as Curator, a position he had occupied nine years before, and one for which his attainments eminently fitted him. He was also professor of bacteriology and pathology at the Army Medial School, and lecturer on those subjects in the Columbian Medical College of Washington. He died of appendicitis, November 23, 1902.
T. L. S.

Reflexes.—A reflex may be defined as the motor or secretory response to a sensory stimulation.

Reflex activity is manifested as one of the fundamental attributes of all living protoplasm but in the higher animals the term is generally restricted to responses of a mechanical type with unvarying results. They cannot be sharply separated from instinctive and so-called automatic actions, in fact, the latter may be considered to be a type of reflex of a higher order, the result of peculiar training or environment. In the terminology of those who adopt a purely materialistic philosophy, all voluntary acts which are dependent upon or the result of an association of ideas are spoken of as "association reflexes."

It is generally conceded that the mechanism of a reflex activity includes a sensory receptor such as skin, tendon, periosteum, etc.; an afferent nerve or conducting path; a reflex "center," generally some part of the central nervous system; and an efferent nerve leading from this center to some part of the body which is capable of responding to the impulse by motion, secretion, or other change. A destruction of any part of this "reflex arc" interferes with the reflex. It must not be thought, however, that the reflex arc is the only part of the nervous system that participates in a reflex act, for Sherrington, in his book on "The Integrative Action of the Nervous System," has shown that even the simplest reflexes are associated with what might be called a "set" in the entire nervous system. Reflexes that conflict with each other cannot be elicited simultaneously even though they involve different parts of the body; for instance, the reflex of withdrawal of the foot and the "scratch reflex." Under these circumstances the reflex that has the greater biologic utility has the upper hand and inhibits all other reflexes inconsistent with its performance.

The nature of the impulse in the case of reflexes is probably the same as that of nerve impulses in general, the rate of conduction, factors influencing it, etc., at the same. The "latent period," *i.e.* the time elapsing between the application of the stimulation and the motor response is greater than would be necessary for the impulse to traverse the nerve. This is probably accounted for by a delay at the synapse or point where the impulse passes from the sensory to the motor neurone and also, in part, by other factors. It is not determined that there are any special nerves for the transmission of reflex impulses only.

Reflexes are classified in several ways: According to the nature of the response, motor, secretory, etc.; according to the part stimulated such as tendon, skin, periosteal; or on a purely topographic basis such as the reflexes of the pupil, of the stomach, or of the upper or lower extremities, etc.

TENDON REFLEXES are produced when a sharp tap on the tendon of a muscle produces after a short interval a contraction of the muscles and in some cases a movement of the part. In taking a reflex, care must be taken not to mistake the jar of the muscle for a reflex. Voluntary or involuntary movements, such as choreic, sometimes make it difficult to determine the presence or absence of the reflex. It is probable that potentially there is a reflex for every skeletal muscle but for the most part these can only be elicited when the general reflex irritability is pathologically increased.

In general, it may be said that reflex activity is increased by anything that removes the cerebral inhibitory factor which in most cases means a lesion of the pyramidal tracts either on the brain or spinal cord, but the reflex activity is also increased by diversion of attention or by simultaneous movement of another part of the body; second, by anything that increases the irritability of the spinal reflex centers such as strychnine, pain, fatigue, etc.

Diminution of reflexes is not of much diagnostic value, many are inconstant or absent normally. Some of the reflexes, however, such as the knee-jerk, Achilles jerk, elbow-jerk, plantar reflex, and corneal reflex are practically always present in normal individuals and their abolition indicates disease, usually a destructive lesion, in some portion of the reflex arc. Abolition may occur temporarily, however, as the result of acute general disease, exhaustion, shock, deep coma, narcotism, and following complete severance of the spinal cord.

The *knee-jerk* is probably the most important of the tendon reflexes for diagnostic purposes. It is prac-

tically never absent in normal individuals. It consists of a sudden contraction of the quadriceps femoris when the ligamentum patellæ is struck. The knee should be partly flexed. When exaggerated the reflex may also be obtained by striking above the datella or even along the crest of the tibia. The afferent and efferent nerve is the anterior crural, the spinal center is in the second to the fourth lumbar segments. Weiler found the latent period in normal individuals to be 0.06 second. The knee-jerk is absent in tabes dorsalis, in multiple neuritis when the anterior crural is involved, in anterior poliomyelitis affecting the second, third, and fourth lumbar segments of the spinal cord, in tumors of the spinal cord or cauda equina in the lumbar region or destroying the lumbar nerve roots. It is absent in Landry's paralysis, in the neural type of progressive muscular atrophy and in some cases of muscular dystrophy, in family periodic paralysis, Friedreich's ataxia, and in some cases of combined sclerosis, also in cases of a lesion completely severing the spinal cord. It may be absent in meningitis and in cases of increased intracranial pressure due to tumor, abscess, etc. In some cases of cerebellar tumor the knee-jerk is absent on the same side as the tumor. It is often absent during attacks of pneumonia. In cases of ankylosis of the knee, although there is no movement of the leg, the contraction of the quadriceps can be felt. The knee-jerk is exaggerated by the conditions mentioned above as causing increased reflexes, especially in pyramidal tract lesions. In case the knee-jerk is diminished it can often be demonstrated by methods of reinforcement: simultaneous gripping of the hands (Jendrassik), or simultaneous deep inspiration or sensory stimulation.

Patellar clonus—a series of contractions of the quadriceps obtained by tapping the patellar tendon or by suddenly forcing the patella downward and holding it. Gross exaggeration of the knee-jerk is thereby indicated.

The *crossed adductor reflex*—a contraction of the adductor muscles of the thigh of the opposite side obtained by tapping the patellar tendon; inconstant in normal individuals. Its presence in a case in connection with a lost knee-jerk would indicate that the sensory portion of the reflex arc was intact.

The *Achilles jerk* is next in constancy to the knee-jerk. It is obtained by tapping the tendo Achillis. The response is plantar flexion of the foot. In case there is any difficulty in obtaining the reflex the patient should kneel on a chair with the feet over the edge. The nerve path is the sciatic. The spinal center is the first to the third sacral segments. It is abolished in the same conditions that cause the abolition of the knee-jerk with the difference as to nerves and spinal segments affected.

Ankle clonus—to and fro oscillation of the foot, when the foot is passively flexed, suddenly, and pressed upward. It is an indication of an exaggerated Achilles jerk and is not present in normal individuals. It generally indicates an organic lesion of the pyramidal tracts. A spurious clonus may be present in hysteria but in these cases the force and rapidity of the oscillations is very uneven. An "abortive" ankle clonus, consisting of a few oscillations only, may occur as a result of increased nervous irritability, fatigue, etc.

Metatarsal reflex of Mendel-Bechterew is obtained by tapping over the fourth or fifth metatarsal bone or the cuboid bone (Spier). In normal individuals or the functionally nervous there is either no response or else the toes from the second to the fifth are dorsoflexed, whereas in cases of organic disease of the pyramidal tract the same toes would plantar flex and spread apart. The spinal center is probably in the fifth lumbar and first sacral segments.

Kernig's sign may be considered as a reflex as it consists in the resistance to straightening the knee when the thigh is flexed on the abdomen. It is present in cases of meningitis and is apparently due to irritation of the nerve roots.

Lasegue's sign in sciatica is the same phenomenon as Kernig's sign and obtained in the same way but is due to stretching the irritated nerve.

Biceps reflex—a contraction of the biceps muscle when the tendon is tapped. In order to obtain it the arm should be partly flexed. The spinal center is in the fifth and sixth cervical segments.

Triceps reflex is a contraction of the triceps muscle obtained by tapping just above the olecranon. The arm should be partly flexed. The spinal center is in the sixth and seventh cervical segments. It may be absent in normal individuals.

The *radial* and *ulnar periosteal reflexes* are obtained by tapping the radius and ulna respectively at their lower extremities. They are inconstant. Clonic phenomena in the upper extremities are rare but a wrist clonus may appear which corresponds to ankle clonus.

The *scapulohumeral reflex*, first described by Pickett, sometimes spoken of as von Bechterew's reflex, is obtained by tapping the inner edge of the scapula. The result is rotation and slight abduction of the arm. The spinal center is in the fifth cervical to the first dorsal segments.

Masseter reflex, or jaw-jerk, is obtained by tapping the point of the chin downward while the subject keeps the mouth slightly open. It has no pathologic significance. When exaggerated there may be a masseter clonus.

The *supraorbital reflex* of McCarthy is obtained by tapping the supraorbital notch. The response is a contraction of the orbicularis palpebrarum. Its afferent pathway is the trigeminal nerve and its efferent path, the facial nerve, so that it may be absent in neuritis of either of these nerves and also in cases of tumor in the cerebellopontile angle.

Chvostek sign is sometimes classed as a reflex. It consists of a contraction of the muscles supplied by the facial nerve when the nerve is tapped at its exit point on the face. It indicates the hyperirritability of the nerve and is seen especially in tetany and spasmophilia. It is sometimes present in normal individuals and is not a true reflex.

Skin and Mucous Membrane Reflexes.—*Conjunctival reflex*—an involuntary contraction of the orbicularis palpebrarum, resulting from irritation of the conjunctivæ. It is usually obtained by touching the bulbar conjunctiva lightly with an aseptic, blunt probe. It is absent in neuritis of the fifth or seventh cranial nerves also when the eye has been cocainized. It may be absent in hysteria.

Corneal reflex—the same movement as in the conjunctival reflex but resulting from irritation of the cornea. Its clinical significance is the same as the conjunctival reflex except that it is not absent in hysteria. Anesthetists sometimes test the corneal reflex to determine depth of anesthesia as it is absent in deep coma. It is not a practice to be recommended because of the danger of injuring the cornea and causing inflammation. In case of cerebellar tumor the corneal reflex may be diminished on the same side as the tumor.

Nasal reflex—sneezing on tickling the mucous membrane of the nostril. Of no clinical significance except that it may be absent in hysteria, usually only on one side.

Pharyngeal reflex—gagging or vomiting movement on irritation of the posterior pharyngeal wall. It is absent in neuritis of the glossopharyngeus nerve or disease of its medullary nuclei and is also frequently absent in hysteria.

Palmar-ulnar reflex—a flattening of the hypothenar eminence following irritation of the ulnar side of the forearm. The fingers should be semi-flexed and

completely relaxed. It is usually absent in normal individuals. Its presence on one side and not on the other may indicate an apical tuberculosis on that side.

Abdominal reflexes consist of movements of the abdomen following irritation of the skin at various points. The *epigastric* is a drawing in of the epigastrium following irritation at that point. The *rectus abdominis* muscle contracts following stimulation of the skin on the same side; they may be divided into an upper and lower abdominal reflex on each side. The *iliohypogastric* reflex consists of a flattening of the abdomen just above Poupart's ligament following irritation of the upper inner surface of the thigh. These reflexes are quite constant in the young and healthy but may be absent in women who have borne children, or in the very obese, or in the aged. They are often absent in acute or chronic peritoneal inflammations. They are sometimes useful aids in determining the level in the spinal cord affected by a myelitis, spinal cord tumor or other affection.

Cremasteric reflex is a retraction of the spermatic cord and testicle following irritation of the inner side of the thigh. It is only constant in the young. The absence of the abdominal and cremasteric reflexes with increased tendon reflexes is strongly indicative of multiple sclerosis.

Gluteal reflex—a contraction of the gluteal muscles following local irritation.

Tensor fasciæ latæ reflex—a flattening of the outer side of the thigh due to contraction of the tensor fasciæ latæ following irritation of the leg.

Plantar Reflex.—Normally in those who have learned to walk the toes flex when the plantar surface of the foot is irritated as, for instance, by the stroking of the sole with a blunt-pointed object. This reflex may be absent in neuritis involving the sole of the foot and in tabes dorsalis or in anterior poliomyelitis if the muscles flexing the toes are affected. The plantar reflex may undergo a pathologic modification into the *Babinski reflex*, in which stroking the sole of the foot causes extension or a dorsal movement of the great toe. The presence of this reflex means organic involvement of the pyramidal motor tracts in some part of their course and is one of the most valuable reflexes for clinical purposes. A similar movement of the toe with similar meaning may be obtained in other ways: stroking the inner side of the leg with firm pressure (Oppenheim); squeezing the tendo Achillis (Schäfer); and, with the palm of the hand on the tibia, the fingers wrapped around the leg, cause deep pressure on the calf muscles (Gordon). In some cases of spastic paraplegia, irritation of almost any part of the body will cause extension of the toes on the same side as the irritation. One explanation of the cause of the Babinski reflex is phylogenetic. In arboreal man the opponens hallucis responded to plantar stimulation, as in grasping. When this muscle became an extensor it still responded and so in the infant that has not learned to walk the reflex is extension. After learning to walk, the automatic act of flexion overcomes the extensor reflex so that plantar stimulation causes flexion unless the brain is disconnected from the spinal centers by lesion of the pyramidal tract, in which case the primitive spinal reflex of extension reasserts itself.

The *reflex of defense* (Babinski) is the withdrawal of the foot, flexion of the knee and sometimes the thigh following irritation of the leg or sole of the foot, This movement may occur when the leg is completely paralyzed for voluntary movement. Its significance is uncertain but it is thought to mean pressure on the spinal cord without destruction as may occur in cases of Pott's disease, spinal cord tumor and the like. Such cases may have a good prognosis if the pressure is relieved.

Reflexes of Special Character.—*Sphincter Reflexes.*—There is a reflex contraction of the sphincter of the *bladder* following irritation of the neck of the bladder or of the posterior urethra. It is constantly present in normal individuals and its absence results in incontinence of urine. In the act of micturition there is simultaneous relaxation of the sphincter and contraction of the detrusor muscles. A lesion high up in the spinal cord causes a spastic condition of the sphincter and retention of urine. The spinal reflex is in the third and fourth sacral segments.

The *anal reflex* consists of a contraction of the sphincter ani from irritation either in the anus or on adjoining skin surfaces. The spinal center is in the fifth sacral segment.

Neither the bladder nor anal reflexes are likely to be disturbed in cases of disease of the peripheral nerves, but they are frequently affected in spinal cord diseases such as tabes dorsalis, multiple sclerosis, etc. The reflexes are abolished from lesions of the spinal centers and also in the case of complete transverse lesions higher in the cord. Incomplete lesions, however, generally cause retention of urine and feces if high in the cord. In some brain lesions these reflexes may also be disturbed and also in deep coma and in epileptic attacks.

Vaginal Reflex.—The sphincter of the vagina may show a reflex of the same sort as the anal and bladder reflex but it is not constant. A hyperirritability of this reflex is found in the condition known as vaginismus.

In the esophagus, at the cardiac end of the stomach, in the gastroduodenal opening, and in several other parts of the body there are sphincter muscles whose activities are largely reflex.

Pupillary Reflexes.—The pupil contracts when light is thrown on the retina and dilates when the retina is shaded. The pupil also contracts when light is thrown in the eye of the opposite side (consensual reaction). The loss of this reaction to light, with the preservation of the other reflexes of the pupil is generally spoken of as the *Argyll-Robertson pupil* or as *reflex iridoplegia.* It is highly significant of syphilitic infection especially as affecting the central nervous system. It need not necessarily mean active syphilis, however, since it may remain unchanged for years and not be accompanied by other signs of syphilis. Nonne has reported its presence in cases of severe chronic alcoholism where syphilis could be excluded, but this is extremely rare. The course of the light reflex is through the optic nerves and tracts, corpora quadrigemina, the Edinger-Westphal nuclei, the third cranial nerves, and the ciliary ganglia. A brain tumor or other lesion injuring this pathway might cause a loss of the reflex to light. In the case of tabes the lesions causing the loss of the reflex are probably located in the ciliary ganglia.

The pupils also contract in looking at a near object or in converging the eyeballs. This is the so-called reflex in accommodation or convergence. It is probably not strictly a reflex but rather an associated movement. It is never absent by itself. In cases of diphtheritic paralysis there is a paralysis of accommodation and also loss of the reflex. The pupil may not react either to light or in accommodation. This occurs in association with extraocular palsies, in cases of paralysis of the third nerve, and may also be present in coma, deep narcosis, shock, epileptic attacks and sometimes hysterical (?) attacks and when the eye is under the influence of mydriatics or myotics. It may also occur in cases of cerebrospinal syphilis.

Wernicke's Hemianopic Pupillary Inaction Sign.—in cases of homonymous hemianopsia the fact that the pupil does not contract when the light is thrown on the blind half of the retina but does so when it is thrown on the other half is a sign that the lesion causing the hemianopsia must be affecting the optic tract somewhere between the optic commissure and

the primary optic centers, especially the external geniculate bodies.

The *ciliospinal* or *cervical sympathetic reflex* is the dilatation of the pupil following irritation of the neck on the same side. It is absent in lesions of the superior cervical sympathetic ganglia and when the ganglia are severed from the spinal cord by lesion of the rami communicantes. An irritative lesion of the cervical sympathetic may cause a continuous dilation of the pupil and a destructive lesion cause a continuous contraction.

Hippus consists of alternate contractions and dilatation of the pupil on stimulation. It has no diagnostic significance except that it is more frequently seen in hystericals and the emotionally unstable.

Springing Pupil.—A contraction of the pupil to light followed by a quick return to its former size. It sometimes precedes the development of a reflex iridoplegia but is more often due to error in technique in testing the pupillary reaction, the subject momentarily accommodating.

Psychic Reflex.—A dilation of the pupil occurring under emotions, fright, anger, shock, or intense interest. It is much more marked in some individuals than in others.

Paradoxical Pupillary Reflex.—A condition where the pupil appears to dilate rather than contract on exposure to light. It may be due either to the psychic reflex overcoming the light reflex, as when a strong electric light is flashed into the subject's eyes in a dark room, or it may be due to faulty technique, *i.e.* the subject converges the eyes when the eyes are covered but relaxes the accommodation when they are uncovered. The paradoxical reflex is said also to occur in tabes and paresis and as a result of fatigue.

Pilomotor, or goose skin, reflex—a contraction of the muscles of the hair follicles causing small elevations in the skin. It may result from exposure to cold or be the result of emotion. According to Haškovec, the reflex is more pronounced in neurasthenic and hysterical individuals, but it has little clinical significance. Mackenzie believes that the pilomotor reflex is limited to the area corresponding to the sensory distribution of the spinal segment that receives the stimulus and he used this reflex in determining the limits of the sensory areas from segments of the spinal cord.

Vasomotor Reflexes.—Local irritation of the skin producing redness due to vasomotor relaxation is a common phenomena. Some stimuli, such as cold, result in contraction of the blood-vessels and paling of the skin. In still other cases there is elevation of the skin and formation of wheals. These responses are much more marked and persistent in some individuals than in others but their clinical value is very uncertain.

Secretory Reflexes.—Most of the glands giving secretion react to stimuli by an increase in the amount; the *lacrymal* as result of irritation in the eye or painful stimulation. The *salivary* glands react to the presence of food or even the sight of it at times, likewise the *gastric* mucosa.

Sudoriferous.—The sweat glands react to external stimuli as well as to emotions. The sweating may be limited to one portion of the body. The intermediolateral group of cells in the gray matter of the anterior horns of the spinal cord seems to be the spinal center and their destruction causes a loss of sweating over the part of the body supplied by the affected segments.

C. D. Camp.

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Refractometers.—Refractometers are instruments intended to measure the extent and direction of the bending of a ray of light in passing through media of different density. For a general consideration of refraction and its relation to dispersion see the article on "spectroscopy."

Refractometers have come into extensive use of late years in food and drug analysis, being adapted for distinguishing between many liquids, especially fatty oils, sugar solutions and alcoholic beverages. Under constant conditions the refractive index of these liquids is characteristic, and hence of value in identifying the substance or determining its purity.

Many forms of refractometers have been devised. In passing from a medium of a given density to one

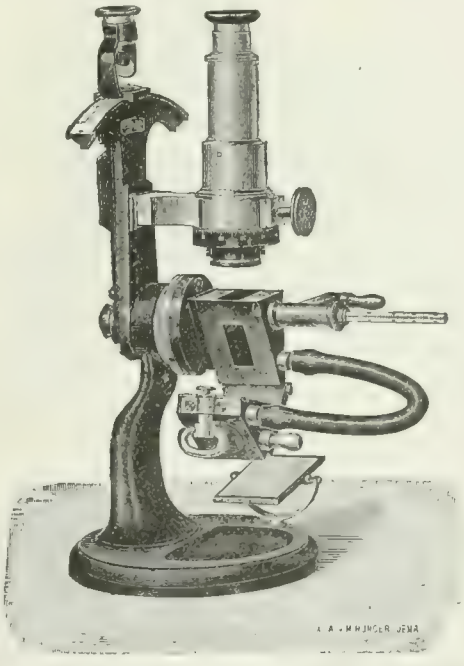


Fig. 4414.—The Abbé Refractometer. (Courtesy of the Arthur H. Thomas Co., Philadelphia.)

of different density, all light rays are refracted in the same direction but not to the same extent. As in the case of the polarimeter (*q.v.*) such differences may be disregarded and the common instruments are adapted to use with daylight. The standard refraction is that of the yellow sodium (*D*) line and is designated n_d. The Abbé refractometer, shown in Fig. 4414, consists in its most important part of twin prisms of flint glass, having a refractive index of $n_d = 1.75$. To make an observation, a few drops of the liquid are placed between the prisms, which are then closed and determination made by adjusting the telescope to a definite appearance of the field when the position is read off. A cheaper and simpler instrument, devised

especially for examination of butter fat and detection of its adulterations and substitutions, but of much wider applicability is the "butter-refractometer" (butyro-refractometer) also devised by Abbé. The general procedure is the same with this instrument as with the first mentioned. Recently a special application of refraction methods has been made in the sugar industry. This "sugar" refractometer furnishes direct reading of the dry sugar contained in juices, molasses and syrups of all kinds. It is a modification of the Abbé instrument and is in general use over the world.

Of quite different type and of special and valuable applications is the immersion (or "dipping") instrument (Fig. 4415). In this the prismatic terminal of

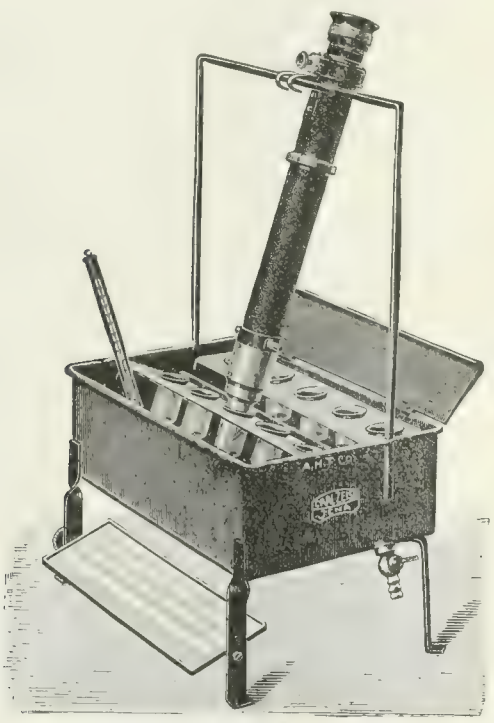


Fig. 4415.—The Zeiss Dipping Refractometer. (Courtesy of the Arthur H. Thomas Co., Philadelphia.)

the tube is immersed in the liquid to be tested. One of its important applications is the determination of the percentage of alcohol in distilled liquids, but it is obvious that many other liquids are capable of examination by it.

These instruments are made by the Zeiss Company of Jena, Germany, and as circulars covering full descriptions of the main features of construction and information for using them are furnished by the makers, it is not necessary here to give further details.

HENRY LEFFMANN.

Reil, Johann Christian.—Born at Rhaude, Holland, February 28, 1759. At the age of twenty he began the study of medicine at the University of Goettingen, Germany. After remaining there for a few years he went to Halle and continued his studies under Meckel and Goldhagen, both of whom became his personal friends. On Nov. 9, 1782, he received the degree of Doctor of Medicine and Surgery. He then returned to Friesland, and carried on the practice of his profession for several years. In 1787 he was given the position of Professor Extraordinary in the University of Halle. In 1788, upon the death of Goldhagen, he was promoted to a full professorship and at the same time was made Director of the Clinical Institute; and in the following year he received the appointment of Pensioned Physician of the city of Halle. He rapidly acquired such a great reputation as a teacher that students flocked to Halle in large numbers from every part of Europe. In 1810 he accepted a call to occupy the Chair of Medicine in the University of Berlin. Three years later, he was appointed Director of the Military Hospitals established at Leipzig and Halle. After the battle of Leipzig there were collected, in these hospitals, no less than 30,000 wounded. Typhus fever soon broke out and carried off a large number of victims. Reil contracted the disease and died Nov. 12, 1813.

Reil attained distinction in several departments of medical science. In anatomy he was justly celebrated for his contributions to our knowledge of the nervous system; he took high rank as a pathologist and also as a skilful medical practitioner; he was a good surgeon; he was greatly esteemed as an authority in all questions relating to the management of the insane; and, finally, he was skilled in the treatment of eye diseases. Of his published writings the following deserve to receive special mention: "Memorabilia clinica medico-practica," Halle, 1790–93; "Exercitationum anatomicarum fasciculus primus de structura nervorum," Halle, 1796; "Ueber die Erkenntniss und Kur der Fieber," 5 vols., Halle, 1797–1815; "Rhapsodien ueber die Anwendung der psychischen Kurmethode auf Geisteszerrüttungen," Halle, 1803; and "Entwurf einer allgemeinen Pathologie," 2 vols., Halle, 1815 and 1816. Several parts of the brain bear his name—ansa of Reil, island of Reil (insula), ribbon of Reil (lemniscus), Reil's sulcus, Reil's triangle, etc.

A. H. B.

Relapsing Fevers.—*Introduction.*—Most American writers of text-books on relapsing fever, in discussing the disease, have exclusively had in mind the European type which, ordinarily, displays two paroxysms of long duration. Their illustrations usually consist of a temperature chart from a case of the European type and a photomicrograph or drawing, showing many spirochetes in the field, or as numerous as they are in the European type of the disease. The American form of the disease, endemic in tropical America, has been overlooked through its resemblance to malaria and to the neglect of the microscopic examination of blood.

The relapsing fevers constitute a group which present sufficiently well-marked differences in their clinical characters, animal reactions, mode of transmission and geographical distribution to warrant some degree of separate treatment.

Synonyms.—Spirillum fever, bilious relapsing fever, epidemic fever of Ireland, epidemic fever of Scotland, famine fever, bilious typhoid, relapsing synocha, febris recurrens, febris recidiva, fièvre à rechute, fièvre recurrente, hungerpest, rückfallsfieber, fiebre espiroquetal, tick fever of tropical Africa.

Definition.—A group of fevers frequently epidemic in type, of wide geographical distribution, caused by spirochetes which usually reappear in the peripheral blood stream at intervals during the disease. Clinically the onset is sudden. There is a paroxysm of fever lasting three to seven days and usually associated with the presence of spirochetes in the peripheral blood. This is followed by a period of apyrexia lasting six or seven days and this, in turn, by another paroxysm of fever lasting one to four or five days. The number of separate attacks may be five or six but varies in the different geographical types of the disease.

GEOGRAPHICAL AND HISTORICAL.—The disease may have been recognized by Hippocrates, but seems to have

been confused with typhus or malarial fever until early in the eighteenth century, when from observations on an epidemic fever in Dublin, in 1739, Rutty called attention to "a disease which terminated in four, five, or six days, sometimes in nine, commonly in critical sweat—subject to relapses, even sometimes to a third time." From time to time the disease was very prevalent in Ireland and Scotland during the eighteenth century and was epidemic in type. In 1826–27 the disease took on the character of bilious typhoid. The disease broke out again in several parts of Ireland in 1842 and continued there in epidemic form until 1848.

While it is remarkable that there are no records of the occurrence of the disease in Europe previous to the eighteenth century excepting those references to a disease of this type by Hippocrates, it may be borne in mind that the disease was probably absent from Great Britain during the period of 1827 to 1843 and has since 1873 spontaneously disappeared from the British Islands, notwithstanding the fact that the conditions which led to relapsing fever as well as typhus fever are undoubtedly present in various foci in some of the larger cities.

The disease had appeared in Scotland in 1841 and became widespread in the larger towns during 1842–44, and it was in these epidemics that a comprehensive study of the disease was made by Barker, Cheyne, O'Brien, and Cormack.

In 1847–48 the disease appeared in London and other large cities in England and later, in 1868, was epidemic among Irish, and also among Jewish emigrants from Poland; it appears to have persisted in England until 1873.

Jenner, in 1850, and Murchison, in 1862, made very careful studies of the disease and brought out clearly its essential features. The latter's description is particularly complete.

With reference to the question of the *de novo* appearance of a pathogenic microorganism it is interesting to note that relapsing fever did not appear in Russia until one hundred years after its occurrence in Great Britain. Previously it had been unknown in Russia.

In 1833 it appeared in Odessa, a seaport having communications with Great Britain. There was an extensive outbreak in Moscow in 1840–41, when it assumed a bilious type of much gravity. In 1857 it had reached eastern Siberia and Sitka, Alaska. Spreading widely in 1865, it extended into Turkestan, Poland, Finland, and the Caucasus. Many cases were seen among troops during the Crimean War.

In Germany the disease appeared during a famine in 1847–48, where it was associated with typhus, but the largest epidemics occurred in 1868–69, 1871–72, 1878–79, when the disease was undoubtedly introduced from Poland through Silesia, Pommerania, to north and east Germany and Galicia. In the epidemic of 1868 Obermeyer discovered the pathogenic agent in the blood in the stage of fever.

The disease may have been introduced into Scandinavia from Finland, for it was reported from the former place in 1851, 1861, and 1865.

Greece, Turkey, and Asia Minor, with the Levantine Islands have often suffered from relapsing fever (see Hippocrates) and the severe bilious type has been very common in those countries. It would appear that relapsing fever was very prevalent in the Levant during the first half of the nineteenth century under the names Levant, Smyrna, and Cyprus fevers. Cropper detected cases in Jerusalem in 1905.

In India the first account of the disease or its recognition, according to Rogers, was that of Lyall, in the Usufzaie Valley, near Peshawar, in the extreme northwestern part of the Punjab in 1852–53. Hirsch was of the opinion that the fever was introduced into the Punjab by muleteers returning from service in Abyssinia, in 1866, but the type of the fever seen in India closely resembles the European form and not that encountered in Abyssinia and tropical Africa, and for that reason may have been introduced through Turkestan, where it was known to exist in 1865 into the northwest of the Punjab.

The disease was observed in jails in the Punjab and United Provinces in the sixties, by Smith, who showed it to be relapsing fever. In the famine of 1876–77 there was much relapsing fever in the Bombay Presidency and in one of the outbreaks Van Dyke Carter investigated the disease and found the spirochete in the blood of patients sick with the disease.

In China relapsing fever became epidemic in Pekin and northern China during the period of 1856–65. An epidemic of fever among miners in northern Manchuria has been reported. One of the commonest fevers in Ting-chau is relapsing fever and the disease has been reported in epidemic form and associated with famine from Tien-Tsin, Shanghia, Hankow, and Pakhoi.

A few cases of the European type were imported into North America among immigrants from Great Britain. Clymer recognized cases in Philadelphia in 1844 among Irish immigrants, and Austin Flint saw a number of cases in Buffalo in 1850–51. In New York City there was an epidemic in 1869–71 and cases were seen at this time in Philadelphia, Washington, in various towns in Maryland, New Jersey and Connecticut and in Boston. An epidemic broke out in California in 1874 among Chinese laborers.

A few cases of the endemic American type of relapsing fever undoubtedly reached seaports of the United States and one was described by Carlisle in 1906. The writer reported thirty cases of this type from Panama in 1909 and other cases have been detected in Cuba, Mexico, and South America. The disease was observed in Colombia by Franco and Robledo and it may have been this type of the disease that Baldou referred to as "Peste des Cordillères" in Peru, Chili, and Bolivia in 1854–56.

The disease is constantly present in northern Africa. It was described from Cairo in 1836 and Algiers in 1867.

The disease was introduced into Mauritius and Réunion in Coolies from Calcutta in 1863–65.

Investigations of tick fever and spirillosis in the Congo Free State, Uganda, British East Africa, German East Africa, and Portugese West Africa, have shown the presence of a special type of relapsing fever in these regions, and the same type has recently been reported from Madagascar.

A few cases have been introduced into the Philippines from India but the disease does not appear to have gained any footing or to be endemic in the islands of the Pacific or in Malaya.

Etiology.—*Predisposing Causes.*—Wherever there are overcrowding, poverty, and squalor, with the resulting absence of personal hygiene and the presence of vermin, it may be assumed that upon the introduction of the pathogenic agent an epidemic of the fever will arise. The transmitting agents of relapsing fever are lice—*Pediculus vestimenti* and *Pediculus capitis*—and ticks of the genus *Ornithodoros*. These ticks resemble the fowl tick inasmuch as they live in the cracks and crevices of walls and bedding and prey upon their hosts at night in a manner similar to bedbugs.

The conditions favorable to an outbreak of disease are: first, the reduction of the individual's resistance to disease by poverty, famine, or exhaustion; second, conditions in which there is a lack of personal hygiene where vermin is propagated, as in squalid tenements, in jails, and in ships, in barracks and in any institution for the segregation of people where there is great overcrowding and no hygienic measures are taken

to control the propagation of vermin; third, the introduction of the pathogenic agent and its biologic agent of transmission.

Time and time again the disease had appeared during famines as its name—famine fever or "Hungerpest"—indicates. Dr. Alison in his observation on the famine of 1846–47, in the Highlands of Scotland and inIreland had noticed with other physicians the connection between famine, destitution, and the epidemic fever of 1846–47, especially, and he regarded the fever as the effect of the unavoidable connection of Scotland with the destitution in Ireland. Murchison, in demonstrating the intimacy of the relationship between relapsing fever and destitution, showed that since 1847 17.5 per cent. of the cases in London were patients paid for by the parochial authorities and totally destitute. A large proportion of the patients for some time previous to their attack had been literally starving. Stokes described the fever of 1826 as famine fever, and Corrigan's paper on the fever was entitled "On Famine and Fever as Cause and Effect, in Ireland." The disease appeared in epidemic form in Germany during a famine in 1847.

The condition of soldiers during warfare favors the development of relapsing fever, and the disease was widespread among the Russian and Turkish troops during the war of 1877–78.

The disease is highly contagious and sometimes an enormous number of persons become infected—40,000 persons are said to have had the disease during 1847–48 and there were 39,337 cases of the disease reported during the Russian war of 1877–78.

When it appears in a family all the members within a few days will come down with it, and contact with the sick, as that of doctors and nurses, as well as the indirect contact of laundresses, is especially likely to convey the infection.

In the tropical types of the disease the fever is spread through the agency of ticks and follows the caravan routes and lines of communication. Native houses, shelters, and barracks are foci of infection.

Season and climate appear to exert no very marked influence on the development of the disease. Winter, with the overcrowding and confinement in night refuges, undoubtedly exerts an influence in the European type of the disease. Mouzels, however, in Indo-China, records an increased incidence of the fever during the summer or hotter months and suspects a mosquito carrier.

No age is immune, but the greatest number of cases occur between the ages of fifteen and thirty years.

Men are more frequently infected on account of the predominance of this sex in barracks, jails, night refuges, as travelers, etc.

Microorganism.—The microorganism when present can be detected in ordinary thin blood films stained by a Romanowsky stain. If spirochetes are suspected in a case during apyrexia or when it is expected they will be very sparse, thick films may be used. Two or three drops of blood are placed on a slide and spread out over an area of two or three square centimeters. The films should be well air dried and then dehemoglobinized in distilled water in a Coplin's staining jar in the refrigerator. When the film is quite white it may be stained by any satisfactory Romanowsky method. With Romanowsky methods the spirochete takes a deep blue or purple color, depending on the stain, reaction of the film, and the degree of differentiation. Carbolfuchsin and gentian violet are also useful stains but none of the anilin stains are permanent, for spirochetes have a remarkable way of decolorizing the staining reagent in the course of time. Spirochetes are decolorized by Gram's method. Silver impregnation methods, however, yield permanent preparations and films may be stained after first drying in air or in the thermostat and placing them in a bath of ten per cent. silver nitrate exposed to direct sunlight. Beautiful preparations of spirochetes in tissue may be obtained by the Levaditi pyridin silver method. Films may be rapidly stained by the method of Fontana. By this method the blood is diluted in a drop of distilled water, the film is dried in air and fixed in the flame. A few drops of five per cent. aqueous tannin are poured over the film and heated for twenty seconds. The film is now washed in running water for thirty seconds. A few drops of ammoniacal solution of silver nitrate are added and the slide is warmed for twenty to thirty minutes when it is washed and dried. The spirochetes take a yellow or brown coloration.

The India ink method of examining the film is simple and satisfactory.

Spirochetes may be detected by the dark ground illuminator in fresh preparations and, as Leishman has observed, they may be detected by dark ground illumination in films that have been dried and stained.

Morphology.—The spirochete is a tapering spiral filament sometimes appearing as a cylinder and at other times as a flat ribbon. Single spirochetes in which no achromatic zone can be detected measure 7.2 to 13.2 microns. Double forms having a central achromatic zone and probably representing a spirochete about to divide transversely measure 13.2 to 17 microns in length. Longer forms with several achromatic zones are occasionally encountered, especially in animals, and these forms represent three, four, and five or more undivided individuals. The breadth of the spirochetes in human blood is constant being about 0.2 microns. The ends are tapering

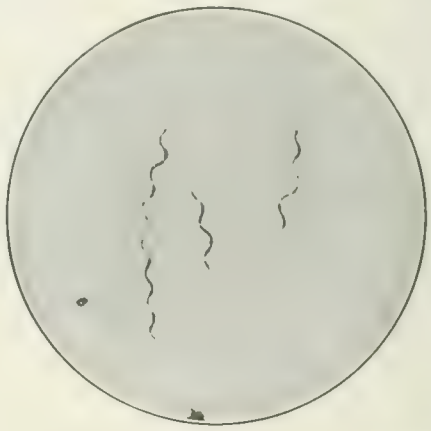


Fig. 4416.—*Spirochæta novyi.* (Novy and Knapp.)

and in some preparations the tapering end is seen to be so attenuated as to suggest a terminal flagellum. The number of spirals or complete S's having no achromatic zone varies considerably in the same film. Coarse and fine curves may be seen not only in one film but sometimes in one spirochete. The spirochete stains uniformly or homogeneously excepting in the longer forms which present one or more achromatic spaces. These spaces, evidently the points of fission, may be displayed beautifully by means of acetone gentian violet or by silver impregnation methods. Nothing homologous with an undulating membrane can be detected and there is no suggestion of nuclear bipolarity. Flagella at one end and both ends as well as peritrichic flagella have been described. Hindle believes that the so-called terminal flagellum is a drawn-out extremity of the pellicle. It seems likely that the motion of the spirochete depends on an entirely different principle from that of flagellar activity. The movements of the spirochetes are rapid excepting just before crisis and their disappearance from the peripheral blood stream. At this time

observations may be made, or the blood of richly infected animals treated with sodium citrate may be employed in noting the character of the motion. Red blood corpuscles become segregated in the film, leaving spaces in the serum where spirochetes assemble. The spirochetes move back and forth with great rapidity and at equal speed in either direction, apparently rotating in one direction in going forward and in an opposite direction in going backward. As the motion becomes slowed-down the spirochete may be seen frequently attached to an erythrocyte by the invisible attenuated filament changing the outline of the erythrocyte in a very marked manner and showing that the spirochete is much more rigid than the erythrocyte.

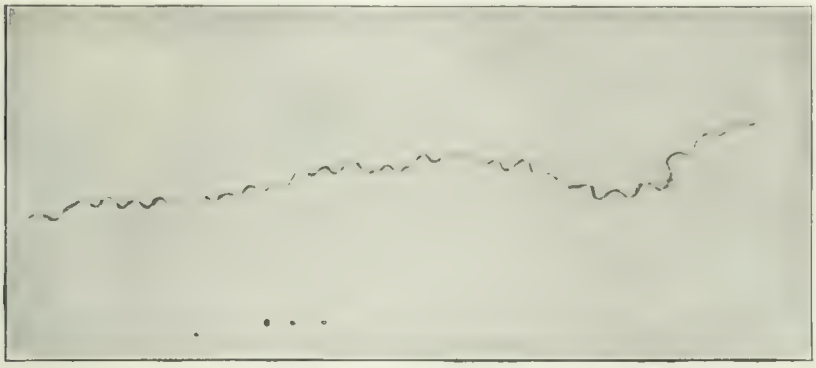


FIG. 4417.—*Sp. novyi;* a long undivided form, with several achromatic zones.

The same relative rigidity of the spirochete and plasticity of the erythrocyte are seen when a spirochete collides with the latter. At the height of infection the ends of the spirochete may become approximated and the rigid outline disappears. The spirochete then appears to be breaking up into fragments still held together by the intact periplast. The appearance now is that of agitated chain, and stained specimens taken at this time show that the spirochete contains several achromatic zones separating the fragments. This phenomenon has generally been overlooked by most observers. It is, however, not only unmistakably true but has an important bearing on the internal structure of spirochetes and of their mode of motion. The writer believes that the mode of motion depends in some way on the relation of these fragments to one another previous to segmentation and crisis and that they possibly function as muscle organs or myonemes. Fresh preparations may appear to contain nothing but perfectly formed spirals while the dried film stained from the same preparation will frequently be found to contain irregularly curved and partly straightened-out forms.

Nature of the Microorganism.—The term spirochete comprises a group of slender filamentous spiral-shaped bodies which may be either free-living or parasitic.

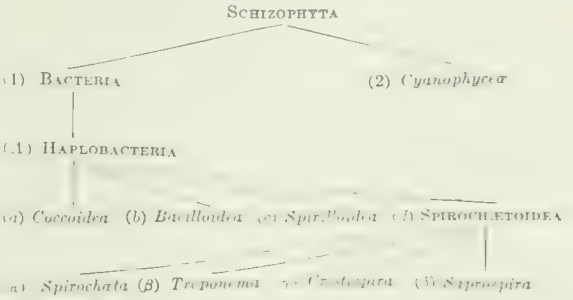
There is no unanimity of opinion with regard to the position of spirochetes in the zoological scale. Schaudinn concluded from certain observations on the blood parasites of an owl that spirochetes were stages in the life history of a protozoon, and a number of writers have placed spirochetes with the protozoa. Novy and Knapp, however, after a consideration of the structural character, rapidity of multiplication, presence of plasmolytic changes, action of heat, persistence of form, immunity, and aerotropism, conclude that the spirochete studied by them from a case of fever of the American type (*Sp. novyi*) belongs to the *Bacteria* and not to *Protozoa*. Nuttall, on the other hand, says that authority is divided as to whether spirochetes are protozoa or bacteria. Judged, however, from their pathological effects and their prompt reactions to immune sera and certain drugs, they show, in his opinion, a pronounced affinity to protozoa and exhibit phenomena not hitherto observed in bacteria.

Spirochetes occupy a unique position as protists, between plants and animals, and the clinical features of the diseases caused by them resemble bacterial diseases on the one hand, and certain protozoal diseases on the other. The study of this group of microorganisms has been approached from several points of view by the bacteriologist, clinician, and cytologist. Each worker has studied the group largely from his own special standpoint and by special methods. One worker by cultivation methods and by dark-ground illumination is positive that the mode of multiplication is by longitudinal division. Another as a result of observations on stained preparations of richly infected animal's blood is equally confident that longitudinal division never occurs, but that the mode is by transverse fission.

Sambon, following Schaudinn's ideas as to the biological position of the blood spirochetes, designated the group as *Spiroschaudinnia* but we now know that Schaudinn was mistaken in his interpretation of the nature of the spirochete of the little owl.

Fantham, 1908, believing that spirochetes constitute a new class of protozoa has placed them with *Trepomemata* in the group *Spirochætacea.*

According to Dobell, who has worked extensively with these and allied groups, the following tentative classification is in accord with our present knowledge of these microorganisms.



Dobell from his exhaustive comparative study of the *Spirochetes, Bacteria,* and *Cyanophyceæ* concludes that the spirochetes may be collected into a single group which may be called the *Spirochætoidea.* "These *Spirochætoidea* are unicellular organisms (*Protista*). They undoubtedly belong to the *Schizophyta* (*Bacteria-Cyanophyceæ*) and not to the protozoa. Among the *Schizophyta* they must be placed in the subdivision *Bacteria* and among the bacteria they probably constitute a group of the same systematic status as the cocci, the bacilli, or the spirilla."

The spirochetes, according to Dobell, differ from the other bacteria in only one feature; though actively motile they possess no specialized organs of locomotion. Every other character which they possess is represented in other forms of *Bacteria.* The group *Spirochætoidea* comprises four different sets of organisms which may be classified in the four genera: *Spirochæta, Treponema, Cristispira, Saprospira.* The spirochetes possess characteristics common in many respects to the *Spirilla* (*Spirilloidea*) and the *Bacilli* (*Bacilloidea*).

Minchin is of the opinion that it appears impossible to include the spirochetes any longer in the *Protozoa*. Dobell has shown that the nuclear and cytoplasmic structures are wholly different—a trypanosome has a flagellum, a spirochete has none; the crista is not an undulating membrane and the cell membranes are not similar; moreover the method of division is quite different in the two classes of organisms.

The writer pointed out in 1908 that in parallel infections of spirochetes and trypanosomes, when films were stained in various ways and the chromatin filament of the trypanosome was in evidence, nothing at all like this structure could be made out in the spirochetes. Staining reactions all indicated that the spirochetes were more closely related to bacilli than to protozoa.

TABLE SHOWING ZOOLOGICAL STATUS OF SPIROCHETES

Characters shared by protozoa	Characters shared by cyanophyceæ,	Characters shared by bacteria.
Periodicity in blood stream.	Absence of anteroposterior polarity (movement).	Absence of nuclear polarity.
Amenable to arsenic medication.	Spiral flexible body clothed with a pellicle.	Diffused nucleus.
Phagocyted by hepatic endothelium.	Absence of organs of locomotion.	No anteroposterior polarity of motion
	Plasmolysability.	Transverse division.
	Transverse division.	Absence of plasmolysis in distilled water.
	Absence of sexual phenomena.	Persistence of form under heat.
	Variation in length but not in breadth.	Rapid multiplication.

Following Dobell the spirochetes may be placed in four different genera: *Spirochæta*, *Cristispira*, *Treponema*, *Saprospira*, possessing the following characters in common—there is no anteroposterior polarity, the body is wound spirally, it is flexible and covered by a pellicle, they are all motile but possess no special organs of locomotion, they are plasmolysable, contain no coloring matter and no cyanophycin granules, they divide transversely, division being simple in treponema and cristispira, or multiple in spirocheta and saprospira; the protoplasm possesses a peculiar chambered structure (doubtful in spirocheta), metachromatic granules are present (doubtful in treponema), no sexual phenomena are known, and the nucleus is probably a modification of the chromidial nucleus. In addition to these general characters we may add that an axial band-like thickening of the pellicle occurs in *Cristispira* (the crista) and *Spirochæta* (the axial fiber). Dobell states that there is only one particular in which spirochetes differ from bacteria, that is, while the bacteria possess special organs of locomotion these spirochetes are motile without possessing any organs of locomotion which, so far, have been demonstrable. Fantham and Porter, on the other hand, claim that longitudinal division as well as transverse division occurs in *Spirochæta duttoni* and *Sp. recurrentis*.

Classification.—Nuttall is of the opinion that the various specific names of the spirochetes causing relapsing fever are to be used for convenience only in distinguishing races or strains of different origin, that they cannot be regarded as valid names in the sense of scientific nomenclature for the reason that virulence and immunity reactions are not adequate tests of specificity. *Sp. recurrentis*, then, may be the only species. While it may be true that we possess no means of specifically separating the different races of blood spirochetes, which may satisfy systematists, it is at the same time true that the febrile reactions in man as well as the pathogenesis in animals are constantly and markedly different in some of these geographical races.

Specific Identity.—It is doubtful if the different strains of spirochetes can be differentiated by means of serum reactions. Nicolle and Blaizot assert that agglutination reactions are the only means of distinguishing the various spirochetes. Crossed immunity experiments are of no value in the determination of species.

The Spirochetes of Relapsing Fever

Spirocheta recurrentis Lebert, 1874, Syn.: *S. Obermeieri;* Cohn, 1875.
Spirochæta carteri Manson, 1907.
Spirochæta berbera Sergent and Foley, 1910.
Spirochæta duttoni Novy and Knapp, 1906.
Spirochæta rossii Nuttall, 1908.
Spirochæta novyi Shellack, 1907.

Animal Reactions.—The animal reactions of the different blood spirochetes are, to a slight degree, inconstant, and this is particularly true of *Spirochæta recurrentis;* they fall, however, into at least three distinct groups.

(A) *Spirochæta duttoni:* This spirochete causes a relapsing infection in man, monkeys, white rats, and white mice with blood taken directly from a human case. The causation of a relapsing infection in infected rats sharply differentiates this spirochete from the other groups.

(B) *Spirochæta novyi:* Man, monkeys of the old-world varieties, white mice, and white rats are infected with ease directly from human cases; but man, old-world monkeys, and mice alone have a relapsing infection. White rats never have more than a single paroxysm.

(C) *Spirochæta recurrentis:* Man and monkeys of the old-world varieties may be infected directly from man. The former shows a relapsing infection while monkeys usually disclose but a single paroxysm. After a passage through rabbits the spirochete may cause a relapsing infection in monkeys. Rats and mice cannot usually be infected directly from man, but after the strain has been carried through monkeys some, not all, rats may be infected and these have a single paroxysm.

In general, passing a spirochete through man will lower its virulence for monkeys and rodents and this is evidenced by a prolonged incubation period, a single paroxysm or failure to become infected. Schilling found when working with a very virulent strain of *Sp. recurrentis* that its virulence depended largely on the stage of infection, that mice injected with the blood of another animal the first day of infection lived longer than mice injected from the same animal on the second day. On the other hand, those injected on the third day of the infection lived slightly longer than those of the first day, and this diminution of virulence on the third day of the infection is explained as the result of the antibodies present in the blood which are injected with the spirochetes. Gonder found that a fowl immunized to *Spirochæta gallinarum* could be reinfected if the spirochete was passed through a Java sparrow, and conversely that an immune Java sparrow could be reinfected after the spirochete had been passed through a fowl; and the writer has observed that the passage of *Sp. novyi* through white mice renders it more virulent for white rats.

Bronfenbrenner and Noguchi found that spirochetes were killed upon exposure to a temperature of 45° C. in from seven to ten minutes while Neiva observed that the fowl spirochetes retained their virulence when kept at 0° C. for forty-nine days.

Spirochetes are highly susceptible to germicides, being from 20 to 100 times more susceptible than *B. coli* (Bronfenbrenner and Noguchi).

Cultivation.—Spirochetes had been kept alive in collodion sacs placed in animals by several workers,

but Noguchi was the first to cultivate them on laboratory media. He has reported the cultivation of *Sp. recurrentis*, *Sp. rossii*, *Sp. duttoni*, and *Sp. novyi*. The method consists in removing aseptically blood from the heart of an infected animal, preferably between forty-eight and seventy-two hours after inoculation. A few drops of this citrated infected blood is dropped onto a piece of sterile fresh rabbit kidney in a sterile test-tube. About 15 c.c. of sterile hydrocele or ascitic fluid is quickly poured into the tube. Some of the tubes are covered with a layer of sterile paraffin oil and some are left without oil. The culture is incubated at 37° C. Subcultures may be made with 0.5 c.c. of the original culture and for growth in these subcultures it is advantageous to have a small amount of normal rat or human blood. No multiplication takes place at 15° C. Transplants may be made from the fourth to the ninth days. On the tenth day there comes a change in the morphology of the spirochetes. Many spherical bodies and irregularly shaped protoplasmic masses are seen. Actively moving spirochetes are sparse. Disintegration of the spirochetes is apparent. They lose their protoplasm and the spiral framework of the body is laid bare (the eviscerated forms of Stephen). Noguchi positively asserts that the spirochetes divide longitudinally.

Hata has used a simpler and, apparently equally useful medium for the cultivation of *Sp. recurrentis*. This consists of normal horse serum diluted with twice its volume of physiological saline solution and then heated to 70° or 71° C. for three hours. A small quantity of infected blood is placed on the translucent, semi-solid surface of the medium and incubated at 37° or room temperature.

Todd and Wolbach have shown that *Spirochæta duttoni* in an infective form cannot be filtered through a Berkefeld filter at atmospheric pressure, but an infective form passes through when the pressure is increased to fifty pounds per square inch.

Several observations on man and animals have been made showing that spirochetes pass through the placenta from mother to fetus.

Life History of Spirochetes.—Dutton and Todd noted the breaking up of spirochetes into granules in the bodies of ticks. The writer observed with *Sp. novyi* that cover-slip preparations of richly infected citrated rats' blood after the lapse of several hours contained many spirochetes *Sp. novyi*, which, while retaining a certain amount of motility, had become broken up into short rods or granules within the periplast; he showed that the endothelium of the liver sinusoids in infected animals contained many phagocyted granules and he expressed the opinion that these granules might be biological units capable of reproducing the spirochete in its perfect form. Balfour called attention to the tendency of the fowl spirochete studied by him in the Sudan, to break up into "infective granules" in the internal organs. These granules are discharged by living spirochetes from one or the other ends of the periplast, and Balfour believed that they entered the erythrocytes, developed in them and underwent a change analogous to schizogony and that this constitutes a phase in the non-sexual life cycle of the parasite. In addition to these bodies, spore-like refractile granules of another type have been described. These usually appear as refractile swellings at the end of a spirochete or treponema. They are not uncommonly seen in cultures of spirochetes. Sometimes the only persisting form will be the swollen body of a spirochete, one end showing undulations while the other will be surmounted by a refractile dot.

It is evident, then, that the word granule has been used for two or three distinct structures concerned in the development or degeneration of spirochetes. First, the bodies referred to by Balfour as infective granules, second, the spore-like refractile bodies appearing in old cultures, and thirdly the Leishman granules or coccoid bodies.

Leishman working with *Ornithodoros moubata*, found that experimental animals could be infected only when the tick voided excreta at the time of biting. The tick does not convey infection through the proboscis but by contamination through the infected excreta.

Leishman has described certain clumps of chromatin granules in *O. moubata* which, he believes, are derived from ingested *Sp. duttoni* and he has seen by dark ground illumination as well as by staining methods the definite extrusion of small and actively motile spirochetes from these granule clumps. He believes that the clumps described give rise to young spirochetes which become free, or actively motile, multiply by fission, and may persist in the tissues of the tick for many months. Leishman's observations tend to show that the life history of the human blood spirochetes is similar to that of the fowl spirochete.

Marchoux and Couvy have investigated the subject of the granules found in the Malpighian tubules of *O. moubata* infected with *Sp. duttoni* and conclude that they have no relation to spirochetes. While these observers are doubtless correct with regard to the nature of the purple granulations in the cells in the tubules, this does not nullify the truth of Leishman's observations that certain clumps may be derived from spirochetes. Gleitsmann, who studied strains of fowl spirochetes and paid particular attention to the "intracorpuscular bodies" in the red blood corpuscles which Balfour believes represent a stage in the asexual life history of the spirochete, is of the opinion that the bodies are degeneration products caused by the toxins of the spirochetes, although he admits that they may represent some independent infection not occupying any stage in the life cycle of the spirochete.

The appearance of the "infective granule" in the erythrocytes of an infected fowl as an "after phase," that is after the total or partial disappearance of spirochetes from the blood stream, is somewhat analogous to the appearance of "anaplasma marginale" in the blood of cattle recovering from an attack of piroplasmosis, and they are very suggestive tinctorially of the nuclear remnants which are seen in the erythrocytes of many animals during recovery from an infectious anemia.

Hindle summarizes the life cycle of *Spirochæta gallinarum* a typical example of a blood spirochete, as follows: The ordinary blood parasite grows until it reaches sixteen to nineteen microns when it divides transversely. As the spirochete disappears from the blood stream it breaks up into coccoid bodies. When the spirochetes are ingested by *Argas persicus* some of them pass through the gut wall into the cœlomic fluid. From this medium they bore their way into the cells of the various organs of the tick and there break up into a number of coccoid bodies. These intracellular forms multiply by ordinary fission in the cells of the Malpighian tubules and gonads. Some of the coccoid bodies are formed in the lumen of the gut and Malpighian bodies; thus, some of the coccoid bodies may be present in the Malpighian secretion and excrement of an infected tick and when mixed with the coxal fluid which is secreted at the time of biting may gain entry into another fowl by the open wound caused by the tick's bite. They then elongate and redevelop into ordinary spirochetes in the blood of the fowl and the cycle may be repeated.

Immunity.—Those who have worked with strains of spirochetes direct from human sources as well as those who have studied the epidemiology of the disease are of the opinion that the immunity conferred by an attack of relapsing fever is not absolute by any means. Litten and Gabritchewsky have observed reinfections after one and one-half years, and Sergent and Foley have reported several cases in which reinfection occurred after six years.

From the experimental study of the disease it is seen that there is a very definite immunity derived from the particular strain causing the infection, but the writer has shown that the immunity conferred by one strain of spirochetes is not sufficient to protect against a second strain of the same species having a different human source although from the same geographical locality. The writer found that while it was impossible to reinfect white mice and white rats with strain A *Sp. novyi* from a case in Panama, October, 1907, which was the strain used to infect them originally, it was always possible to infect them by using strain B *Sp. novyi* from a case in Colon, January, 1908. Clinically, morphologically, and by pathogenesis the strains were identical. Inoculation of strains A and B were made into animals immunized to A, with the result that animals which had recovered from an infection by A and were immune to it, could always be infected by B. Contrariwise an animal that had recovered from an infection by B was readily infected with strain A as early as nine days after spirochetes of the B strain had disappeared from its blood, thus showing that there are specific strains in a locality having specific immunizing powers.

Novy and Knapp have shown that in infected rats spirochetes die far more rapidly in decline blood than in onset blood and the former may early lose its infectivity. Agglutination and bacteriolysis of spirochetes are also constant factors in the mechanism of defense, and Novy and Knapp have demonstrated the presence of an immune body. Schilling states that in rats infected with *Sp. recurrentis* antibodies can be demonstrated in serum as soon as spirochetes begin to diminish in numbers in the blood stream.

Serum from convalescent relapsing-fever cases exerts a parasiticidal action on spirochetes *in vitro*. Gabritchewsky found that an infected monkey did not possess powerful parasiticidal agents in his serum until thirty-six hours after crisis. Four days after crisis the serum was inactive, the animal, however, remained immune to reinoculation and Browning calls attention to the doubt which arises as to whether crisis and the consequent immunity to reinfection are due to precisely the same factors as those which operate in conferring passive immunity or which produce parasiticidal action *in vitro*.

Whether phagocytosis plays an important part in the mechanism of defense is still a debated question. Levaditi and Manouelian believe that the critical destruction of the blood spirochetes is essentially by phagocytosis and is not bactericidal. Novy and MacNeal observed in intraperitoneal inoculations of spirochetes into hyperimmunized rats, that phagocytosis was carried out by mononuclear leucocytes, not polymorphonuclear leucocytes as Metchnikoff had asserted for the spleen of monkeys. Levaditi and Roche found that the destruction of spirochetes at the crisis was not due to the presence of bacteriolysins or opsonins in the blood, but that these substances seemed to develop some hours later. They believed that some spirochetes survived the crisis and that these being resistant to the antibodies present in the blood at that time were able to multiply. Resistance to antibodies was cumulative and hereditary. Other writers, notably Manteufel, believe that the parasiticidal agent is the serum, and phagocytosis is not an essential feature. The mechanism of defense in spirochetal disease would seem to be a combination of agglutination, opsonization, phagocytosis, and bacteriolysis.

Hereditary immunity has been observed in animals and is presumed to occur in man.

Hyperimmune serum shortens the duration of the infection in animals infected with the same strain as that from which the serum is derived, but considering the observation made by the writer that the serum prepared from one strain is not potent against another it is unlikely that preventive and curative sera will ever be used advantageously in the treatment of these infections.

Rôle of the Spleen in Spirochetal Infections.—Metchnikoff in 1887 found that at the close of an infection with *Sp. recurrentis* in monkeys, there was a segregation of spirochetes within phagocytes in the spleen. Soudakewitch experimenting with splenectomized monkeys believed that the spleen was the sole organ in which spirochetes were destroyed. Tictin observed that there was no phagocytosis of spirochetes in infected animals in the lymph nodes or bone marrow. Breinl and Kinghorn showed that in splenectomized animals the spirochetes disappeared from the peripheral blood after the attack as promptly as in normal animals, and that relapses occurred in the ordinary way, also that active immunity against reinfection was not influenced by the spleen. It was also shown that the infection in splenectomized animals was usually more severe with *Sp. recurrentis* and *Sp. duttoni*. It is inferred from this that if phagocytosis is a necessary factor in the mechanism of defense, this may be carried out by hepatic endothelium as well as by that of the spleen.

Relapse.—The opinion has been expressed that relapse is due to the survival of a few spirochetes in protected places in the body and their subsequent multiplication after crisis, but it seems likely that this will not fully account for the phenomenon. It is evident in some cases of malarial infection that cold, wetting, overwork, surgical or other shock, an alcoholic debauch, etc., may bring on a relapse of malaria in a person already infected. We believe that the external cause upsets the apparatus of defense whereby the body is kept in a state of equilibrium. In other infections, such as trypanosomiasis in certain animals, and particularly spirochetosis in man, a relapse is the striking feature of the disease, and takes place without the agency of an external cause. According to Browning the explanation is that the parasites which have survived the action of the antibodies elaborated at the time of the primary attack, themselves develop an immunity to these antibodies and thus become serum resisting, and that such a condition probably represents an extreme degree of the process of accommodation which leads to latent infection.

Mode of Infection.—Infection is usually the result of the bites of ticks and lice, but it is believed that the spirochetes may penetrate the intact skin, for infections following autopsies on infected animals are not uncommon. Spirochetes may pass through the intact mucosa of the conjunctiva and genital tract, and may also pass through the intact placenta.

The relapsing fever of Europe is usually associated with the presence of vermin, and Flügge in 1891 suggested that lice were responsible for the transmission of the European type of the disease. Nuttall believes that it may be regarded as established that lice, *Pediculus vestimenti* and *P. capitis*, transmit relapsing fever and are presumably the ordinary vectors in most parts of the world. Fehrmann, however, from the observation that Mohammedan Tartars shave the head and pudenda yet get relapsing fever believes that *P. capitis* and *P. pubis* cannot be vectors.

It is an interesting commentary on the prevalence of vermin in the period of 1840 that Dr. Welsh of Edinburgh when acting as a clerk in the Royal Infirmary in the course of four months wrote—"my three colleagues, two of the young men in the apothecary shop, two house maids, and thirteen or fourteen nurses caught the disease, and the matron and one of the dressers died of it. In this hospital my friends Messers Stevenson and Cristison, the matron, two apothecaries in succession, the shop boy, washerwoman, and thirty-eight nurses have been infected. Four of the nurses have died. With the exception of two or three nurses, who have been but a short time in the hospital I am now

the only person in this house who has not caught the disease. Several students whom curiosity led too near the persons of the patients might be adduced as additional evidence. . . . . When it begins in a family we always expect more than one of them to be affected. I could mention instances of four, five, six, and seven being sent to the hospital out of one family. Eight, nine, and ten out of one room, twenty and thirty out of one stair, and thirty and forty out of one close, and this all in the course of a few months. Hardly any of the nurses, laundry women, or others coming in contact either with the patients or their clothes have escaped." Personal hygiene and hospital administration have certainly improved since that period!

Bayon from clinical data believes that the relapsing fever of Russia is transmitted by *P. vestimenti* and not by *Cimex*, and Mackie observed during an epidemic of Indian relapsing fever that the boys who were heavily infected with lice acquired the disease and upon dissecting lice from the boys' ward he found that 24.1 per cent. contained spirochetes. During an epidemic of relapsing fever in northern China *Sp. recurrentis* was obtained often in great numbers from lice, in five out of ten cases of the fever.

Nicolle, Blaizot, and Conseil, have recently demonstrated experimentally that relapsing fever is transmitted by the body louse. The Algerian strain *Sp. berbera* a variety of *Sp. recurrentis*, was used in the experiment. When a person is bitten by an infected louse the irritation caused by the bite may cause him to scratch that part of the skin. The louse is often crushed and its contents get onto the skin and under the finger nails. The excoriation of the skin due to scratching opens a portal of entry for the spirochetes and infection results. The bite alone of the infected louse is harmless. Hereditary transmission of spirochetes was demonstrated by these observers, for eggs laid by lice infected from a monkey were permitted to hatch and the young lice when inoculated into a second monkey produced infection. Lice appeared to be infective from the eighth to the nineteenth days. Female lice were more susceptible to infection, and *P. capitis* experimentally is as susceptible as *P. vestimenti*. According to the observers, the spirochetes were found only in the cœlomic fluid; the contents of the digestive tube and the feces were noninfective when tested out on monkeys.

Infection by Ticks.—Livingstone, in his travels described a human tick disease in Portuguese East Africa and stated that "before the Arabs came bugs were unknown" and he speaks of "ticks that follow wherever Arabs go." Among the natives in Africa tick bites are commonly held to be responsible for a sickness which may result fatally.

In 1904 Dutton and Todd announced that a spirochete was the pathogenic agent of the human tick fever of the Congo and that they were able to infect monkeys with spirochetes through the bites of *Ornithodoros moubata*, and they were successful in transmitting the disease through the bites of ticks newly hatched in the laboratory from infected parents. They noted the presence of living spirochetes in the stomachs and Malpighian tubules of infected ticks up to five weeks after their feeding on infected animals, and also that when in some preparations of the stomach or Malpighian tubules no parasites were seen at first, the preparation became crowded with them if a little human serum were added. They also found on six occasions some spirochetes morphologically identical with *Sp. duttoni* in the anal and coxal secretion of the ticks. Koch, working in East Africa, confirmed the findings of Dutton and Todd and observed that spirochetes penetrated undeveloped eggs within the ovaries.

Negative transmitting experiments with *Cimex lectularius* were carried out by Breinl, Kinghorn, Todd, and by Nuttall. Fulleborn and Mayer were unable to transmit the disease by means of *Stegomyia fasciata*.

Mollers, in 1907, showed that ticks infected with *St. duttoni* may feed repeatedly on uninfected animals without losing their infectivity for a period of eighteen months after the first feeding. He showed also that the third generation of ticks may retain evidences of infection induced in their grandparent even though their parents had never been directly fed from an infected animal.

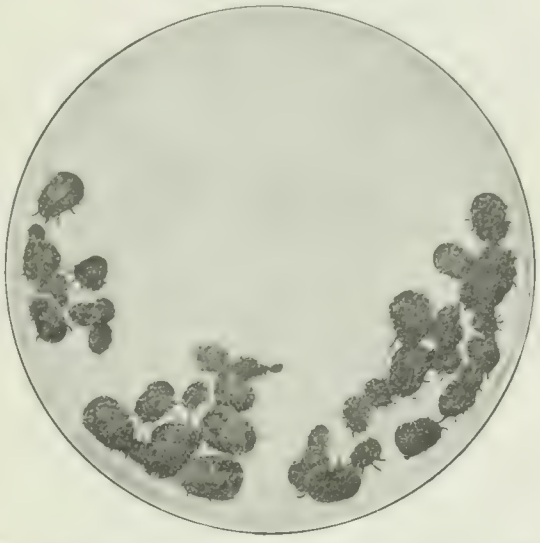


Fig. 4418.—Photograph from Life of *Ornithodoros moubata;* slightly enlarged. (After Dutton, Todd, and Newstead.)

A very important contribution to the subject was made by Sir William Leishman, who believes that infection takes place either by regurgitation or by the excretion of infective matter from the alimentary canal, the spirochetes entering the cutaneous wound made by the tick's bite. Leishman by means of interrupted feedings was able to assert that salivary glands and coxal fluids were not infected but that spirochetal infection resulted from the entrance of infective

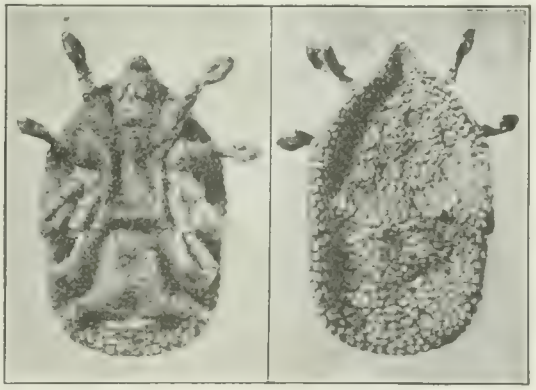


Fig. 4419.—*Ornithodoros talaje*, var. *capensis;* × circa 12. (After Nuttall.)

matter, excreted by the tick during the act of feeding, into wounds caused by the tick's bite,. These observations were confirmed by Hindle who found that when infected ticks were kept at a temperature of about 21° C. the gut and contents, sexual organs, Malpighian tubules, and excrement were infective, but when kept for several days at a temperature of 35° C. all organs, including the salivary glands, became infective, and

that the incubative period is shorter in animals inoculated with this material.

Manteufel, in 1908, showed that *O. moubata* was an equally efficient host for *Sp. recurrentis* and Brumpt found that this tick could transmit *Sp. marchouxi* as well, although he was unable to induce *O. moubata* to transmit *Sp. novyi* and *Sp. berbera*, the causes of American and Algerian relapsing fevers respectively. Brumpt has shown that the relapsing fever of Abyssinia is transmitted by *O. savignyi*. Neumann, in 1909, succeeded in transmitting *Sp. duttoni*, *recurrentis*, and *novyi* by means of *O. moubata*, and he found that, occasionally *Sp. duttoni* could be transmitted by *Hæmatopinus spinulosus*, the rat louse. Hindle urges, however, that *O. moubata* is probably the only ectoparasite which naturally transmits *Sp. duttoni*. Nuttall believes that neither the ticks nor the spirochetes are specifically adapted to each other in an obligate manner, for the fowl tick as well as *O. moubata* has served to transmit *Sp. duttoni*, *Sp. recurrentis*, and *Sp. novyi*.

Mouzels has shown that there has been for several years a very marked increase in the number of cases of relapsing fever at Hanoï during the hottest season in the year, March to June, and that this is very suggestive of mosquito carriers. The same author believes that fleas are also responsible for the carriage of relapsing fever in Indo-China.

Types of the Disease.—If the relapsing fevers are considered from their geographical distribution, the biological transmitting agent, the animal reactions, and immunity reactions of the spirochete, and lastly the clinical types in the human cases, they will be found to fall into three groups with possibly several subgroups:

American (Tropical)	Eurasiatic-Mediterranean	Tropical African
	European	East African
	Indian	Congo
	Persian	Arabian (?)
	Indo-Chinese	
	Chinese	
	North African	

This subdivision, of course, cannot be defended in all particulars for the data we possess are still far from being complete. Relapsing fever occupies a unique position among the epidemic fevers; not only is the spirochete difficult to classify on account of its possessing characters common to both bacteria and protozoa but its clinical characters are somewhat polymorphous.

The Relapsing Fever of Tropical America.—*Synonyms;* Relapsing fever of Colombia, Relapsing fever of Panama, Fiebre spirochetal ó recurrente.

Geographical distribution.—Colombia and Panama. Cases have also been reported from Mexico (Vera Cruz) and Cuba.

The first case of relapsing fever noted after the American occupation in Panama, occurred in 1905 at Colon Hospital and the spirochete was detected by the late Dr. H. A. Stansfield. Since then about forty-five cases have been detected by microscopic examination.

Fig. 4120.—*Ornithodoros savignyi;* dorsal and ventral aspects. (After Christophers.)

The spirochete *Sp. novyi*, Shellack, 1907, was very thoroughly studied by Novy and Norris and their confrères in 1906 from the virus obtained from Carlisle's case. Shellack, in 1907, believed that he had demonstrated immunological differences between *Sp. novyi* and *Sp. recurrentis*. In 1909 the writer reported thirty cases of the disease occurring in Panama and pointed out the fact that there was a distinctly American type of the disease and that Carlisle's case fell in with this type. Blanchard called attention to the discovery by Franco of the presence of a febrile spirochetosis in Colombia, South America. Blanchard suggested that *O. turicatus* is the species of tick concerned in the transfer of the disease. Robledo has also expressed this opinion. The latter was unable to induce *P. capitis* to transmit the disease. Franco believes that the disease is not transmissible by ticks at the high altitude of Bogotá (2,600 meters) for, although his cases were observed in that city they were in persons who had come from the lower altitudes, usually Bogotános returning from their vacations, or travelers arriving from the coast.

The animal reactions are of importance in identifying the specific spirochete. The temperature curve in human cases is quite different from that of the European type and consists usually of about four paroxysms of relatively short duration. The first paroxysm, which is the longest one, may last three days. The second, third and fourth are usually twenty-four to forty-eight hours in duration. Abortive paroxysms are frequently seen, in which the tempera-

ture rises during the apyrexial period for two or three degrees and lasting but a few hours. Superimposed paroxysms are occasionally encountered in which, immediately after crisis, another paroxysm of fever appears. The temperature is never sustained and continuous as in the European type but each paroxysm of fever displays remissions and frequently intermissions. The disease is always mild. However, if it were introduced into a population already debilitated by famine or disease it might assume virulent characters.

The disease undoubtedly has made its appearance in the seaports of the United States and no doubt has been overlooked or called malaria. Careful routine blood examinations will reveal the spirochetes

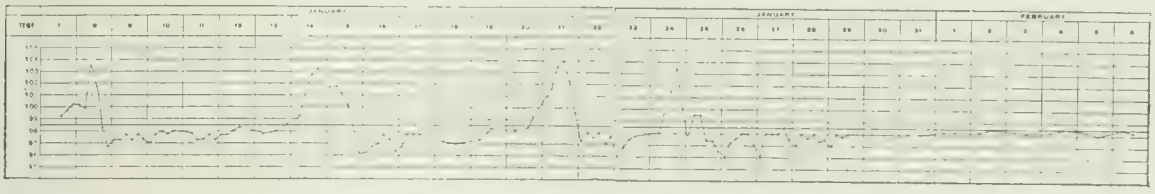


Fig. 4421.—Type of Temperature Curve Caused by *Sp. novyi.*

but *they are always sparse compared with the numbers encountered in the European type of the disease.* This is so constant a feature that the disease may be differentiated from the European form by this characteristic. Spirochetes are found one in twenty or thirty oil-immersion fields when they are most numerous, but several smears may be searched at times during a paroxysm before finding a single spirochete. Inoculation of rats, mice, or monkeys of the old-world type will reveal spirochetes when they are very sparse, apparently absent, or only suspected.

The transmitting agent is undoubtedly *Ornithodoros talaje* or *O. turicatus.* These ticks with habits like the bed-bug, are found in all native villages. The larval form, according to Banks, passes a portion of its life on the house rat. The tick is known in Panama as *"Chinche mamone,"* and in Colombia by the names *"Chirivico," "Berrinche" "Cuesca,"* and *"Chinche."*

The Relapsing Fever of Eurasia and Northern Africa.—This type of the disease is very widely distributed. In the past it prevailed extensively in the British Islands, Germany, Russia, The Levant, Egypt, Algeria, and northern Africa. In Asia it has been reported from India, Persia, China, and Indo-China.

world monkeys are susceptible to infection, but it is usually necessary to pass the virus through a monkey before white rats, white mice, or other small rodents can be infected.

The temperature curve is usually characteristic, there being two rather prolonged paroxysms of fever in which the temperature is generally sustained. The first paroxysm lasts five or six days, the thermometer remaining at 39°–40° C. (102.2°–104°F.). After about ten days of apyrexia the first relapse appears. In it the temperature may be sustained but is often remittent or rarely intermittent.

The mortality is very high in some localities and in some epidemics, but on the whole it is low. High mortality rates are more frequently observed in association with poverty, famine, and conditions leading to extreme debility. The North African type of the disease is not usually severe.

There are large numbers of spirochetes in the blood at the height of infection sometimes twenty to thirty in an oil-immersion field. Carter in India came across enormous numbers, sufficient sometimes to cause mechanical blocking of the capillary circulation.

The transmitting agents are *Pediculus vestimenti* and *Pediculus capitis.*

The Relapsing Fever of Equatorial Africa.—*Synonyms:* Tick fever; African tick fever.

Geographical and Historical.—The disease is found in the Congo Free State, and Angola on the west; Uganda, German East Africa, Portuguese East Africa, Zambezi valley, Somaliland, and Madagascar on the East. In August, 1903, Nabarro discovered a spirochete in the blood of a patient in Uganda. Ross and Milne and Dutton and Todd the following year demonstrated that the cause of tick fever was a spirochete.

Sp. duttoni is the name given to the spirochete discovered by Dutton and Todd in the Congo while *Sp. rossii* is the cause of the fever encountered on the East. These terms are merely used to distinguish the East and West strains and do not refer to any specific differences in their immunity reaction.

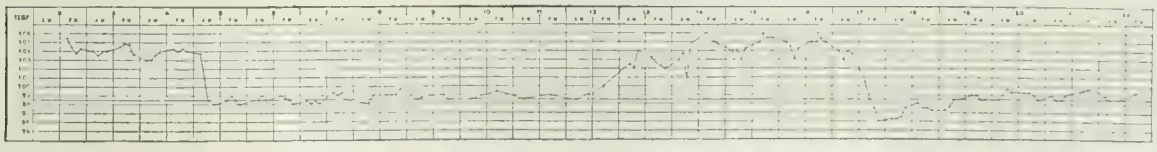


Fig. 4422.—Type of Temperature Curve Caused by *Sp. recurrentis.*

The spirochete causing the fever of Europe is *Sp. recurrentis* while that encountered in India is known as *Sp. carteri.* The term *Sp. berbera* has been given to the form seen in Algeria. Morphologically there are no constant specific differences between the blood spirochetes and no attempt should be made to identify them by measurements, for authorities completely disagree on this point.

The animal reactions of the three above-mentioned spirochetes are practically identical. Man and old-

Carter has described a form of relapsing fever in Arabia transmitted by ticks and possible this is a subgroup of the African type.

The spirochete cannot be identified by any constant morphological peculiarity. The animal reactions are distinctive and help to differentiate this type from others.

The temperature curve usually consists of a series of paroxysms of short duration sometimes as many as six to ten paroxysms of fever being noted and the

disease lasting from three to four months. The first paroxysm usually lasts three days. Cases have been reported, however, in which there have been but one or two paroxysms, but the previous history in some of these cases, particularly among natives, has been defective. The disease appears to be more severe among Europeans than among natives. The mortality, however, is usually very low in both classes.

Spirochetes are generally sparse in the blood. At times they are found with great difficulty after the first paroxysm. The greatest number ever seen is two or three to the oil-immersion field during the height of an attack. *Ornithodoros moubata* is the transmitting agent. The immunological reactions of *Sp. duttoni*, according to Shellack, place it in a distinct class from the other spirochetes. It is questionable, however, whether there is any immunity reaction known at present beyond the animal reactions that will separate this spirochete from others.

tion, which, however, brings no relief to the headache or other painful symptoms. In the Eurasian type of the disease a delicate grayish-yellow tint of the skin may be observed, particularly on the face, and this may be followed by a distinct jaundice.

The temperature abruptly falls to subnormal, particularly in the American and African types, in from two to twenty-four hours. In severe cases this is associated with collapse and in the ordinary case by epistaxis or hemorrhage elsewhere, or by diarrhea.

The pulse rate is diminished in frequency during the period of apyrexia, and usually remains lower than normal—from fifty to sixty—after the crisis.

There is commonly a complete but gradual amelioration of symptoms—the thirst disappears, appetite returns, and the headache and myalgia cease to annoy the patient, leaving him a little weak, perhaps, but otherwise apparently normal. The duration of the first attack is from three to twelve days. In

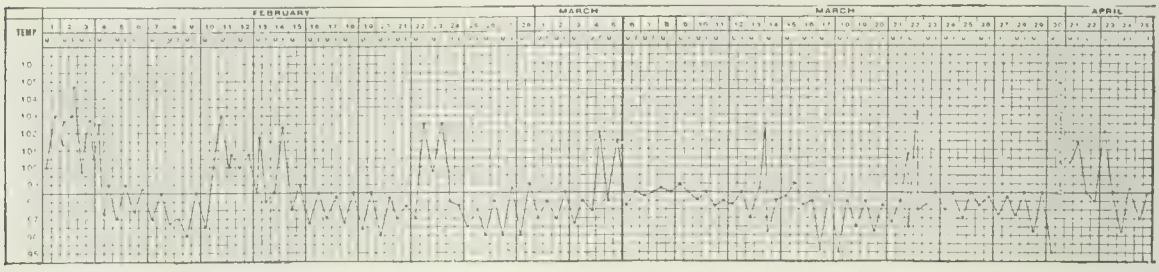


Fig. 4423.—Type of Temperature Curve Caused by *Sp. duttoni*.

General Symptoms.—The incubation period is from five to ten days and, judging from animal experiments, this would seem to depend upon the dosage of virus for, other things being equal, the incubation period may be shortened by increasing the number of spirochetes injected. In two cases of laboratory infection derived at autopsy, the periods were six and seven days.

One of the chief characteristics of the disease is its sudden invasion. The prodromal symptoms—extreme lassitude and intense headache with pain in back, limbs, and epigastrium or over the spleen, are soon accompanied by a chill—frequently a violent chill with severe rigor. The fever rises in a few hours to 102–105° F. and sometimes 107° F. the first day. Feebleness and prostration are not so marked at first but may develop later, and the patient, though weak, frequently can walk into the hospital during the first attack. Vomiting occurs in adults but is commoner in children. Thirst is extreme and there is usually marked anorexia. Insomnia and restlessness at night are very annoying symptoms. Myalgia is very distressing. The patients in severe cases may moan and groan in pain not only during waking hours but during sleep. The pain is sharp, darting, and severe and is accentuated by movement or pressure. Any group of muscles may be involved but it is especially pronounced in the calves of the legs. The headache persists and the symptoms continue during the attack. On the last day of the fever when it may have reached its highest reading, crisis occurs accompanied by copious sweating. A very striking feature is the progressive and rapid enlargement of the spleen, which is usually very tender, and pressure over it may provoke a severe paroxysm of pain. The liver also is enlarged and tender. Patients complain of a bad taste in the mouth and the breath is very heavy and fetid. The tongue becomes coated white or brown. The pulse is rapid, ranging from 90 to 130. The body during the second and third day may be bathed in perspira-

the European type of the disease the average duration is seven to eight days; in the tropical African four days, and in the American about three days.

The first interval or period of apyrexia lasts from seven to ten days not infrequently broken in the tropical types by an abortive or incomplete paroxysm consisting of a rise of temperature lasting but a few hours. A number of cases—as many as twenty per cent. in some epidemics it is stated, consist of a single paroxysm. Franco has seen a few cases of this type in Bogotá and similar instances have been reported from India and Uganda.

The second paroxysm appears as suddenly as the first, and there is a return at once of the original symptoms increasing in severity until the fastigium is reached. The duration of this second paroxysm is usually shorter than the first, being two to five days and always nearer two days in the tropical types and nearer five days in the Eurasiatic types. The intensity of the symptoms in the second attack is in most cases less than in the first, and each succeeding paroxysm is less severe than the preceding one. In the Eurasiatic type there are usually but two paroxysms; in the American type there are commonly four, while the tropical African type may present six or more paroxysms at intervals of seven or eight days.

Convalescence may be slow or rapid depending on the severity of the attack, the amount of debility, or of other complications.

The case mortality is usually not great but may rise in certain epidemics of the Eurasiatic type to a considerable height, this is usually among unduly debilitated patients or in times of famine. Death may occur in the debilitated during the height of the first paroxysm, or when complicated by pneumonia, during the second one. Cases have been recorded in which after a period of calm, sudden death has followed an attack of general prostration.

Temperature.—In spite of certain vagaries there are three distinct types of temperature curves pre-

sented by the three groups of fevers (see charts), and a sufficiently large number of cases will fall into these groups among the geographical types of the disease. The following tables illustrate the duration of attacks and intervals and the number of same, in the different types of the disease.

Eurasiatic Type—Table from Hodlmoser

Duration of attack in number of days.	Percentage of patients in their first attack.	Percentage of patients in their second attack.	Percentage of patients in their third attack.
1	0.0	11.3	2.5
2	0.0	10.6	2.5
3	1.1	16.9	2.5
4	5.0	2.5	10.7
5	6.5	27.5	10.7
6	21.2	7.5	
7	19.1	0.6	3.6
8	20.2	0.0	
9	9.7	0.0	
10	7.9	0.6	
11	4.5		
12	2.5		
13	2.2		
14	0.4		

Table from Mouzutkowsky

Attacks.	1st	2d	3d	4th	5th
Duration in days, paroxysms.	6¼	5½	3½	2½	1
Duration in days, intervals	5¼	6⅛	9	10½	0

There can be no question but that the second relapse is infrequent in the Eurasiatic type of the disease. Russian and Indian writers emphasize this point. Different epidemics, however, present some variations from this statement. Carter observed in India that a second relapse occurred in twenty per cent. of the cases, a third occurred in five per cent., while a fourth relapse was seen in two per cent.

Popoff states that at the Botkin Barracks Hospital, St. Petersburg, during a ten-year period, the number of attacks in the cases ending in recovery was as follows: 32.5 per cent. had only one attack; 35.5 per cent. had two attacks; 25.5 per cent. had three attacks; 6.5 per cent. had more than three attacks.

Casaux, from Indo-China, reports that out of 161 cases forty-four had one attack, fifty-five had two attacks, thirty-seven had three attacks, nineteen had four attacks, three had five attacks, and three had six attacks. The average duration of the first attack was six days, of the second attack four days, and of the third attack three days. The average duration of the first interval was eight days and of the second interval, seven days.

There are few available records of any detailed observations among natives or Europeans on the tick fever of Africa. Most observers claim that the fever is not so severe among natives in an endemic region, for it is believed that they have had the fever during childhood, and they are reported as usually having but one or two paroxysms. Dutton and Todd found no marked difference between natives and Europeans suffering from the disease. There are several good accounts of laboratory infections among Europeans and in these cases there have always been from four to seven paroxysms.

The temperature in the first paroxysm rises abruptly and in the Eurasiatic type may be continuous. In the tropical forms it is usually remittent or irregular. The second attack displays greater remissions and intermissions or pseudo-crises may be seen. The termination of a paroxysm is sometimes preceded by a precritical rise.

The fall in temperature usually occurs late at night. Abortive or incomplete paroxysms are not infrequently seen in the tropical types of the disease. A striking feature is the subnormal critical fall in temperature frequently to 95° F. This is seen in all types. In the tropical forms a very striking characteristic is the marked subnormal oscillations in temperature during the apyrexial period.

Pulse.—The increased pulse rate is closely correlated with the rise in temperature and there is a corresponding reduction in the rate during the period of subnormal temperature. A pulse of 100 to 110 corresponds with a temperature of 103° to 105° F. while the pulse of 50 to 60 corresponds with a temperature ture of 95.5°–97.5° F.

Respiration.—This shows a simple correlation with the temperature and pulse rate, rising to from 28 to 32 during the paroxysm of fever. The subnormal oscillations of temperature noted above are associated with an increase in the respiratory rate, so that we may see a temperature of 98° with a pulse rate of 80 but a respiratory rate of 24. These subliminal correlated oscillations of temperature, pulse rate, and respirations are very striking.

Nausea is a common symptom, but vomiting is not so constant though it may be frequently seen in children.

The *tongue* in mild cases remains moist or becomes coated white and furred save the tip and margins.

Cough is observed occasionally.

Jaundice is commoner in some epidemics than in others and is seen oftenest in the Eurasiatic type of the disease. From the fact that it was always associated with jaundice, a severe type of the disease was formerly known as "bilious typhoid." In the North African type jaundice has been seen in fifty-three out of 160 cases, and a larger proportion of the jaundiced patients died than of those not showing the sign. In India jaundice is seen in half the fatal cases and only fifteen per cent. of the surviving ones. When jaundice has occurred with vomiting of dark grumous material the disease has been mistaken for yellow fever.

Headache is persistent and tormenting throughout the entire attack letting up completely or only gradually after the crisis.

Giddiness and vertigo are seen only in the more severe cases and during the height of the paroxysm.

Restlessness is a marked symptom, resulting not only from the fever but from the myalgia and headache.

Delirium occurs in a very small proportion of cases and is usually associated with hyperpyrexia.

The *pains* in the back and the cramp-like or darting pains in the calves of the leg are common symptoms. There is frequently hyperesthesia of the skin, epigastric pain, and tenderness.

The *bowels* show no striking change. It is not uncommon to observe slight diarrhea during paroxysms and this may be accentuated at the time of crisis, and replace sweating to some extent, ceasing promptly after crisis.

Anorexia is a striking symptom. This is usually confined to the pyrexial period but may extend over the entire course of the disease.

The patient suffers from persistent *thirst* throughout the pyrexial period.

Skin.—On account of the frequency with which perspiration occurs during the paroxysm the skin may be constantly moist and not hot or dry. According to the older writers relapsing fever was said to have no characteristic eruption. There is an erythematous blush over the face and upper part of the body in some cases; others may present varying suggestions of icterus of a dirty yellowish hue. Carter has described a rash occurring in ten per cent. of his cases and seen at the height of access. It is rare before the fourth day. The rash appears first on the abdomen and front and sides of the chests and arms; rarely on the legs. Its appearance is that of a collection of minute red blotches one to six millimeters in diameter, circular, flattened, and slightly raised with well-defined edges not effaced by pressure. These blotches often become petechial or purple in color. Rogers does not

regard them as specific for relapsing fever. During the crisis miliaria and sudamina may appear. Herpes of the lips, nose, and ears is not uncommon. Desquamation has been observed during convalescence.

Many cases of *ophthalmia* have been noted in some of the British epidemics.

The *spleen* enlarges at a very early period. It is soft, very tender and pressure may provoke a paroxysm of pain. It extends four to five centimeters below the costal margin, and the enlargement continues throughout the disease though it may become reduced somewhat during apyrexia. This enlargement occurs before there is any appreciable blood destruction. The danger from rupture is as great as, if not greater, than as in typhoid fever. In times of famine or whenever conditions prevail favoring the association of the disease with scurvy, subcapsular hemorrhages and abscesses may be encountered.

The liver is also enlarged and tender during an attack.

Epistaxis and Hemorrhages.—Epistaxis is seen during a paroxysm in the American type and in a small proportion of the European cases. Fatal hematemesis has been recorded in a few instances and when this is associated with jaundice the disease might well be confused with yellow fever.

Thrombosis of the femoral veins and spontaneous gangrene are said to occur.

Urine.—In the milder forms of the disease there may be no pathological changes in the urine. The excretion of urea may be increased and some individuals, particularly tropical negroes, may show a trace of albumin. The diazo test is negative but indican is increased. A few hyaline casts may appear in the sediment. In the severe icteric forms of the disease there may be severe nephritis and even hematuria.

Blood Changes.—The erythrocytes may be slightly increased at first, to be followed by a slight reduction, but although there is no apparent destruction of erythrocytes on the large scale the basophilic stippling is well-marked throughout the course of the disease. Three weeks after the last paroxysm in an ordinary case the erythrocytes have regained their normal number. Basophilia will have disappeared and the hemoglobin returned to 100. There may be a leucocytosis at the onset but this is replaced by a distinct leucopenia as the disease progresses. The leucocyte count may reach 3,600 per cubic millimeter and a normal count be regained within a week. The blood plasma is distinctly altered and the blood as drawn from the ear is usually dark in color.

associated with cardiac exhaustion or weakness; abortive or incomplete, in this form there is but a single paroxysm, usually mild in character.

Carter described a very fatal form of the disease resembling typhus under the name of icteric fever. This is characterized by deep jaundice, hemorrhagic petechiæ, irregular and prolonged pyrexia, early prostration, and tendency to localized inflammations. These represented five per cent. of the cases admitted to hospital and from fifteen to twenty per cent. of the fatal cases. The pyrexia persists for seven to eight days tending in the worst cases to fall by crisis. There is a typhoid condition and sometimes the disease is mistaken for yellow fever.

Complications.—These occur oftenest in debilitated persons but may depend on the epidemic being a particularly virulent one. In tropical countries the commonest complication is malaria, either tertian or estivoautumnal. Clinically it is almost impossible to differentiate malaria from relapsing fever by an examination of the patient. The temperature chart, however, will suggest that there is some alteration in the characteristic curve of relapsing fever. In estivoautumnal fever there is a tendency for the paroxysm to be prolonged and the abrupt invasion and crises may be modified. Naturally the blood examination will disclose the complicating factor, when present.

In times of famine and in armies, jails, and barracks, whenever conditions favorable to the development of typhus fever arises, then relapsing fever may be complicated by it.

Relapsing fever may also be superimposed upon scurvy when this disease is prevalent.

Bronchitis and laryngitis are not uncommon complications. They may appear during the first attack and, while not severe, may give rise to much discomfort for the cough increases the headache and abdominal tenderness.

Pneumonia is a serious complication. It is sometimes croupous in type but may be of the bronchogenic or pyemic type associated with infarctions and gangrene. This complication is rare in tropical types.

Parotitis may occur as in other serious fevers.

Abortion nearly always occurs when pregnant women develop relapsing fever and this usually occurs during a relapse.

Diagnosis.—In the typical case the course of the disease is so distinctive that the diagnosis may usually be made without the aid of the microscope, but we have noted above that a certain number of cases have but a single paroxysm; moreover in the Eurasiatic type, as there are commonly but two paroxysms and the first may have been experienced before the patient is seen or has entered the hospital, there may be but one febrile paroxysm to guide the clinician. The importance, then, of interrogating every case of fever by means of the microscope is evident.

The sudden onset, rapid elevation of temperature,

	January 31, second paroxysm pyrexia.	February 1, crisis.	February 2, beginning of apyrexia.	February 4, apyrexia following abortive paroxysm.	February 8, pyrexia.	March 7, 27 days after last attack.
Polymorphonuclears	68	49	39	42	41	42
Large mononuclears	17	13	11	11	20	10
Small mononuclears	12	36	40	36	30	37
Eosinophiles	1	0	8	8	8	10
Transitionals	1	0	2	2	1	0
Mast cells	1	2	0	1	0	1
Erythrocytes	5,880,000	5,590,000	5,050,000	5,850,000	....	5,500,000
Leucocytes	6,900	4,800	5,500	3,600	6,600	8,600
Basophilia	+	....	+	....	+	None.

In a case of the American type reported by Baetz from which the accompanying table was taken, we note the relative increase of small mononuclears, the leucopenia, diminution in the polymorphonuclears, and the basophilia.

Special Clinical Forms.—The following terms have been used to characterize predominant features in the respective forms of the disease: bilious typhoid, the icteric form of the disease; syncopal, a form

and early enlargement and tenderness of the spleen are very characteristic. Subnormal temperature following crisis is more pronounced in the tropical cases and an equally characteristic sign is the subnormal oscillation of temperature as well as the pulse, the latter being correlated with the temperature and its rate being abnormally slow during the period of apyrexia. The return of the attack after a calm of several days with all its original features should at once suggest relapsing fever.

Most cases of erroneous diagnosis are due to the semblance of the disease to malaria.

Microscopic examination of the patient's blood should be made during the paroxysm. Doubtful cases may be cleared up by animal inoculations even in the period of apyrexia. Fifteen cubic centimeters of blood should be inoculated into a monkey, white mouse, and white rat, each animal receiving 5 c.c. intraperitoneally. An old-world monkey should be used, for the new-world varieties are all relatively insusceptible. A temperature reaction should not be depended upon to detect a positive result in subinoculated animals; a careful examination of stained films of the animal's blood on each of six succeeding days following the inoculations should be made. The spirochetes may be very sparse and remain but a few hours in the animal's blood. Spirochetes do not appear in the peripheral blood until some hours after the onset of fever and they disappear a few hours before the temperature falls to normal. Rarely it is possible to demonstrate them microscopically during the apyrexial period.

Dark ground illumination may be used for demonstrating the spirochete or films may be stained by Romanowsky. Leishman has called attention to the fact that in stained slides spirochetes, when present, may be detected by dark ground illumination. Spirochetes are never numerous in the American type of the disease and many fields may have to be searched before finding one, whereas in other forms of the fever, notably the European type, twenty to thirty or more spirochetes may be seen in one oil-immersion field. Brault and Montpellier report finding the spirochetes of the North African fever in the sweat, tears (in a case of iritis), and cerebrospinal fluid. The protein constituents of the cerebrospinal fluid are increased in relapsing fever and there is a lymphocytosis in half the cases.

Loewenthal's Reaction.—This test is of special value during the apyrexial stage when spirochetes are absent from the peripheral blood. A drop of blood from the suspected patient is taken and added to a drop of blood containing spirochetes from another patient. A cover-slip preparation is then made, sealed, and incubated at 37° C. for half an hour. The agglutination of spirochetes indicates a positive reaction.

One of the difficulties attendant upon the diagnosis of relapsing fever is that if patients enter the hospital at the end of the first attack when the blood is negative they may be discharged before the onset of the next relapse. Ordinarily they cannot be kept in the hospital long enough to establish a positive diagnosis.

In the presence of epidemics, relapsing fever may be detected complicating other diseases or marking more or less completely the features of the other disease. Patients acutely ill and having recently arrived from endemic centers, such as immigrants from Russia or travelers from tropical American ports, should be specially examined for spirochetes.

In typhoid fever the invasion is not so abrupt as in relapsing fever but in obtuse patients this may not be of much help. Blood cultures and blood examinations should be used to clear up the diagnosis.

Yellow fever, severe cases at any rate, may be differentiated by the albuminuria, black vomit, absence of marked splenic enlargement and by the fact that the jaundice is more delicate in type in uncomplicated yellow fever.

Dengue, seven days' fever, and pappataci fever will be difficult to differentiate without blood examination.

Whenever possible the patient should be required to remain under observation from seven to twelve days after the fall of temperature so that a relapse, if it occurs, may be detected and the patient prevented from disseminating the infection.

Prognosis.—The prognosis in relapsing fever is favorable on the whole but depends on the geographical type of the disease and the particular epidemic. The Eurasiatic type is the most serious, but much depends on the condition of the patient, for in times of famine and whenever the resistance of the individual is reduced from any cause the mortality naturally will be high.

In St. Petersburg the case mortality in 1865 was 14.97 per cent. During the Russo-Turkish War the mortality in the army of the Danube was twelve per cent. and twenty-six per cent. in the army in Asia (Popoff).

During the London epidemic Murchison collating results from several sources placed the case mortality as 4.75 per cent. in 14,119 cases and this is probably an average mortality for this type of the disease. The death rate in the so-called bilious typhoid form has been as high as forty to sixty per cent. In India, when the disease first appeared in the North West provinces the mortality was thirty per cent. In 616 cases described by Carter, in which spirochetes were demonstrated in the blood the mortality was 18.02 per cent. In Egypt, according to Sandwith, the mortality was 14.4 per cent. while Mouzels has recorded the following rates from Tonkin.

Year.	No. of cases.	No. of deaths.	Mortality rate.
1908	2,300	625	27.17
1909	1,581	627	39.65
1910	315	95	30.15
1911	840	350	41.66

The African type is generally less severe than the Eurasiatic, according to most authors. Bayon, however, from experiences with both types believes that the African is the more severe, and Dutton and Todd record a death rate in this type of fifty per cent. in one caravan.

The American type is mild and, so far as the writer can ascertain, no deaths have occurred in over ninety cases collected from Central and South America. It must be remarked that most of the cases of this type have occurred in men well nourished and physically fit. The introduction of the disease into a debilitated native population would undoubtedly result more seriously.

In the Asiatic form of the disease somewhat more than one-half the deaths occurred at the height of the first attack, one-fourth during the first interval, one-fifteenth in the first relapse, and the rest at some time later due to cerebral hemorrhage, exhaustion, or pneumonia.

In Russia, during 1890–91:

50.48 per cent. of those that died had but one attack.
39.8 per cent. of those that died had two attacks.
7.76 per cent. of those that died had three attacks.
1.9 per cent. of those that died had four attacks.

Relapsing fever is much less fatal among children than in adults. Women are less frequently attacked than men, but them ortality is higher among them.

The prognosis is rendered grave by the appearance of such complications as pneumonia, splenic infarction or rupture, nephritis, and jaundice, particularly the latter.

Loewenthal believes that a relapse will not occur if on the seventh day of apyrexia the bactericidal reaction is produced within less than half an hour, but there would seem to be no positive indication from either the pulse rate or temperature curve of the approaching relapse.

Pathology.—There are no distinctive pathological findings in relapsing fever. The usual parenchymatous changes are found in the viscera, viz., cloudy swelling and fatty change. In the icteric cases the tissues are more or less bile stained and in other severe cases ecchymoses and petechial hemorrhages may be found in the mediastinum, epicardium, cortex of kidney, conjunctiva, and the gastric mucosa. In severe cases hemorrhagic effusion into the pia-arachnoid, chiefly over the vertex, is seen. The spleen is enlarged, particularly if death occurred during pyrexia, when the spleen is larger than in the apyrexial period. Its weight in extreme instances may be five or six times that of normal. It is essentially the spleen of an acute infection. The pulp is dark colored and diffluent. The Malpighian follicles are enlarged and sometimes obscured by the excessive pulp. The follicles are not infrequently the seat of necrosis similar to that seen in some other acute infections. In this instance they take on a dirty yellowish-gray appearance and their consistency is granular and friable. The enlargement of the spleen is, in great measure, due to the engorgement of the splenic spaces by erythrocytes, many of which contain basophilic granulations. The endothelium of the spaces is swollen and the follicles are hyperplastic. Usually the capsule is smooth and tense but it may be the seat of a subcapsular hemorrhage, abscess, or gangrene. Infarctions are sometimes encountered.

The blood-forming organs disclose activity for there is hyperplasia of the bone marrow. The yellow marrow of the long bones becoming cellular and reddish gray in color and replacing the normal yellow marrow of these structures. The liver is enlarged and the gall-bladder is filled with a non-inspissated pale yellow or brownish-colored bile.

From animal experiments it would appear that there may be phagocytosis of spirochetes by endothelium lining the liver sinusoids but the mechanism of defense may be somewhat different in man, and it must be remembered that the hematopoietic system of rodents is from the human point of view embryonic, so that any attempt apply the results of animal experiment in rodents on man may be illusory. Levaditi has shown that in the mouse sacrificed at the height of infection there is much phagocytosis of spirochetes by mononuclear cells in the liver sinusoids and this has been confirmed for *Sp. novyi* by the writer. Bertarelli claims to have found spirochetes in the cytoplasm of splenic cells and also in the hepatic glandular epithelium of individuals dying of relapsing fever. Christian found in monkeys that the phagocyted spirochetes were in cells of the endothelial type and not in polymorphonuclear leucocytes nor in hepatic glandular epithelium, and he found in the spleen the remains of spirochetes in cells of the endothelial type and not in the polymorphonuclear leucocytes.

Christian has shown in the case of monkeys infected with *Sp. recurrentis* that the liver sinusoids are filled with polymorphonuclear leucocytes usually segregated in foci and filling the sinusoids at these points. There is usually a moderate number of mononuclear cells of endothelial type present in the same location. The spleen showed focal necrosis with infiltration by polymorphonuclear leucocytes of the Malpighian bodies. Hepatic necroses in the rat have been described by Levaditi.

Specific Treatment.—Mouzels expresses the truth when he says that the treatment of relapsing fever should be divided into two periods: "avant et après le 606." The action of salvarsan is rapid. It arrests the disease in its development, and, if given early enough and in sufficient dosage, there is usually no relapse. The spirochetes have disappeared from the blood six hours after the administration of the drug. Convalescence is very much shortened and the stay in the hospital reduced sixty per cent. The dosage in children should be estimated from the weight of the patient as five milligrams per kilo. The drug should be given intravenously, for success in treating the disease requires prompt and strong action.

Pancot treated 102 cases of relapsing fever giving salvarsan subcutaneously, and only six died; the dosage was 0.2 grams. He believes that the mortality without specific medication would have been fifty to seventy-five per cent.

Eighty-seven patients were treated by intravenous injections of salvarsan.

6 were given 0.1 gram of salvarsan and 4 relapsed.
11 were given 0.15 gram of salvarsan and 4 relapsed.
20 were given 0.2 gram of salvarsan and 8 relapsed.
27 were given 0.25 gram of salvarsan and 13 relapsed.
23 were given 0.3 gram of salvarsan and 13 relapsed.

Out of the total of forty-two relapses spirochetes were detected in the blood of only twenty.

Salvarsan delays the appearance of the relapse, some not appearing until the twentieth to the twenty-seventh day. Relapses should be treated with an intravenous injection of 0.15 gram. Pancot advises the dosage of 0.2–0.25 gram.

Conseil treated eleven cases of relapsing fever of the North African type. The dosage was 0.008 gram per kilo of body weight. Ten of the patients were cured as the result of one injection. One case relapsed but the severity of the disease seemed to be diminished. Conseil states that the injection of the drug was followed in every instance by a very violent reaction, the patient being completely prostrated for a period of from five to twenty hours, after which he rapidly recovered.

In the majority of cases of relapsing fever receiving 0.2–0.3 gram of salvarsan intravenously during the febrile stage the fever falls in from seven to fourteen hours and spirochetes cannot be demonstrated in from four to ten hours after the injection and usually no relapse will occur.

Swift and Ellis employing *Sp. duttoni* propagated in white rats and white mice have shown that sera of animals injected with salvarsan or neosalvarsan have a definite toxic effect on *Sp. duttoni*. Spirocheticidal serum was most active immediately after injection and disappeared at the end of six and one-half hours. Neosalvarsan is slightly more active.

The spirocheticidal action is increased, they say, by heating to 56° C. for thirty minutes, due in part to the destruction of some inhibitory substance in the serum and in part to the direct effect of heat upon the serum and salvarsan mixture.

Levaditi and Arzt have studied the mode of action of salvarsan and find that the spirochetes are engulfed by the Kupfer cells and by macrophages; they are completely destroyed by them in the liver sinusoids and, to a lesser extent, in the spleen. Levaditi believes that in diseases which terminate by crisis such as relapsing fever there is an "opportune moment" when the best therapeutic results can be achieved. This is just before crisis and the nearer this period is approached in the administration of the drug the more quickly will spirochetes leave the blood stream, and smaller amounts of the medicament will be required. This is explained by assuming that the host has been preparing to rid the blood stream of the parasite and at this period is in the best position to do so. The ordinary mechanisms of destruction by phagocytosis and spirocheticidal substances are utilized, the medicament prevoking a "precocious crisis."

In an epidemic in northern Manchuria, Andrew gave intravenous injections of neosalvarsan using 0.75 gram for two patients. There was very marked improvement within twelve hours and patients showing jaundice quickly revived under treatment and only one death was recorded out of seventy patients treated.

After the injection of neosalvarsan films were made every hour up to the sixth hour and thereafter every four hours. In the majority of cases about six hours after the injection of neosalvarsan the spirochetes were observed to be more elongated in appearance and more concentrated at certain places in the film. Usually the spirochetes disappeared from the peripheral circulation when the temperature reached normal but this was not constant. They were never encountered, however, later than twenty-four hours afterward.

There are a few cases of relapsing fever of North African type in which relapses occur after the injection of salvarsan and especially neosalvarsan. In these cases Conseil found that "galyl" and "ludyl", in dose of 0.3—0.5 gram, sterilized the body more effectively than either salvarsan or neosalvarsan, for in no case was there a relapse.

Mercury and antimony compounds, while possessing some spirillicidal value are not to be compared with organic arsenic preparations.

Other drugs used are quinine and Fowler's solution but neither one has proved of any value in Panama, for three grams of quinine per day for five days could not prevent a paroxysm or shorten one.

Symptomatic Treatment.—The use of salvarsan and neosalvarsan has so completely changed the treatment of relapsing fever that it should not be necessary to make any recommendations under this caption. The patient should be treated, as in any other specific fever with due attention to diet, cleanliness and general hygienic measures. For weakness and exhaustion at the crisis in debilitated persons, such stimulants as alcohol. strychnine, digitalis, or ammonia should be used.

Serum Therapy.—The experiments of Novy and others with a single strain of spirochetes indicated that possibly a hyperimmune serum might be produced which could be used for treatment or cure, but it has been shown that immunity derived from one strain of spirochetes is not protective against another strain of the same species and this renders it rather difficult to prepare an efficacious polyvalent serum. Specific chemotherapy now precludes the necessity of serum therapy.

Prophylaxis.—The biological agents concerned in the transmission of relapsing fever are now well known and Nuttall has shown that the spirochete is not specially particular about the choice of host, for under certain circumstances it may be transported by either tick, louse, or bug. It will be advisable, therefore, to take precautions against each one of these carriers, and the measures directed against them essentially are: ridding the sick of vermin; cutting and burning hair whenever possible; immediate sterilization of the clothing of the sick, remembering that the morbidity has been very high among those handling patients' linen; and the destruction of vermin in the houses or sites occupied by those sick of the disease.

Isolation of the Sick.—A microscopic examination should be made of the blood of all suspected febrile cases to detect cases of infection and isolate them so that they may not continue to infect their environment.

The hygienic condition of the people, particularly the poorer working classes should be improved; overcrowding should be avoided as much as possible. When the relapsing fever of Europe was introduced into the United States there were very few secondary cases and this is due, no doubt, to the absence of overcrowding.

Mackie points out that the body louse is one of the easiest of all blood-sucking parasites to eradicate, for personal cleanliness and the disinfection or even the plain washing of clothes is sufficient to kill the lice, especially if the garments are afterward exposed to the sun to dry. It is probable that the isolation of patients together with the disinfection of clothes and bedding and the avoidance of actual contact will suffice to cut short epidemics of relapsing fever.

Travelers in the tropics in endemic regions should avoid native huts, beds, and bedding along caravan routes. The native houses, particularly the bamboo beds in Panama, are frequently infested with *Ornithodoros*. The resting places of caravans should be avoided. Hammocks may be used or beds placed off the ground and protected by oil cups.

Soldiers in long winter campaigns and natives of cold regions present difficulties but proper hygienic measures should be carried out as far as practicable.

Wu Lien-Teh from his experiences in northern Manchuria recommended ventilation and sweeping of dwellings with the admission of plenty of sunlight into the rooms and the white-washing of walls. Bathing facilities should be given the miners as soon as they emerge from the pits. A large steam-pressure sterilizer should be installed where the clothing may be sterilized once a week free of charge. This will insure killing the vermin and their eggs. Coolies should be provided with an extra suit of clothes and should be given simple lessons in hygiene.

Samuel T. Darling.

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Remak, Robert.—Born at Rosen, Germany, of Jewish parents, July 26, 1815. He studied medicine in Berlin, and began, at a very early period of his career, to devote himself, under the guidance of Johannes Mueller, the famous physiologist, to microscopical investigations. His graduation thesis (1838) bore the title: "Observationes anatomicæ et microscopicæ de systematis nervosi structura." From

1843 to 1847 he was one of Schoenlein's clinical assistants, and devoted much of his time during this period to pathological and especially to embryological researches. He was appointed professor extraordinary in 1859. He died at Kissengen Aug. 29, 1865.

Remak did a great deal of original work in three different branches of medical science—the microscopic anatomy of the nerves, embryology, and electrotherapeutics. In each one of these branches of knowledge he discovered something of a permanently valuable character. For example, he was the discoverer of the axis cylinder and of the nerve fibers which bear his name; he demonstrated the fact that the germinal membrane is composed of three layers, and he explained in what manner each of these layers participates in the development of the principal systems of the human body; and, finally, he was the first to make use of the constant electric current in the treatment of nervous diseases.

Remak's more important published writings are the following: "Weitere mikrosk. Beobachtungen ueber die Primitivfasern des Nervensystems der Wirbelsäule," in *Froriep's Notizen*, 1837 "Anatomische Beobachtungen ueber das Gehirn, Rückenmark und Nervensystem," *ibidem;* "Ueber den Inhalt der Nervenprimitivröhre," in *Mueller's Archiv.*, 1843; "Ueber die Entwicklung des Hühnchens im Ei," *ibidem;* "Ueber extracellulare Entstehung thierisches Zellen und ueber die Vermehrung derselben durch Theilung," in *Mueller's Archiv*, 1852; "Ueber methodische Elektrisirung gelähmter Muskeln," Berlin, 1855; "Galvanotherapie der Nerven- und Muskelkrankheiten," Berlin, 1858; and "Ueber die embryologische Grundlage der Zellenlehre," in *Mueller's Archiv*, 1862. A. H. B.

Rennin.—Rennin or chymosin is the milk-curdling enzyme of the gastric juice. In pancreatic juice an enzyme possessing a similar activity is also present. Similar enzymes are widely distributed in the plant kingdom and in the bodies of microorganisms rennin-like enzymes may be produced. See also *Gastric juice.* F. P. U.

Reproduction.—The various processes by which new organisms are produced are included in the general term, *reproduction.*

It was thought by the ancients that many organisms of complicated structure, such as worms, insects, plants, etc., could be formed from mud, decaying material, and other dead matter by a process of spontaneous generation, or *abiogenesis.* It was proved by Redi in 1668 that abiogenesis does not occur in insects, but it remained for Pasteur and his colleagues in the latter half of the nineteenth century to show that even the minute and simply organized bacteria are always produced by division of the living substance of pre-existing individuals of the same species; that is, reproduction in the present condition of the world is always a process of *biogenesis.*

Not only is every organism produced by a pre-existing organism, but every cell arises by division of a pre-existing cell, and every nucleus by division of a pre-existing nucleus. (See *Cell.*) Moreover, there is good evidence for the belief that the minute but apparently important elements of the nucleus, known as *chromosomes* (*q.v.*), are also produced only by division of pre-existing chromosomes. So reproduction, like all other vital functions in health and disease, must be regarded as essentially a cellular phenomenon.

Reproduction may be either sexual or asexual. The essential feature of *sexual* reproduction is the development of a new individual, the *zygote,* by the union of two cells, the *gametes.* If the gamites are alike the union is called *isogamy;* if they are unlike, *anisogamy.* The former occurs among the protozoa and lowest plants, the latter is the only form of sexual reproduction in the higher animals and plants. The gametes of the higher animals, are the ovum and the spermatozoon, and the zygote is the fertilized egg. (See articles *Ovum, Spermatozoa,* and *Impregnation.*) The capacity to produce one kind of gamete, together with the associated peculiarities, constitutes the quality of *sex* (*q.v.*). Both of the reproductive elements are cells derived from apparently indifferent germ cells by an interesting process of development, which is discussed under the heading *Maturation.* This process takes place in certain special organs, for which the general name is *gonad,* the female gonad being called the *ovary* and the male gonad, the *testis.* When the eggs or spermatozoa are ripe they are discharged from the gonad, and fertilization may take place outside of the body, as in most fishes, or within the oviduct (Fallopian tube, uterus, etc.), as in man. In man and other mammals the discharge of the ova is associated with certain peculiar physiological phenomena described in the article on *Menstruation.*

Fertilization having taken place, the egg proceeds to divide by the usual process of cell division, and by repeated divisions forms a mass of cells which becomes the embryo. The details of this process vary in different animals, as will be seen by reference to the article on the *Segmentation of the Ovum.* Sooner or later the cells of the embryo begin to differ among themselves in accordance with their destiny in the formation of organs. The causes of these changes are discussed under the title *Differentiation,* and the development of the embryo in form and structure is described in detail in the articles *Fetus, Area Embryonalis,* etc.

Both during development and in the adult condition there is a noticeable similarity between parent and offspring at corresponding stages. This is a fact of great importance, and is fully treated in another place (see articles *Heredity* and *Variation*).

When reproduction takes place by some method without the aid of a fertilized egg, it is said to be *asexual.* In the bacteria and some of the lower animals the reproducing individual divides into two or more nearly equal parts. This is called *fission* (*q.v.*). In the yeasts, the higher plants, and some animals, a small part of the parent grows more rapidly and becomes differentiated into a new individual. This is *budding* (*q.v.*). A third form of reproduction occurring normally in some species is known as *parthenogenesis* (*q.v.*), which may be regarded either as an asexual or as a degenerate sexual process. In such cases the offspring is produced by the development of an egg without fertilization.

In some animals sexual and asexual reproduction occur alternately, giving rise to an *alternation of generations.* In many animal parasites, especially parasitic protozoa, we may distinguish between reproduction that is multiplicative, and that which is propagative. *Multiplicative* reproduction increases the number of individual parasites within the host, and is usually asexual; *propagative* reproduction leads to the dissemination of the parasites to other hosts, and is usually sexual. The damage suffered by the host depends largely upon the kind of reproduction that predominates in the life history of the parasite.

Robert Payne Bigelow.

Reptiles, Poisonous.—All poisonous reptiles, with the single exception of the lizard Heloderma, belong to the order Ophidia—snakes. It is a popular error that snakes are easily divided into harmless and poisonous ones by readily recognized characteristics. Such division, however, is by no means a simple affair. The usual classification into Colubridæ—comprising all harmless snakes—Colubridæ venenosæ, and Viperidæ indicates the close anatomical relationship between harmless and venomous snakes, and in ex-

ternal appearance mimicry is so frequently displayed that no one at a hasty glance is able to distinguish a harmless snake from its venomous relation. Thus, even experts have been subject to fatal mistakes. Indeed, nothing but a close inspection of the dentition can determine the nature of a specimen in question.

Distribution of Snakes.—It is but natural that the popular mind and imagination should have been occupied since time immemorial with poisonous snakes. The frequent and almost mysterious deaths after snake-bite have surrounded the whole class with a halo of fear and reverence which has not been confined to a few localities, but, in fact, has spread throughout the whole inhabited world, for poisonous snakes are found in all countries of the temperate, and more so, of the tropical zone. Numerous genera of the Hydrophids, elegant swimmers with a laterally compressed tail, swarm throughout the whole intertropical part of the Pacific Ocean. Their bite is justly dreaded.* The tropical islands, however, and the tropical countries of the old continent are haunted by the worst kind of snakes, the Elapidæ. A large number of genera and innumerable types of every genus render parts of these countries, and especially of the islands, almost uninhabitable. The chief representatives of this genus are the Cobra di capello (*Naja tripudians*) and the somewhat smaller, though not less dangerous Krait (*Bungarus fasciatus*), both living throughout the whole of East India. The most formidable is the King-Cobra or Hamadryas (*Ophiophagus elaps*), the largest of all poisonous snakes; it attains the length of fourteen feet and it alone enjoys the reputation of attacking and even pursuing man. Its nearest relative, the Aspis of Cleopatra (*Naja haje*), the symbol of the Egyptian kings, lives throughout almost the whole of Africa. In the Western world this genus is represented by the beautiful coral snakes alone; one tof hem, *Elaps fulvius*, lives in our Southern States, where it is little feared on account of its alleged good nature, or rather its lack of irritability; its poison is, however, as active as that of its East Indian congener. Snakes are very numerous in Australia. Two-thirds of these are poisonous, and they belong exclusively to the family Elapidæ; the Tiger snake (*Hoplocephalus curtus*) and the black snake (*Pseudechis porphyriacus*) have a fearful reputation. Europe has none but various species of vipers; the well-known common viper (*Pelias berus*) lives in England, Germany, and chiefly in France. In the departments of Vendée and Loire Inférieure alone were reported 321 cases of bites with sixty-two deaths in six years, in Auvergne fourteen cases with six deaths; in the South around the Mediterranean the more dreaded sand viper (*Vipera ammodytes*) is found. East India again has one of the most formidable vipers, the chain viper (*Daboia russelii*), and in Africa there is the sluggish but very poisonous puff-adder (*Clotho* s. *Bitis arictans*). The greatest number of species of vipers are found in America, all of them belonging to the subfamily of the Crotalidæ or pit-vipers, so called from a deep pit lying between the nostril and the eye.†

* It may soon be a disagreeable surprise to find some of them in the West Indian tropical waters. Since the Suez Canal has made such transmigration possible, the Panama Canal may do the same.

† The object of this pit, which sinks into a cavity of the maxilla—as it were, a reversed maxillary sinus—is unknown. Leydig calls it the seat of a sixth sense, which means nothing else but that he has no explanation. At closer inspection I found the bottom of the pit not lined, but overspread by a thin membrane, the continuation of the external integument. Under this membrane, showing abundant ramifications of nerves, we find a cavity which opens by a duct at the anterior margin of the orbit. According to the careful investigations of Dr. Pollitzer, who followed it up by serial sections, the nerve connects with the auditory nerve. Pricking or any other irritation did not produce any reaction, nor did the destruction of one or both membranes have any effect upon the movements or the hearing of the snake. The hearing capacity of snakes is still a mooted subject with authorities in natural history.

The chief representatives of the pit vipers in the United States are the rattlesnakes. The banded rattlesnake (*Crotalus horridus*) is present throughout the whole territory from the Atlantic to the Rocky Mountains and far into Canada. Of the remaining six species of rattlesnakes we have to note the largest of all North American snakes—the diamond back (*Crotalus adamanteus*) of Florida and the South, and the swift prairie rattler (Crotalus confluentus) in the Mississippi Valley, and in the great Western basin; finally the smallest of all, the massasauga or ground-rattler. To the same subfamily belong those without rattles, the Southern water-snakes, the

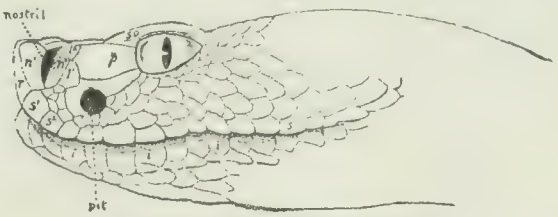

Fig. 4424.—Head of Rattlesnake.

moccasin (*Ankistrodon piscivorus*)—animals so sluggish that they do not try to escape from an approaching man, and hence are not a little dreaded by the negroes working in the rice-fields; and finally, the beautiful copper head (*Ankistrodon contortrix*), which is not at all rare in the whole East—in fact, lives almost in the same expanse as the banded rattlesnake. In the Tropics almost all species grow to a larger size; thus the copper head is repeated in the larger *fer de lance* (*Bothrops* s. *Lachesis lanceolatus*) of the West Indies; the rattlesnakes of Central America grow larger, as does the *Crotalus durissus*; and in the Orinoco Valley there lives the bushmaster of the Dutch settlers (*Lachesis mutus*), about as large as a huge diamond back. An abundance of pit-vipers is found throughout South America. While there is only one true rattler (*Crotalus terrificus*), living all through Brazil and the tropical regions, more than a dozen species of the genus Lachesis of varying size infest the different districts of our Southern continent. Also three distinct species of the Colubrid Elaps are noted.

Poison Apparatus.—Snakes are provided with numerous teeth—solid, pointed, recurved hooks, which serve rather to drag the prey down into the esophagus than for purposes of attack and defense. While the teeth stand in a single row along either branch of the mandibula, they seem to be almost indiscriminately scattered all over the maxilla and palate; nevertheless, two rows of larger maxillary with two nearly parallel rows of palatine teeth are readily distinguished. These are the functionary teeth which, after being shed—a frequent occurrence—are replaced by the numerous succedaneous teeth scattered throughout the mucous membrane of the palate. A poisonous snake exhibits the same arrangement of palatine teeth. Almost the entire row of maxillary teeth, however, is wanting, and its strength, as it were, is concentrated into one powerful tooth, the poison fang, which projects at the anterior end of the maxilla. (Fig. 4426.) It is true, we often find two or three teeth at this point; these are the functional fangs with one or two succedaneous ones which replace the primary functionary whenever lost by accident or shedding. Only the Elapidæ exhibit

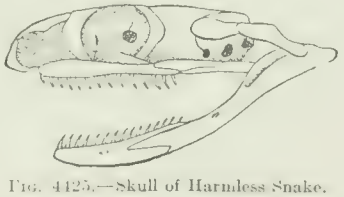

Fig. 4425.—Skull of Harmless Snake.

one or two ordinary conical teeth which are situated directly behind the grooved fang. The fangs are in all cases firmly inserted in the maxilla, immovable, almost erect, in one family, the *Colubridæ venenosæ* (comprising the cobras and hydrophids); in the Viperidæ, however (including the true vipers and pit-vipers), the movable fangs are only erected for biting, and otherwise in the resting they are folded back toward the palate like the blade of a pocket-knife in a plica of mucous membrane. The maxilla of the *Colubridæ venenosæ* is rather elongated and horizontal like that of the harmless snakes, but it is considerably shortened and placed almost vertically in the vipers. This short jaw bone, bearing at its lower end the firmly socketed fang, articulates at its upper end with the lacrymal bone, around which it rotates by the action of the pterygoid muscle.

Fig. 4426.—Skull of Cobra (Elaps).

Some writers are of the opinion that, by looking at a wound inflicted by a snake, the species of the animal can be ascertained, and from the foregoing description it can readily be understood how from the accompanying figures the bite of a harmless or poisonous snake could be determined. (Fig. 4429.) We must, however, bear in mind that a snake, while biting, very seldom implants all its teeth, and a wound scratched sideways by a gliding fang may be more dangerous than the impression of the whole dentition.

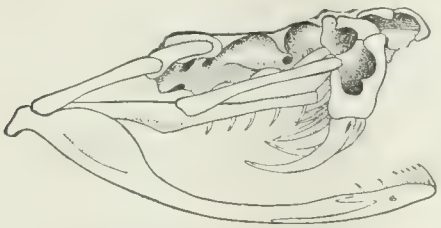

Fig. 4427.—Skull of Rattlesnake.

Another classification is sometimes made by dividing the venomous snakes according to the shape of their fangs, whether they carry short, cone-shaped, furrowed fangs or long, pointed, tubular ones. This condition is brought about developmentally in the first instance by the folding of the dentine which leaves a longitudinal furrow with an indication of a perforation at the upper and lower end along the anterior surface; and in the second by a complete approximation which produces a perfect tube. The

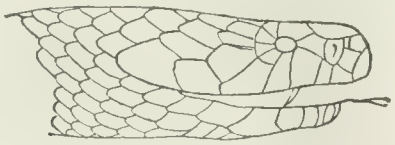

Fig. 4428.—Head of Cobra.

pulp cavity is entirely separated from the poison canal To the first class, the Proteroglypha, belong the Hydrophids and Elapidæ, or cobras; the latter class, the Solenoglypha, comprises the vipers and pit-vipers. The result of a poisonous bite is not dependent upon the shape of the fangs, except that a longer tooth, such as that of the viperine snakes, is capable of injecting the poison to a greater depth; indeed, the viperine poison apparatus is the most perfect of any in the venomous snakes.

There is a third class of poisonous serpents, the so-called Opisthoglypha, the furrowed fangs of which, as the name indicates, are situated toward the rear of the mouth. It has long been doubted whether they should be classed among the poisoners, and for this reason they were grouped under the name of "suspecti." Recent investigations, however, have proven to a certainty that they also poison their prey, which mostly consists of small, cold-blooded animals. Catching them first with the innocuous front teeth, they push them gradually backward into the reach of the poison in the back teeth, to the action of which the animals soon succumb.

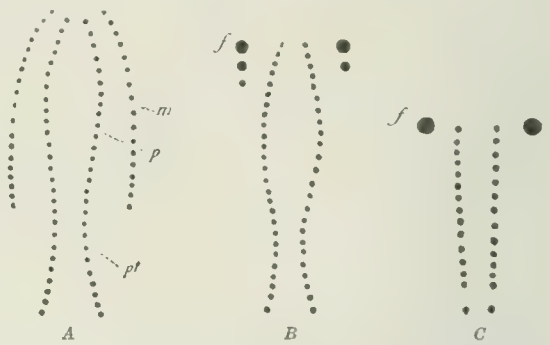

Fig. 4429.—Impression of the Teeth of *A*, harmless snake; *B*, cobra; *C*, viper. *f*, fang; *m*, maxillary; *p*, palatine; *pt*, pterygoid teeth.

The poison gland completes the poison apparatus; the former is closely in contact with either side of the skull, directly below and behind the eye, and is under the influence of the different portions of the temporal muscle. The button-, tube-, or almond-shaped glands taper to a narrow anterior duct, which carries the secretion of the gland to the base of the fang and is provided with a sphincter muscle, so that the snake is able to retain the poison at will, and, indeed, many do so for months. The extraordinary development of the glands, as in the Crotalids, gives to the head that triangular shape which was erroneously considered the characteristic of all poisonous snakes, and which gave to some species the name Trigonocephalus. The elongated glands of the Ethiopian snake *Causus rhombeatus* extend under the skin on both sides of the spine to the extent of one-sixth of the body's length, while in the East Indian Callophis they reach from the head into the abdominal cavity about one-third of the total length of the body. In spite of these abnormities the poison gland must be considered physiologically as the homologue of the mammalian parotid; the latter is the only one of the salivary glands which produces an albuminous seromucous secretion of slightly digestive power. It is anatomically of great interest that even in the harmless snakes the beginning of a poison gland can be traced. It was long known that a part of the supralabial gland —the yellow portion (Duvernoy, Schlegel, Leydig)—is easily separable from the rest; it has not only a duct of its own which in the "suspecti" leads to the posterior grooved tooth, but it also possesses a histological structure differing from that of the supralabial gland. Undoubtedly, this yellow portion of the innocuous snakes is the analogue of the poison gland; even its

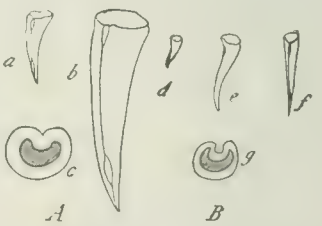

Fig. 4430.—Proteroglypha. *A*, Elapidæ. *a*, Fang of king cobra, eleven feet long (natural size, eight millimeters in length); *b*, the same enlarged (3 diam.); *c*, cross-section. *B*, Hydrophidæ. *d*, Fang of pelamys (natural size, three millimeters in length); *e*, the same enlarged (3 diam.); *f*, front view; *g*, cross-section.

aqueous extract has been shown to be poisonous to small animals (Blanchard). The structure of the poison gland is that of a compound racemose gland with elongated acini; the glandular substance has columnar, the duct pavement epithelium.

Description of Venom.—The secretion of the other salivary glands and of the mouth is alkaline, while the poison is always acid. The color of the latter varies from a light straw greenish yellow to a deep orange. The viscous fluid, either clear or turbid (bitter in Naja) is not odorless as often asserted; it has a specific smell for every species, which it is not easy to describe, but easy to recognize. Thus the odor of crotalus poison may be called "mousy;" that of the *fer de lance* is said to resemble the odor of fresh

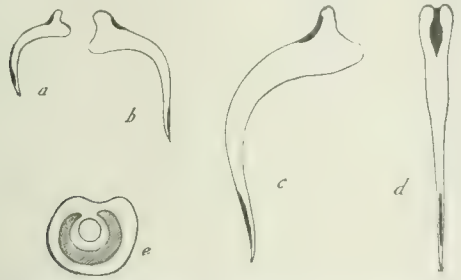

Fig. 4131.—Solenoglypha: Viperidæ. *a*, Fang of banded rattlesnake, three feet long (natural size); *b*, fang of diamond-back rattlesnake, six feet long (natural size); *c*, the same enlarged (2 diam.); *d*, front view of the latter; *e*, cross-section.

salt water. Its specific gravity varies from 1.030 to 1.077; the solids are variously stated as from twelve to sixty-seven per cent.; my own samples are mostly dried down to twenty-five or twenty per cent. of the original weight. The poison cracks in scaly translucent chips of a light yellow to deep brown color and also has a characteristic odor. Fresh poison under the microscope shows nothing but a few scaly epithelia and a number of finely granulated, amorphous, albuminoid masses, which undergo no change in a hanging drop, even after a long while. It was often, and even is to-day, asserted that bacteria or cocci exist in the poison. After thoroughly sterilizing the collecting apparatus I was not able to see the least sign of bacterial life in broth or gelatin cultures of the fresh poison; also in acid media in which the experiments were repeated no trace of life was to be found. In order to determine whether the poison, which itself destroys life, might for that reason be free from microbes, I mixed fresh poison with *B. subtilis* and *B. coli* for one-half hour and then inoculated it on gelatin. The growth was lively, even more so than in the control plates, probably because the gelatin was liquefied at the points of contact with the poison.* A bacterial action, therefore, cannot be assumed; the rapidity alone with which the poison acts in the system would exclude bacterial influence.

Fig. 4432.—Location of the Poison Gland in Tragops belonging to the Opisthoglypha. *a*, Poison gland; *b*, supralabial gland.

Chemistry of the Venom.—The first chemical analysis was made in 1843 by Prince Lucien Bonaparte, who established the proteid nature of viper poison and called the poison "viperine." Almost twenty years later (1861) Weir Mitchell found a similar protein in crotalus poison, which he named "crotaline." Other investigators claimed to have found alkaloids or ptomaines, when Weir Mitchell, associated with Reichert, published in 1883 the results of their studies, that the active principle of snake poison was of an albuminoid nature; but instead of one ingredient they had discovered two. One of them, easily dialyzable and not coagulable by heat, was called venom peptone; the other, not dialyzable but coagulable by heat, venom globulin. The proportions of both were not alike in cobra and crotalus poison; even among the Crotalidæ they found wide differences. Thus cobra poison had ninety-eight per cent. of peptone and two per cent. of globulin; but moccasin venom had ninety-two per cent. of peptone and eight per cent. of globulin, diamond-back only seventy-five per cent. of peptone and twenty-five per cent. of globulin. Besides the proteid there are a coloring substance, several salts, and some fat. Mitchell's report was mainly corroborated in 1886 by Wolfenden, who discovered globulin and several albumins in variable proportion in the poison of cobra and daboia; one of the latter he designated serum albumin; the other, corresponding to Mitchell's peptone, syntonin, or albumose. Kanthack's analyses likewise demonstrated the presence of a proto- and heteroalbumose in cobra poison. Martin and McGarvey Smith found a harmless albumin and two very toxic albumoses in the poison of the Australian snakes.

The venoms retain their efficacy for long periods of time, under suitable conditions. Poison, when dried or mixed with glycerin, has proved itself as active as fresh poison, even after a lapse of twenty-two and twenty years, respectively. Putrefaction destroys it after a long time; freezing, continued through weeks, does not alter it, but it is soon changed by heating when the temperature is raised to different heights, according to the different chemical composition. While the peptones are destroyed when exposed to at least 100° C. for an hour, the globulins in most venoms are rendered innocuous at 80° C. for fifteen minutes; the poison of the viper *Bitis arietans* requires 100° C. for quite a while (Beaujean). The coagulated proteins are inert in this state, but they regain their toxicity when redissolved. Alcohol renders it inert for a time only. Absolute alcohol seems to coagulate all poisonous ingredients, but the presence of an infinitesimal part of water is sufficient to retain the toxicity of the supernatant fluid. Poisonous serpents, when preserved in alcohol, have to be handled, even after years, with the greatest care, as has been demonstrated by a fatal accident to an assistant in the St. Petersburg Museum.

Physiological Effects.—Absorption of venon from connective tissue, whether introduced by hypodermic injection or by the bite of a snake, takes place through the blood-vessels, more rapidly when the blood-vessel is wounded directly. Serous membranes absorb it very readily. Its resportion through mucous membranes varies. All venoms are absorbed by the conjunctiva and also in the alimentary canal, although they are considerably modified by gastric and pancreatic secretion. It is no surprise, therefore, that much larger doses are tolerated by the intestines. That they are nevertheless absorbed is proven by the observation that active immunity can be produced by feeding venom. We must expect, however, that the local disturbances caused by the poison of vipers (extravasations and necroses) alter the absorbability to some extent. On the other hand, absorption through the rectum is extremely rapid and the action is said to be swifter than by hypodermic injection.*

The two substances of Weir Mitchell were recog-

* Experiments with sterile snake poison have demonstrated that it liquefies gelatin like some digestive ferments, *e.g.* trypsin. Wehrmann finds that it peptonizes fibrin weakly and does not clarify amylum. Flexner states that in agar culture of *B. anthracis*, *B. coli*, and *B. typhi* the bacteria underwent rapid involution. My own numerous observations, recorded above have been negative. Later experiments have proved that the reaction of different bacilli varies considerably and that some do not react at all.

* It is to be noted that Brazil reports: an injection of the very hemorrhagic venom of *Lachesis alternatus* into the rectum showed no effect whatsoever.

nized for years as the typical efficient ingredients of snake poison and were then classified among the toxalbumins or toxins especially among those of bacterial origin. Further chemical investigations have shown that the peptone abounds in a so-called neurotoxin, the globulin or globulins in hemotoxin, thus confirming the old dimly felt belief that snake venom was both a nerve and a blood poison. But these two ingredients are again divided into a number of dissimilar toxins such as cytolysin, agglutinin, hemolysin, hemorrhagin, etc., so that finally we must consider the venom of each species of snakes as a compound of several of the toxins named, varying not only in the percentage of each toxin but also in toxicity. The different toxins have not yet been isolated, but they can be separated from the native compound. Thus we have seen the hemotoxic substances alone destroyed by moderate heating; the neurotoxic ones, when the venom is shaken with an emulsion of brain substance, unite with nerve cells (Flexner). Although the effect of hemotoxic groups is more spectacular in its action upon the blood-vessels, the deadliest of all is the neurotoxin which not only accounts for the high mortality after the colubrine venom but often also decides the final issue after viper bites.

Yet the neurotoxins and the hemotoxins of the diverse species differ widely, the neurotoxin of the comparatively small hydrophids (Enhydrina) is the most rapidly and thoroughly acting of all and the hemotoxin of Bothrops resists the action of gastric juice. The reaction to heat in the single group of the So. American Lachesis ranges from 70° to over 134° (Brazil).

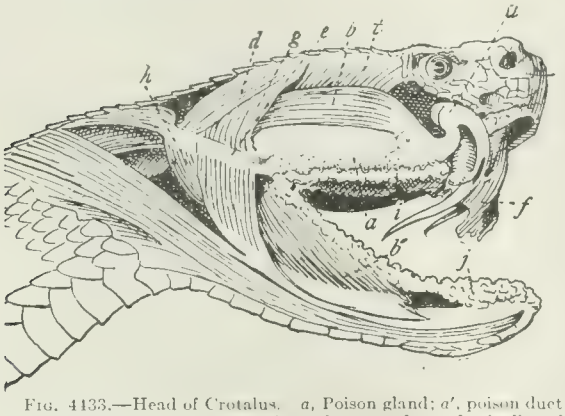

Fig. 4133.—Head of Crotalus. *a*, Poison gland; *a'*, poison duct with sphincter muscle; *b*, *d*, portions of temporal muscle; *f*, plica of mucous membrane.

An entirely new aspect was given to the constitution of the toxic substance of snake venom in 1906 by the analyses of Faust (of Strassburg, now of Würzburg) who isolated from cobra venom a nitrogen-free non-albuminous) body, called by him Ophiotoxin. It is a yellowish amorphous powder which, when injected intravenously, shows all the efficacy of the native venom in fivefold strength but seems almost inactive when administered hypodermically. The latter phenomenon Faust attributes to an instantaneous binding by the tissue proteins; he also holds that its intimate combination with proteins in the native venom serves to prevent its decomposition, but that it also augments its absorbability and thus increases its toxicity.*

* The absolute or very near identity of the proteins of the various venoms, even in snakes differing so widely as, *e.g.* the colubrine cobra and the viperine dabora was demonstrated by Lamb through a precipitine test. He prepared an immune serum in rabbit with cobra venom which gave a marked precipitate with the homologous (cobra) venom. Comparing the same serum with other venoms he found that most of the precipitates were identical. Hence he concluded that the proteins of the diverse venoms have no relation to the latter's real toxic properties.

A few years later (1911) he succeeded in isolating a similar body from crotalus venom, the crotalotoxin which exhibits the characteristics of its native substance together with a neurotoxic effect but without agglutinating power. He has classed these two toxins together with a body, bufotaline, previously isolated from the skin glands of the common toad (Bufo) which has a digitaline-like effect. These three bodies resemble closely a number of vegetable toxins, the sapotoxins, and therefore are grouped by him under the name of animal sapotoxins. It is probable that all three are derived from cholesterine-like bodies which are found throughout the amphibian world.

It must be added that the results of Faust are not accepted without weighty objections. Brazil had the method of Faust imitated at his laboratory but did not succeed in isolating the same body. Although Faust's ophiotoxin is evidently toxic he does not think it represents the whole toxic strength of the native venom. The last word about the chemistry of venom has not yet been spoken.

Symptomatology.—From the foregoing remarks it will be perceived that different cases of snake poisoning cannot have an identical course, and that the numerous contradictions of the mostly incomplete records of snake-bites are to be explained only when we consider each type of poisoning separately. Leaving aside the cases of almost instantaneous death which are due to general or extensive thrombosis, especially when the venom has been accidentally injected into a large blood-vessel, we have first to make a distinction between the two great classes of snakes, the colubrines and the vipers.

To illustrate the first class, let us briefly describe the effects of a cobra bite: two small, scarcely visible punctures in the skin are found, whence radiates a burning and stinging pain with gradually extending moderate edema followed by a numb feeling at the spot. Within an hour, on an average, the first constitutional symptoms appear—a pronounced vertigo, like that of drunkenness, an irrepressible somnolence, quickly followed by weakness of the legs, which is increased to paraplegia, ptosis, falling of the lower jaw with paralysis of the tongue and epiglottis, inability to speak and swallow, with fully preserved sensorium. A mass of viscous, frothy saliva is constantly dribbling from the open mouth; nausea and vomiting set in; the paralysis becomes general, the patient lies motionless. The pulse, a little accelerated, is somewhat weaker in the beginning, but keeps a moderate strength until even a few minutes after the cessation of respiration. The latter, also accelerated in the beginning, soon becomes slower, labored, and more and more superficial, until it dies out almost imperceptibly. The pupils, somewhat contracted, react up to the last moment. Slight convulsions, which we are accustomed to see in asphyxia, sometimes occur shortly before death. Absorption is exceedingly rapid; already after thirty seconds a distinct areola is visible around the bite. Death occurs at the latest within fifteen hours, in thirty-two per cent. in the first three hours. When the patients do not die of paralysis, they recover remarkably quickly and without later consequences. The symptoms of cobra venom have been aptly compared to the effect of curare. The autopsy reveals no changes in the skin at the point of injection; the subcutaneous tissue, however, is thickly infiltrated with reddish serum; the surrounding blood-vessels are congested. All the internal organs are congested, and the bronchi are filled with frothy mucus and perhaps with fluids which have been forced into the patient's throat. The serous membranes are covered with small ecchymoses, the more the longer since the bite. The blood is liquid, laked and dark.

Viper.—After the bite of a viper, *e.g.* a rattlesnake, the local disturbance is most pronounced; violent

pains at the bleeding wound, hemorrhagic discoloration of its surroundings, and later also of more distant parts; bloody exudations on all the mucous membranes (nose, mouth, conjunctiva), and hematuria or rather hemoglobinuria. The serous membranes, peritoneum, and pleuræ are the places of predilection for the bleedings, and all hemorrhages are accompanied by a proportionate swelling which sometimes grows to an immense size. Usually, somewhat later than after cobra poisoning, but possibly within fifteen minutes, constitutional symptoms develop, viz., great prostration with nausea and vomiting. A continuous fall of blood pressure is noticed. Respiration, in the beginning accelerated, grows slow and stertorous. After a temporary increase of reflexes, which in susceptible animals and after large doses may rise to convulsions, opisthotonos, and tetanus, paresis supervenes, with paraplegia of the lower extremities, which progresses in an upward direction, ending in complete paralysis. Albuminuria appears after about six hours. In such a condition death may result inside of twelve hours. If the patient recovers from the paralysis, a septic fever may develop in consequence of the enormous and multiple hemorrhages, to which he may succumb after a lapse of time. Eventual recovery sets in very suddenly, even in the most desperate cases. Not rarely, however, there remain suppurating gangrenous wounds which granulate poorly, break open repeatedly, and may lead later on to a deep necrosis, even of the bones.

The effect of the bite of the tropical vipers, especially the East Indian Daboia Russelii, is undoubtedly more pronounced and violent. Sanious discharges from all mucous membranes are prominent features; such hemorrhagic extravasations from lungs and bowels may persist even during recovery. Albuminuria is never missed; even hematuria is observed as a rule. The autopsy shows a deep bloody infiltration at the bite, down into the necrotic muscles, hemorrhages of distant muscles, particularly of the intercostals; all serous membranes, chiefly the endocardium and the peritoneum, are completely covered by countless extravasations of all sizes; the lungs show subpleural ecchymoses and infarctions; the kidneys are hemorrhagic in the glomeruli and pelvis, and there is cloudy swelling of the epithelium of the canaliculi. Hemorrhages have been observed also in the serosa and in the substance of the central nervous system. Soon after the bites of the South American *Crotalus terrificus* not rarely an amblyopia is observed which may last for several days or even months and in case of recovery disappears entirely. Brazil attributes it not to a large intrabulbar hemorrhage but to an affection of the optic nerve, because the ophthalmoscope showed only a number of small punctate hemorrhages. Altogether the effect of *Crotalus terrificus* is said to resemble more that of cobra than of its other name sakes. It emphasizes once more the point that not all the venoms of one genus are exactly alike, varying perhaps only in toxicity, but that there are connecting links which not only join one genus to the other more closely, but also bridge over between different families, *e.g.* vipers and colubridæ. The blood is clotted but after six or eight hours may be found fluid again.

A disproportionate swelling is to be noted in poisoning by the European viper; it sometimes extends over the whole body. The poison of the African viper, the puff-adder, acts in a stupefying manner from the very beginning; the animal stricken stands without motion or reaction as if the whole cerebral cortex were eliminated; complete sensory and motor paraplegia ascends gradually with sharply defined limits.

The Australian snakes occupy an intermediate position between the two types just described, for, besides a prominent cobra effect, they produce moderate hemorrhage and always hemoglobinuria.

Wall relates a peculiar variation after the bite of the East Indian *Bungarus fasciatus*. Some cases cannot be distinguished from the acute cobra poisoning, yet in others a certain chronicity of symptoms is seen which can be compared only to the incubation period of infectious diseases. From two to six days may have elapsed after the bite without any symptoms, when unexpectedly a general debility sets in with albuminuria and a sanious discharge from the eyes, nose, and rectum. The patient invariably succumbs within a short time.

Another type of temporary recovery and of one or several relapses of acute intoxication is recorded by Brazil after the bite of *Crotalus terrificus*. The patient after the use of antivenomous serum may be up and around when about a week later the same symptoms of acute poisoning set in suddenly and are again subdued by antivenine. Another such relapse may occur a week or two later which also responds to the remedy. Brazil attributes these phenomena to particles of venom unneutralized by the first quantity of antivenine which have been lying occluded somewhere in the organism. He considers it therefore safe to watch these cases for several weeks.*

An interesting incident is the periodical relapse of inflammation and suppuration which is said to occur mostly annually, almost to the day of the first injury. The cases reported are too numerous, and have been observed by too good authorities, to admit of a doubt. While in some instances there appeared only a scaly or vesicular eruption of the skin, in others a suppurating inflammation set in, *e.g.* with regular loss of a nail. All the cases on record are from the United States and include all species of snakes—copperhead, rattlesnakes, and Elaps. They have been watched for six, ten, twelve, and even eighteen successive years. Perhaps the best authenticated case is that of a draughtsman of the Smithsonian Institution, who, according to Yarrow and Stejneger, for ten years had the same inflammation of the finger, bitten by an Elaps, almost to the date of the accident. A cure was finally effected by the use of the South American herb, Micania-guaco. Piffard gives the history of a young woman who had been bitten at the wrist by a rattlesnake six years ago. Every three months since that time almost to the day several large vesicles appeared at the same place. Observing himself this rash to appear more than three times in regular intervals, he heard years later that it had gradually disappeared.

To use for comparison a well-known and familiar complex of symptoms, we might call the sequelæ of a cobra bite an *acute bulbar paralysis* of the most furious and vehement kind. Likewise, for the second type, that of viper poisoning, an analogy is found in *acute ascending spinal paralysis*, the last stage of which exhibits alike bulbar symptoms and inhibition of respiration. It should be remembered that the common ascending spinal paralysis is also ascribed to an infection. Yet, whereas in the two diseases named, the development of the nervous symptoms is very slow and gradual, and they may take years or at least weeks to advance to a fatal exitus, in snake poisoning the effect is almost instantaneous. Experimentally the same and still quicker result can be achieved by applying the venom directly to the fourth ventricle in the medulla (nuclei of the accessory and hypoglossal nerves, and also the origin of the pneumogastric). It is evident that snake venoms affect the motor ganglia of the anterior horns and chiefly the medulla oblongata, exercising a selective influence upon the adjacent centers of respiration and deglutition. There we have to look

* If this explanation is accepted it would be a unique phenomenon of biochemical action. It can be understood that a group of bacteria or protozoa may not be reached by an active antidote and may be dormant somewhere, they retain, however, their individual life which may be resuscitated at some future time. In this connection we may not forget that antivermine injected (passive immunity) loses its power within a few days.

first for histological changes. The now numerous reports concur practically in the description given in 1900 by both J. Ewing and Bailey: "of a pronounced acute degeneration of the ganglion cells throughout the central nervous system. The chromatic bodies generally disintegrate with some loss of the chromatic substance, the outlines of the Nissl bodies being completely observed; the nucleus and nucleolus may be normal or swollen and opaque; the dendrites irregular, shrunken or detached. These changes are to be found in the cells of the cortex, the cerebellum, olfactory lobe, basal ganglia, medullary nuclei, anterior horns, and spinal ganglia—most marked, however, in the anterior horn, the Purkinje cells, and the mitral cells of the olfactory lobe." Alt, after poisoning with puff-adder venom, finds the changes in the posterior columns so marked that they are perceivable to the naked eye. While after rapidly fatal doses no microscopic changes occur, they may be expected after two or three hours following a cobra bite and within ninety minutes after that of Enhydrina. Lamb and Hunter found the traces of the acute and chronic type of Bungarus intoxication well depicted in their different slides. They also found that the most active of all neurotoxins, that of Enhydrina, did not only cause a chromatolytic degeneration of the cells in the shortest time but also granular disintegration of myeline with fragmentation of the axis-cylinder.

As to the pathological changes in other organs they resemble those which we are wont to find in all kinds of poisoning of whatever origin, especially by the toxins of zymotic diseases, *e.g.* fatty degeneration of the liver with inflammation of the bile ducts, beginning as early as thirty-five minutes after poisoning, in chronic cases focal necrotic destruction of liver cells, acute parenchymatous nephritis, disseminated pneumonic patches, slight beginning of fatty degeneration of the heart muscle, etc. (Nowak). Pearce found that Crotalus venom causes a hemorrhage of the glomerular tufts in the kidneys but not a chronic glomerular nephritis. It produces a persistent albuminuria and extensive tubular degeneration and cast formation with death preceded by great emaciation after five or six weeks.

The hemotoxic effect, though less fatal than that of neurotoxin has always attracted public attention because its phenomena are more spectacular. It not only attacks both plasma and corpuscles but the walls of the blood-vessels as well. The appearance of the large blood-vessels at autopsies is rather puzzling; sometimes they are filled with large dark clots, at other times liquid blood is seen throughout which does not coagulate even after a long exposure to the air.

For years it was an accepted dogma that viperine venom causes an intravascular thrombosis and that that of the colubridæ leaves the blood fluid forever. Although some exceptions to this rule have been found, we may in general after Noc's (Calmette's laboratory) suggestion divide all venoms into the coagulating and the anticoagulating kind. To the first belong mostly those of the viperine, to the second the colubrine snakes and, contrary to expectation, the well-characterized vipers, the North American Ankiotrodon and the Indian Daboïa. This is not the place to discuss the different theories of physiologists on blood coagulation; the addition of snake venom would but introduce a new unknown quantity to three or four unknowns. Thus we must be satisfied for the present with the facts related above. It may be added that coagulation varies in degree and velocity according to the species and quantity of venom injected. Martin (of Sydney) found a singular effect after using the venom of the Australian colubridæ. Although the intravenous injection of a large quantity caused the expected thrombosis (positive phase), a small quantity injected in intervals destroyed coagulability entirely (negative phase); they immunized, as it were, the blood against coagulation by that same venom.

Direct introduction of a larger quantity of poison into a blood-vessel may cause a sudden complete intravascular clotting of the whole mass of blood, with the exception of that in the pulmonary veins and the left heart. Many contradictory reports of the blood pressure, sudden stoppage of respiration, etc., are cleared up by the sudden massive thrombosis.

Another important effect of venom upon the plasma is the obliteration of its germicidal property. We know that normal blood serum destroys microorganisms or at least retards their growth. Welsh and C. B. Ewing were the first to show that this faculty was annihilated in the blood of animals killed by crotalus poison, and Martin has confirmed it for the venom of the Australian black snake. This explains both the well-known rapid putrefaction of the poisoned organs and the danger of subsequent decomposition of the extravasated blood and the resulting sepsis during convalescence. Hemolytic studies have shown that the germicidal power of serum is rendered inactive through the fixation of the serum complements by the venom. The first effect of snake venom upon blood *in vitro* is agglutination, speedily followed by hemolysis (the escaping hemoglobin is not changed, the spectrum remaining normal). A great variation in susceptibility to this latter reaction is distinguished in the different animals, but most noticeable is the difference of hemolytic power in the several varieties of venom. Contrary to what we should expect from the prominent symptoms, cobra venom is most actively hemolytic; those of moccasin, copperhead, and rattlesnake are hemolytic in less degree in the order named.

On the *modus operandi* of hemolysis a long series of painstaking studies has been published by Flexner and Noguchi, and by Preston Kyes (Ehrlich's laboratory). They are of great scientific value concerning immunity and serum therapy (Ehrlich's side-chain theory), but their recounting would lead too far from the practical object of this article. The gist of their result is: washed blood corpuscles are left untouched by snake venoms. The latter acts as an amboceptor combining with a complement contained either in the serum or in the stroma of the corpuscles as endocomplement. This body, present in both, is lecithin which forms with venom a non-toxic, yet hemolytic lecithid and, while destroying the corpuscles, loosens their hemoglobin. The latter is voided through the kidney but its crystals sometimes clog the renal canaliculi completely. At the same time it was found that cholesterine, added to the venom and lecithin solution, acts as an antidote.

Another element destructive to the circulation is a toxin called by Flexner and Noguchi hemorrhagin. They explain its action as that of a cytolysin directly injurious to the cement substance of the endothelial cells of the capillaries and small veins, thus allowing the enormous diapedesis which is often seen after viper intoxation; in fact, the escape of blood cells may be so great that after some hours not more than one-half of the normal number can be counted in the blood. The genus Lachesis both in South America and in Asia seems to be the richest of all in hemorrhagin.

The leucocytes emigrate likewise, but are attacked by a different hemolysin and may be entirely dissolved inside of thirty minutes; the large mononuclears disappear first, the lymphocytes last.

Before briefly summarizing the mode of dying from snake poison we must once more call attention to the complexity of these compounds simply called cobra or viper venom which, however, vary so widely in the percentage and toxicity of their different toxins. In all of them undoubtedly the most potent factor is neurotoxin, nevertheless a death occurring within a few minutes is due to general thrombosis; a patient who dies within twenty-four hours may succumb in the first hours to paralysis of the respiratory center,

later to general paralysis; lethal exitus, after such a period, days or even weeks after the bite, may be the result of sepsis or of general prostration following prolonged suppuration.

It is now easy to understand that the danger of a snake-bite must vary considerably. Statistics cannot give us an adequate idea as regards this point. Not all cases are reported, and not all bites reported are those of venomous snakes. Moreover, chance is an important factor as regards the sequelæ; *e.g.* in what condition was the snake when biting? Were one or both fangs deeply implanted, or was the skin merely scratched? How old and in what condition of health was the bitten individual? India, as is generally known, has the largest mortality from snake-bites—a fact easily explained by the enormous number of snakes, and these the most deadly, the cobras. Nevertheless, indolence and superstition of the population may increase the number of fatal accidents considerably. Those may be right who believe the smaller number of deaths in America and Australia to be due to the greater intelligence of the people, because a rational treatment, especially the early application of a ligature, is instituted in time.* In default of reliable analyses, the only way to decide this point has been shown by Calmette to be that of comparative experiments. After carefully graded hypodermic injections, to determine how much poison may kill a kilogram of animals (mostly rabbits), the following table has been worked out:

1 gm. of cobra and aspis kills . .	4,000 kgm. of rabbit.
1 gm. of hoplocephalus kills.....	3,450 kgm. of rabbit.
1 gm. of fer de lance and pseudechis kills..	800 kgm. of rabbit.
1 gm. of *Crotalus horridus* kills.....	600 kgm. of rabbit.
1 gm. of *Pelias berus* kills.. ..	250 kgm. of rabbit

But even this method has not yet yielded undisputed results, for Martin claims for Hoplocephalus 4,000 and for pseudechis 2,000 kilograms. At any rate the toxicity of snake venom is exceedingly high. A comparison with the toxins of infectious diseases shows that only that of diphtheria comes up to 4,000 kilograms, toxopeptone to 3 kilograms, and the albumose of anthrax to not more than 80 grams. Besides the high toxicity it is also the extremely rapid absorption and consequent early appearance of grave symptoms which distinguish snake venom from other toxins.

If the most serious cases (*e.g.* when both fangs, and especially those of a large tropical snake, have thrown their full dose of poison into the tissues) are left out of consideration the prognosis is not so bad as is generally believed. Weir Mitchell gives the mortality of crotalus bites in one place as twenty-five per cent., in another as not more than twelve per cent.; that of the Australian snakes is said to be only seven per cent.; but for India Fayrer states it at from twenty-five to thirty-five per cent. Brazil's figures for tropical South America come up to twenty-five per cent. It has been mentioned how quickly an amelioration may set in, even after the most serious nervous symptoms have preceded. This is undoubtedly a reason why so many remedies have gained the undeserved reputation of being a sure cure. Most of the patients would have recovered without them. Comparing these conditions with the results obtained in experimental bacteriology, we should say that in most cases of snake-bite the minimum lethal dose of toxin is seldom injected, so that the body cells are still able to combine with and fix the toxin, in consequence of which they not only speedily recover, but also, as we shall see later on, develop a certain immunity by casting off antitoxin.

Treatment.—The proof of the utter helplessness of therapeutics of past years is the long array of remedies recommended and used at all times for snake-bite. The object of treatment is threefold: first, to prevent absorption of the poison; second, to accelerate its elimination; third, to destroy or neutralize it, and to treat symptoms of imminent danger. If the wounded limb, *e.g.* a finger, cannot be amputated quickly, at least the circulation should be checked or retarded by a ligature, as practised since time immemorial. A ligature is applied as tightly as possible, not only at one, but at two or three places—*e.g.* when a finger has been bitten, round the finger itself, at the wrist and at the elbow. The experienced Wall is so convinced of the advantages of Esmarch's rubber band that he not only recommends every physician in India to have one in readiness, but wants to see it in every well-regulated household. The ligature is relaxed at intervals of some hours to prevent gangrene, but is applied again as soon as practicable.

Warning is given to be careful after some bites even with the well-approved ligature, *e.g.* after those of a member of the genus Lachesis. Hemorrhage, coagulation, and gangrene are so intense after this venom that a ligature might increase this danger.

It has been an often recommended custom to suck the wound with the lips or to apply cups. The result of such a measure is at least doubtful, because of the finely punctured bites; the sucking should be preceded by a long scarification into the deeper tissues. It is still safer to excise a large area of these tissues or to destroy them with the actual cautery. Wall, taught by long experience, recommends proceeding in the most ruthless manner. By these means the absorption of poison can be limited to a possible minimum, so that the system shall gain time to overcome the whole quantity at intervals.

How can we hasten the elimination of the injurious substance? The kidneys are attacked to a greater or lesser degree by the poison, especially that of vipers; hence it is doubtful whether we should be permitted to increase their activity.* The vicarious excretion by perspiration, stimulated by diaphoretics (*e.g.* jaborandi) has had doubtful results. It has been demonstrated, however, that part of the poison is excreted by the stomach. Alt found that alkaloids, chiefly morphine, after hypodermic use were excreted by the stomach almost to one-half of their amount. When he tried the same method for snake venom, it was discovered that the animals whose stomachs were washed out were saved, whereas the controls died; at the same time, the washed-out fluid was again poisonous to other animals. Hence it is probable that the use of the stomach pump may be of good service. Those who have read a minute description of, or have personally witnessed, the snake dance of the Hopi and Zuñi Indians of Arizona will remember that after the performance the dancers, who are sometimes bitten by the snakes, receive a potion prepared by the priests which contains an emetic. The whole crowd stand around a certain part of the parapet to empty their stomachs freely. This custom has undoubtedly been justified by long experience.

The question then remains, Are we able to render innocuous the poison in the tissues surrounding the bite? This efficacy has been claimed for a whole series of specifics, which owe their reputation partly to old traditions, partly to experiments in the test-tube. The majority of these specifics, which it is

* The statistics of the Indian Government have given for years an average annual mortality of 20,000 persons. Recent advices, however, have called this number again into doubt, as has been done before. It seems to be the practice of officials in remote, isolated districts to ascribe in their reports any case of death to snake-bite, whenever it is thought desirable to cover a crime or even a neglect of duty on the part of the official. Yet other tropical countries also show an enormous annual loss of life from snake-bite. V. Brazil estimates from statistics of a part of Brazil the number of accidents throughout the republic at about 20,000 and the mortality at 5,000.

* There are cases on record where babies, suckling their bitten mothers, succumbed under the typical symptoms of poisoning.

true neutralize the poison *in vitro* after a shorter or longer period (carbolic acid, *e.g.* only after twenty-four hours), destroy all tissues to such an extent that it seems preferable to apply the cautery. Even the much-praised permanganate of potassium, recommended especially by Lacerda, of Rio, Brazil, has not fulfilled the high expectations, for neither locally applied in a one per cent. solution nor injected intravenously has it the elective faculty to single out snake venom for oxidation in presence of other proteins. One per cent. of chromic acid has gained somewhat of a reputation; it does not destroy the tissues simultaneously with the poison, but it merely makes them shrink. Calmette has frequently tested hypochlorite of lime in a solution of two per cent.* He found both its local and repeated hypodermic application near the bite as well as its internal administration of good effect; not less so a one per cent. solution of chloride of gold as a local remedy.

Ammonia, extensively used internally and externally, is nothing but a stimulant. Feoktistow actually advises against it, because he thinks he has seen after its use increasing hemorrhages, caused by higher blood pressure. Wall also cautions against exciting the circulation by stimulants; he advises to keep the victim as quiet as possible and to husband his strength. Neither has alcohol any local effect as a coagulating medium; it is to be rated also as a mere stimulant. It has always met with appreciation on the part of the real or, more so, of the alleged victim. Indeed, the use of this infallible specific has often been carried to such an extent that it was impossible to decide whether the patient succumbed to snake venom or to an acute alcoholism. In one case, *e.g.* the use of five quarts of whiskey is recorded. It is, moreover, a fact that intoxicated persons, when bitten in this state, have not proved to be better protected against snake-bites than sober people; and the enormous doses which we often hear of as having been administered deserve nothing but condemnation. If a stimulant seems advisable, it is better to give hot coffee or tea or to administer camphor subcutaneously.

As to a rational treatment, it is necessary to inquire first as to the prominent morbid changes which threaten life. Are they irremediable or are they transient? That they are transient is proved by the many individuals who survive a snake-bite in spite of the gravest symptoms. We have seen that the poison exerts, first, a hemolytic action; second, a destructive influence upon the cells of the medulla. We know at present of no pharmaceutical remedy which will arrest either the escape of the hemoglobin into the plasma or the rupture of the capillaries, nor is any drug known that will check the influence of toxin upon the nerve cells. The changes in the ganglion cells, the dissemination and disappearance of the Nissl granules, whatever this may mean, must be fully reparable, since, as we have seen, rehabilitation takes place rather suddenly without leaving any sequelæ. If we are not able, *e.g.* to reëstablish the function of the respiratory center immediately, could we not at least tide over the dangerous period of deep depression? One method suggests itself to a medical mind, *i.e.* artificial respiration. The heart beat ceases several minutes later than respiration, and in one experiment Fayrer succeeded in keeping up the circulation for eight hours longer by artificial respiration. Fayrer and Lauder Brunton strenuously recommend that it be continued not only for hours but for days, with or without a tracheal cannula. This advice seems to have fallen somewhat into disuse, especially since Martin claims that in poisoning by Australian snakes he saw no good results from artificial respiration, death occurring in spite of it in fifteen minutes after the heart stopped. Notwithstanding some failures, we are justified in trying it for an extended time, always keeping in mind that an abrupt change may set in in the most desperate cases. We may especially consider it, since the new method of intratracheal insufflation has considerably simplified artificial respiration.

For the sake of completeness we may consider a remedy which for quite a while has been praised with a certain persistency as a specific, *i.e.* strychnine. First used by Pringle in Australia, it was tested in India, and in spite of the little encouraging reports was enthusiastically championed by Dr. Muller, of Sydney. He declared that the failures were due to insufficient doses, and he began with a dose of at least 0.01 gram, repeated several times until slight tetanic symptoms appeared.*

Many cases in Australia have been treated with strychnine, and upon the advice of the Government Indian surgeons have also used it quite extensively. Nevertheless, the results are not so convincing that we could rely upon this drug as a specific. The experiments of Kanthack and Feoktistow were negative. Interesting, however, is the latter's positive experiment that artificial tetanus, brought on by strychnine, was arrested by snake venom. Roux states that tetanus antitoxin has a certain influence upon snake poison, but not inversely. Atropine has been recommended as a stimulant for the respiratory center. Not many instances of its use are recorded, but there is no reason why it should not be resorted to as well as strychnine.

It may be appropriate to relate the few instances in which snake poison has been used therapeutically. Dr. Amaden, of Glens Falls, near Lake George, a country abounding in rattlers, cured a man, aged twenty-five years, with unmistakable tetanus by two injections of one drop of fresh rattlesnake poison. It should be mentioned that snake venom has been used in an unsystematic way for several other diseases (*e.g.* yellow fever), of course without success. Recently it has been asserted that during the plague in India some successful inoculations of cobra poison (gtt. $\frac{1}{50}$ and $\frac{1}{25}$) were made, and that some similar experiments in monkeys gave equally good results. Later correspondence, however, is silent regarding these experiments. The treatment of lepra with snake venom has been without any result.

Antivenomous Serum.—The therapeutics of snake-bite were in this state of hopelessness when in 1895 Calmette, and almost simultaneously Fraser, surprised both the scientific and the lay world with an antivenomous serum. It is to serum therapy and immunization, as we shall presently see, that we have to look for the successful treatment of snake-bites.

Regarding this topic the question first arises: Are there animals as often asserted, which are immune to snake poison? In East India the mongoose (*Herpestes ichneumon*) a rat-like animal, the deadly enemy of the cobra, has the reputation of immunity; and in Europe the droll, bristled hedgehog (*Erinaceus europæus*) is considered as the natural destroyer of vipers because of its reputed invulnerability. More accurate observers have shown that the mongoose owes its apparent safety to a low susceptibility (from ten to twenty-five times less than rabbits, Elliot; six times, Calmette) against both cobra and viper venom, but more to its agility, and that the hedgehog is partly protected by its spinous coat. It possesses, however, a higher resistance to snake poison than other animals, and from my own investigations I might figure a resistance of about four times that of a rabbit of equal weight (six times, Palm). A relative immunity toward

* He advises against the employment of more concentrated solutions which are less active and produce eschars.

* The tolerance toward strychnine seems to be quite extraordinary in these cases; thus 0.035 gram was used in the case of a boy thirteen years of age within three and three-quarter hours, 0.05 gram in five and one-half hours, 0.05 gram in four and one-half hours, 0.066 gram in seven hours, 0.25 gram in six days.

various toxins is well known to exist in different animals as it surely does in hogs, especially wild hogs.* The poisonous snakes themselves possess a high but not absolute immunity against their own poison and that of other species, the ones with weaker poison a relative immunity toward those with stronger venom, and even the non-poisonous snakes enjoy a certain security against the bites of the poisonous ones. The king-snakes of our Southern States, which are the enemies and destroyers of our poisonous serpents, seem to enjoy a perfect immunity.† Although Weir Mitchell finds that, at least in some cases, crotalus is not immune against its own poison, it is a common occurrence among venomous snakes in captivity that they bite each other furiously without any evil effect. One of Cunningham's cobras resisted inoculation with an amount of cobra venom sufficient to kill one thousand fowls. This faculty is ascribed to inner secretion, to the incessant influx of toxin into the circulation. The discovery of Blanchard, that the extract of the ductless yellow part of the supralabial gland of *Tropidonotus natrix*, the European representative of our common gartersnake, and even its blood serum, kills small animals with distinct symptoms of poisoning, seems to corroborate this theory. Flexner and Noguchi found the blood sera of crotalus and ankistrodon highly toxic upon guinea-pigs, while that of the innocuous pinesnake (Pityophis) is less so. In fact the blood sera of all snakes exhibit more or less toxicity, and all their organs show the same in proportion to the higher or lower amount of blood they contain. Calmette believes this toxicity due to a forerunner of venom from which the latter is produced through the process of secretion from venom glands. Phisalix and Bertrand reversed this idea for, after finding the serum of vipers fatal to their test animals, they extirpated the poison glands and, when a long time—168 days—had elapsed, the blood serum was harmless.

The venom apparatus is a strong weapon for defense and offense, but it is a mooted question whether it serves the snake for some other purpose. All workers agree on the point that there are also different ferments, such as proteolytic, lipolytic, etc. Still it is doubtful whether these contribute any important element to the toxic effect. They all are very labile and a moderate temperature destroys them. They are probably secreted from other than the poison glands and, though admixed with the venom, may chiefly help the digestion of these carnivorous animals. Cunningham, finding after many experiments with cobras that their serum has no antitoxic action, comes to the conclusion "that the natural immunity of cobras is perfectly distinct in its nature from the artificial immunity, which is established in other animals as the result of continued treatment with cobra venom, and that it is unconnected with any material of the nature of an antitoxin in the blood."

The idea of immunization is by no means a modern one. Even in antiquity we hear of it; Plutarch relates that Cato the younger, while marching through the desert of Cyrenaica (Tripolis), took along a number of those Psylli who cure the bite of serpents by sucking out the poison with their mouths and have likewise certain charms by which they stupefy and lay asleep the serpents." The same kind of men are still plying their trade in Africa. Among savage tribes of ancient and modern times, wherever poisonous snakes abound, attempts at protection against snake venom are made under various forms, sometimes associated with mystic ceremonies. The poison is rubbed into the skin, as is done in Bengal, or fine scratches are repeatedly made in the skin with the teeth of venomous snakes which still have some dried venom clinging to them, or it is taken internally in the fresh state, or parts of the dried poison glands are eaten (as practised by the savages of South Africa). A shepherd, immunized in this way, admitted that the dried gland of the cobra had an intoxicating effect, which he compared to that of Indian hemp, except that, whereas the latter lost its effect gradually, the action of the first was not impaired by habit. Or it is used as an inoculation in the interior of Africa (Serpa Pinto). Le Vaillant records some rather disgusting practices of immunizing among the Hottentot snake doctors. Sometimes together with inoculations one of the reputed antidotes is employed for an extended time, as *e.g.* the *curados de culebras* of Mexico use a composite plant, *Micania guaco.**

Sewall, of Ann Arbor, Mich., was the first to introduce methodical inoculation of snake venom with the idea of immunization. His experiments, in which, by gradually increased doses, he made his pigeons secure against seven times the lethal dose of massasauga poison, were published in 1887. Some similar experiments with the venom of vipers by Kaufmann and by Phisalix and Bertrand at Paris followed, but above all Calmette, director of the Pasteur Institute of Lille, France, after a number of failures succeeded (1894) in securing immunity, and at the same time in elaborating a protective antivenomous serum which with other homogeneous preparations must be considered to-day the only reliable antidote to the deadly action of snake poison. Fraser, who worked independently of Calmette for six years on the same subject, has produced (1895) a similar serum, called by him antivenene. It is dried in thin, yellowish, transparent scales, in which state it is said to keep indefinitely. Calmette manufactures his serum by inoculating with cobra venom or with a mixture of cobra, crotalus, viper, and hoplocephalus venoms, in both of which the hemolytic agent has first been eliminated by heating to 75° C. or by mixing with a small quantity of a one per cent. solution of hypochlorite of lime. The inoculation of horses has been carried on in some instances for two to three successive years, so that these animals, which succumb to a dose of twenty-five milligrams of cobra poison, finally tolerate a dose of two grams. A prolonged feeding of venom also imparts immunity, but requires larger doses and produces less protective power. Antivenomous serum or antivenine was put up and sold in vials of 10 c.c. each, now it is also sent out in the dried state. Its protective value is calculated by Calmette in the following way: If 1 c.c., injected into the ear vein, is found to protect a rabbit of 2,000 grams (two kilograms) against a fatal dose of venom (0.001) injected two hours later, it is said to contain 2,000 antivenomous units, and a vial of 10 c.c. consequently 20,000 units. A quick test can be made by injecting 2 c.c. of antivenine into one marginal ear vein which is followed five minutes later by an injection of 0.001 cobra venom into the other ear vein. It is said no serum is sent out without possessing a strength of at least 10,000 units; and for the tropical countries serum of as high as 40,000 units is manufactured.

* It has also been recommended to set free and acclimatize in districts infested by venomous snakes, some of the animals known to be not only resistant to venom but also to destroy poisonous snakes. Of all such animals known undoubtedly the European hedgehog, mentioned above, would be the best. Otherwise harmless, he feeds on a number of injurious insects, on mice, and on venomous snakes.

† I have injected a king-snake (*Ophibolus getulus*) of Florida, of 700 grams weight, with 1 gram of fresh moccasin poison, a quantity which can never be injected by a single bite of the largest venomous snake. With the exception of a pronounced local swelling and some apparent sick feeling for a few days, the snake survived this experiment well. A crotalus of three feet in length and about 500 grams weight receive four drops of cobra venom: it sickened within an hour and was found dead in the morning. Brazil considers snakes, poisonous and non-poisonous, which feed on snakes (ophiophagous) as the most resistant to snake venom.

* From facts to be reported later on, it seems not at all improbable that certain herbs may contain substances which are capable of reducing the toxicity of venom.

The manufacture was originally practised only at the Pasteur laboratory of Lille, France, under Calmette's supervision. Later other serotherapeutic institutions were established in East India, Japan, Australia, and Brazil. Only the United States have thus far neglected to take any steps in this direction. Although in quarantine, health laboratories, in extinction of malaria, yellow fever, hook-worm disease, etc., large sums have been liberally spent, in the suppression of dangerous reptiles and the treatment of their evils nothing has been done, and Americans are compelled to rely in this regard on the liberality and help of smaller governments. It is true that the abundance of poisonous reptiles in tropical countries makes it more imperative to those governments to provide for the suppression of those pests, still our own whole country, and especially parts of it are infested by these perils to an extent that it requires the assistance of the government to safeguard the life of its citizens. For private means the enterprise is too costly and hazardous, but the government ought to consider it as a public duty. At the same time we should not forget that with the ample material on hand science has a splendid opportunity to work out some of the most interesting scientific problems of serology and bacteriology.*

It has been shown by experiment (Myers, Martin, Semple, Flexner) that 0.1 centigram of Calmette's serum neutralizes 0.1 milligram of dried cobra poison, both *in vitro* and *in corpore*. This proportion holds good for the hemolytic and antibacteriolytic and the inhibitory action of venom upon clotting of the blood. Of rattlesnake venom even 3 milligrams are neutralized by 1 c.c. of the serum. For the counteraction of the neurotoxic principle of the venom, somewhat larger doses of antivenomous serum are required. For practical purposes it may be stated that it acts as a full protective in a dose of from 5 to 20 c.c.; and the 10 c.c. contained in Calmette's vial or 10 c.c. of dried antivenine, dissolved in 10 c.c. of boiled and cooled water for hypodermic injection, are therefore amply sufficient for the average case of snake-bite when injected even one and a half hours after the introduction of venom. If more time has elapsed, or graver symptoms have set in—as may occur after the bite of a large tropical snake—it is advisable to inject 20 or even 30 c.c. simultaneously. Fraser recommends injections into the injured limb rather than into distant parts, and the administration of repeated smaller doses instead of one large dose; but Calmette thinks they are best made into the lax skin of the hypochondrium. Although antivenomous serum is absorbed rapidly from the subcutaneous tissue, it may not be quick enough in severe and belated cases; then it is advisable to resort to direct intravenous injection. Passive immunity thus conferred by antivenine acts very rapidly and energetically, but disappears very soon again, inside of from two to four days, while immunity, created by gradually increased inoculations of venom, lasts for months (five to eight), the longer the larger doses were finally employed (active immunity). Even the young guinea-pigs of a mother thus immunized acquire immunity for several months.

Calmette's statements have not been accepted without contradiction. Fraser does not agree with him on all points, nor did the experiments and practical experience of the Indian surgeons and of Martin thoroughly confirm his premises and predictions. Not only has controversy arisen as to the curative value of antivenomous serum, but also other questions have been stirred up in relation to the chemical and biological action of toxin and antitoxin, questions which have been solved to a great part, but are still debatable. The interest of the subject warrants us going into some details as regards the controversy.

First, it was objected that Calmette asserted his antivenomous serum to be equally effective against all kinds of venom, in direct opposition to Behring's law that every toxin requires a specific antitoxin. It should be borne in mind that Calmette's horses are immunized with a venom in which the hemolytic element has been destroyed. Hence while he may work out an antitoxin to the more important constituent, the nerve poison, he neglects the other agent entirely. And indeed Cunningham declares an antivenomous serum which is efficient against cobra venom absolutely valueless against Daboia venom and inversely, while Martin claims that Calmette's serum has a slight but distinct protective effect against one of the constituents of Australian snake venom; but, on account of its present slight antihemotoxic strength, it is practically valueless in Australia. Calmette admits that his cobra antivenine does not protect against the hemotoxins of the viperidæ. Still he emphasizes the paramount importance of the neurotoxin and insists that his antivenine at all events prevents a fatal exitus. In those countries, therefore, which abound in vipers he recommends the inoculation of gradually increased doses of viper venoms (Lachesis, Vipera, Russelii, Crotalus, Hoplocephalus, etc.) on the foundation of horses immunized previously to cobra. He claims the method as easy to execute in a few months and the resulting polyvalent serum as capable to suppress the hemotoxic effects of vipers. Other investigators (Stephen and Myers, etc.) have supported Calmette's view and ascribe to his antivenine a limited value against all venoms, a condition which only requires a larger dose with heterogeneous venoms.

Later researches have indeed confirmed the validity of Behring's law (that every toxin requires its specific antitoxin) also regarding the effect of venoms: nay, the extremely sensitive biological tests of recent years in the alembic of the animal body have taught us the finely graded differences of blood and sera not only of related species but even of individuals of the same species. They have equally shown that the various neurotoxins and the various hemotoxins of the different species of snakes are dissimilar in their reaction to the antivenines worked out with the venom of one or the other snake. Arthus in his extended experiments has come to the conclusion that the antivenines are zoologically specific and that their full action is brought out only against the venom by which they have been prepared. To produce an antivenine for each species of snake is an impossibility, moreover very few of the bitten victims would be able to give a description of the snake. Calmette's suggestion, therefore, to create a polyvalent serum in each country with its predominating snakes is most practical. Vital Brazil of São Paulo, South America, has worked out this problem to great perfection. Living in a country which abounds in different species of vipers and also some of the Elapidæ he uses for immunization a mixture of various species of Lachesis and of Crotalus to produce a polyvalent viper antivenine, called antiophidic serum, another special anticrotalic, an antibothropic (Lachesis) and finally an antielapine. As long as it is doubtful what species of snake has wounded the patient the antiophidic serum is injected; but when the symptoms of crotalus or lachesis bite become more manifest, the special antivenine is injected in addition. The results thus obtained are said to be very satisfactory. It has been complained that the hemorrhagic influence of viper venoms has been very embarrassing in the proper immunization even of larger animals. Addition of hypochlorite of lime, shaking with chloroform, tryptic digestion, etc., have been recommended with success by several investigators (Calmette, Flexner and Noguchi, Ishizaka) at least for the first injections. Brazil seems to have overcome all these difficulties by starting with minimal doses of pure venom (0.00005 or $\frac{5}{100}$ milligram) or by preceding the inoculation by a small intravenous injection of antivenine.

* The Pasteur laboratories in New York City are at present the only dispensers of antivenine in this country.

Another objection was made that the curative power was entirely overrated, since Calmette used as a test for estimating its value only one minimum lethal dose of poison. Fraser thus calculates that for a man weighing sixty kilograms a dose of 330 c.c. of antivenine would be required,* an amount which because of its bulk and price would preclude its practical employment. Statistics and calculations do not, however, bear out this objection, for, with rare exceptions, not much more than the lethal dose is injected by the snake in the average instance. These considerations lead us to the much discussed question: is the influence of antivenine biological, *i.e.* does it stimulate specific antivenomous energy in the body cells or does it simply form a chemica combination? The French school (Calmette, Metchnikoff, Roux) have advocated the first view, but Fraser, Martin and the German school (Behring, Ehrlich) have always defended the chemical standpoint. Numerous experiments of Martin and Cherry, Flexner and Noguchi, Arthus, etc., have established the chemical action to a certainty. Also the French savants incline now to this side.

Observations of interest were reported by Phisalix. While experimenting with viper venom exclusively he found many substances which exhibited apparently a decided antitoxic effect—*e.g.* cholesterin, separated from biliary calculi and from carrots, or tyrosin, obtained from the bulbs of the well-known flower Dahlia, and from mushrooms.† All these bodies, some of vegetable origin and the highest final products of protein metabolism, had a decided immunizing effect against viper venom, as had also the serum of the animals treated with these substances. They were capable, however, of raising the resisting power of the organism but little above the minimum lethal dose of venom; and, moreover, to be at all efficacious, they had to be injected at least twenty-four hours previous to the administration of the venom.‡ A similar antitoxic influence is exerted by the cortical substance of the suprarenal glands.

Calmette, after repeating the above experiments, has extended them by using bouillon, bile, normal and antitetanic serum, etc., with the same apparent antitoxic effect, which is little pronounced and transient. He claims that all these substances act only as cell stimulants, to counteract the deleterious influence of the venom. Advocates of Ehrlich's theory would as well say that they stimulate the cell to the overproduction of a toxophil side chain, which as antitoxin is received and kept ready for use by the blood plasma. It is immaterial which theory we may apply. The experiments of Phisalix have not been carried far enough to result in practical conclusions. They are mentioned again as of historical interest and, if renewed may help to unravel the mysteries of the relation between toxins and antitoxins. But we must bear in mind that for investigations of this nature snake poisons, as Martin has pointed out, are particularly well adapted. They have the advantage of being less sensitive than other toxins to light and heat, and of being comparatively easy to obtain in a form which preserves a remarkably constant composition.

To sum up, the most commendable treatment after a bite of our North American snakes would be:

One or several tight ligatures should be made above the wound, followed perhaps by deep scarifications; then injection of a full dose of antivenine 20 to 30 c.c. of the liquid or 2 to 3 c.c. of dried antivenine dissolved in 20 or 30 c.c. sterile water. If antivenine is not at hand injections of 20 to 50 c.c. of a two per cent. solution of hypochlorite of lime should be made at several points near the bite and elsewhere. Stimulation, if necessary, by camphor hypodermically, hot coffee, or tea; lavage of the stomach; artificial respiration for hours; and, not least of all, continuous encouragement of the victim, for a deep mental prostration goes together with the physical depression of the nervous centers.

Heloderma (ἦλος δέρμα = nail skin).—It remains now to consider the only poisonous reptile not belonging to the snake group, the lizard heloderma, which is represented by two species.* The habitat

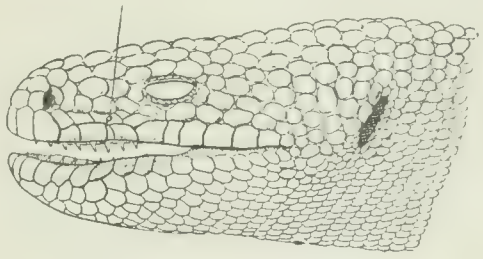

Fig. 4434.—Head of Heloderma. Side view.

of one of them, *Heloderma suspectum* Cope, is in the southwest of the United States, in New Mexico and Arizona, around the Gila River, while its somewhat larger congener, *Heloderma horridum*, lives in Central America. Its popular name, "Gila monster," denotes the awe and fear with which the animal is regarded by the native population, but the same is hardly justified by its exterior nor by its habits. The length attained by the adult animal varies from eighteen to twenty-two inches. Its skin, which is studded with innumerable horny elevations, like small, round nail-heads, exhibits a salmon or orange color, interrupted by black rings and irregular figures; the slow and sluggish, dragging gait does not enable it to make an attack or onslaught. The breath is said to be offensive and to issue from the mouth in puffs of black vapor; but only the black tongue is sometimes thrust out, and the exhalations and saliva have the pleasant odor of fresh calamus or sweetflag. Its reputation as a monster seems to be founded upon the fact that the natives have occasionally observed grave consequences following its bite. It undoubtedly bites very rarely, and then only when it is teased or cornered. When pursued it throws itself upon its back and bites in this position, holding on as tightly as a bulldog.

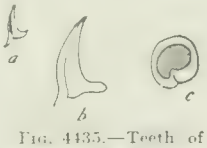

Fig. 4435.—Teeth of Heloderma: *a*, Natural size (3 mm. in length); *b*, enlarged 3 diam.; *c*, cross section.

* Fraser's argumentation appears to be erroneous. We must bear in mind that the tiny quantity of venom injected by a snake does not at once inundate the whole body. Although it may injure the blood throughout the circulatory system to some but not irreparable extent, it has, as the pathological reports show, certain places of selection, *e.g.* not the whole medulla but some cells of the anterior horns and the centers of respiration and deglutition. If venom has a chemotactic selective capacity for these places, we may as well assume that the dose of antivenine has a similar chemical affinity to ferret out the venom distributed throughout the system and to combine with it like an acid does with a base.

† There are, no doubt, many other substances of similar action, and it is not improbable that some of the popular antidotes to snake venom, like the plant mentioned before, Micania, owe their partly deserved reputation to an influence similar to that stated above as exerted by cholesterin, etc.

‡ Possibly in these cases the presence of a large amount of cholesterin in the blood serum acts in the same way as it does with other protoplasma poisons, *e.g.* saponin; it combines directly with the toxic substance, thus preventing the cholesterin of the blood cells themselves from doing so, and from being destroyed. (Ransom.)

* The latest and model study of this subject has been made by Leo Loeb, Carl Alsberg *et al.* at the Univ. of Pa. in 1910–12.

The fact that but occasionally grave sequelæ follow the bite of a Gila monster accounts for the many discrepancies that have prevailed as to its toxicity until very recently, not only among the natives, but also among the best scientific observers. The first confirmation of its poisonous nature seemed to be established by the discovery of grooved teeth, about three to four millimeters long, four on either branch of both maxilla and mandibula, in shape similar to those in the snakes Opisthoglypha or "suspecti."* The mandibula appears somewhat swollen, owing to the projection of its disproportionately large, elongated submaxillary glands, whose four separate ducts lead to the base of the above-described grooved teeth. The buccal secretion is whitish, transparent, slightly turbid,

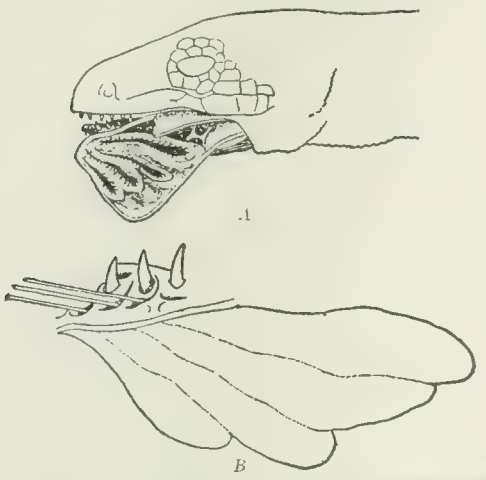

FIG. 4436.—*A*. Lateral View of the Head of *Heloderma suspectum*, showing poison gland consisting of four independent ears; each ear is cut tangentially showing its central duct or cavity. *B*. Enlarged slightly diagrammatic view of the poison gland, designed to give a clearer view of external openings of poison ducts and their relation to the teeth. Three bristles are shown inserted in the last three openings. (Henry Fox.)

somewhat viscid, alkaline, mostly contaminated with traces of blood; it has the fragrant odor of calamus and shows some scaly epithelia, salivary corpuscles, and some amorphous granula. The latter seem to be the bearers of the toxic substance. A hanging drop soon swarms with bacteria mostly *B. coli*. Gelatin is liquefied with lemon-colored colonies. When biting on a rubber cord an animal yields on the average five to six drops; a large animal once gave twenty-two drops. The saliva dries in grayish-white scales to one-eighth or one-tenth of its original weight.

The arrangement of the teeth and of the glands makes us understand why opinions as to the poisonous nature of heloderma have differed so widely. When an animal seizes its victim only with the front teeth, or does not lie on its back while biting, none or very little of the buccal secretion may enter the wound. When, however, a vigorous bite has been inflicted, the consequent phenomena have proven the venomous character beyond any doubt, and the hypodermic application of the pure saliva in sufficient doses has invariably proved fatal to the small animals experimented upon—rabbits, mice, and frogs.

Contrary to what occurs in snakes (see p. 533), the blood of heloderma is never poisonous, not even after extirpation of the glands: a proof that the venom takes its origin in the glands only. The poison is chiefly neurotoxic; it affects the same ganglia (mainly of the respiratory center) as snake venom and shows within one hour the identical extensive changes in the ganglion cells of the anterior horns (Bailey). The only visible effect upon circulation is a lowering of blood pressure, no hemorrhage except in mice around the optic nerve with protrusion of the eyeball, and in guinea-pigs hemorrhagic erosions and ulcers in the mucosa of the stomach. A much dilated heart and an enormous congestion of all internal organs are found. A faint hemolysis is noticed *in vitro*, but no trace of it in the body; it is even difficult to find the spot where the venom has been injected. Leucocytes are not at all affected, but on the contrary they are increased in number when immunization is going on. Cold blooded animals are more resistant than warm blooded; the heloderma itself shows a high resistance to its own venom. Santesson found a nucleine and an albumose in it. Alsberg after modifying Faust's method discovered also a protein free substance as the active principle. He finds it different from cobra or crotalus poison, still the presence of neurotoxin classes it with snake venom and the efficacy of Calmette's antivenine again shows that there is a graded specificity in the neurotoxins of different species. Some enzymes in the venom, *e.g.* diastase, lipase, etc., are not secreted by the poison glands, but are derived from elsewhere. He claims that because of lack of material he was unable to complete his analysis.

The first effect of the injection—an inability to sit or stand—is manifested after a short time, about ten to fifteen minutes in frogs, thirty minutes in rabbits. A certain drowsiness, similar to a narcosis, overpowers the animal; paralysis and insensibility seem to proceed from behind forward. The respiration is not labored, but becomes gradually slower and superficial until the animal expires after a few hours with some hardly noticeable twitchings. The heart has first a period of increased activity, which is followed by gradual paralysis and a great fall of arterial pressure, due to vascular dilatation. While these symptoms prevail after a small dose of venom, large doses seem to act directly upon the heart muscle, the animals dying within ten to twenty minutes with dyspnea and convulsions. Some investigators explain these symptoms as the consequence of general muscular paralysis (Stantesson); others, as a paralysis of the central nervous organs (Van Denburgh). The local symptoms, with rare exceptions, are entirely wanting; it is even difficult to find the spot where the venom has been injected. Some cases of persons bitten by a heloderma however are on record in which extensive and painful local swelling is noted. There is a report of at least one death after the bite of a Gila monster to which apparently every one refers who has written on this subject. This statement is made in a way that it rests on the authority of Sir John Lubbock, but this renowned scientist had nothing else to do with it but that he had a letter, sent to him, read at a meeting of the Zoological Society of London in 1888. The communication or rather clipping from the "Cochise Record" (Arizona Territory) of May 2, 1884, says: a colonel Yearger while playing with a Gila monster was bitten on his right thumb. Instantly the poison took effect and although every convenient remedy (undoubtedly also a liberal dose of whiskey) was applied, he lived but a few hours. A doctor arrived only several hours after death which had been very sudden." The paper adds in a vague reporter's way: "As this is the third or fourth death which has occurred in the territory from bites of this reptile, it should set at rest, at once and foreever, the theory prevalent, that their bite is not poisonous." The authority is not supported in any other way, and yet, when we read of the grave symptoms which Mme. Phisalix of Paris experienced from such a bite, it cannot be denied that a full vigorous bite may cause the death of a person,

* There is possibly another poisonous lizard in East India, *Lanthanotus borneensis*, which differs considerably from Heloderma, but which is provided with shallow grooved teeth. As to its toxicity nothing is known (Steindachner).

in good health or debilitated. Although only a single tooth had penetrated the side of her index-finger, violent pains and swelling of the whole arm, fainting spells, and heavy perspirations came on for nearly a week.

Treatment.—In most cases a treatment on general surgical principles will suffice to subdue the local phenomena, but a ligature ought not to be omitted to give the organism time to overcome the effects of the injected toxin. As stated before, the use of Calmette's antivenine is not only logically appropriate but has been repeatedly proven as decidedly effective. It may be added that it has shown good effects in other heterogeneous poisonings, as in those by scorpions. GUSTAV LANGMANN.

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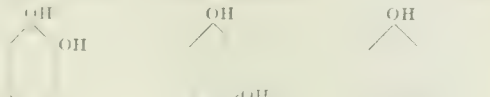
Resection of the Joints.—See *Excision.*

Resorcinol.—Resorcinol, chemically *metadioxybenzol*, $C_6H_4(OH)_2$, is one of a trio of isomeric diatomic phenols, of which pyrocatechol and hydroquinone are the other two members. It was formerly



called resorcinum or resorcin and was official in the United States Pharmacopœia of 1890 under that title.

Resorcinol occurs in colorless, needle-shaped crystals, having a peculiar smell, resembling that of carbolic acid, and a bitter-sweetish taste. Resorcinol dissolves readily in water, and still more readily in alcohol and in ether. In its effects resorcinol resembles its congener, phenol, but is, in general, less active than that substance and, in particular, very much indeed less poisonous constitutionally. Resorcinol inhibits bacterial growth, but probably less potently than phenol. Locally, the drug is without effect upon the sound skin, but applied, undiluted, to a moist mucous membrane it is mildly caustic, while at the same time anesthetic and healing. By reason of the anesthesia it produces, resorcinol may be applied even to such sensitive parts as the mucous membrane of the larynx (Andeer). Internally, resorcinol may be given in very considerable doses, as compared with phenol. After a dosage of from gr. xxx. to gr. xlv. (2.0–3.0) there set in, in a few minutes, quickening of heart action and of breathing, reddening of the face, and buzzing in the ears, with giddiness. Within fifteen minutes sweating begins, and the pyrexial temperature rapidly falls—so rapidly as perhaps to reach the normal point within an hour. The sweating does not last long, so that after the lapse of an hour from the time of dosing, the patient may have a naturally moist skin only, with temperature and pulse rate reduced to the normal. Resorcinol is variable in its action; sometimes the fall of temperature is slight, and sometimes the by-effects are excessive and even alarming. In overdosage resorcinol may induce constitutional poisoning after the general type of poisoning by the phenols—giddiness, insensibility, profuse sweating, great reduction of temperature, and general collapse, with olive green coloration of the urine. Such alarming condition has followed a succession of doses increased from half a drachm to two drachms. Locally, resorcinol is possibly available for a simple "antiseptic" effect, but is surpassed in this therapeusis by so many other agents as to be little used for the purpose. But for a combined antizymotic and *healing* effect the local application of resorcinol may be quite serviceable. Thus injections of a five-per-cent. aqueous solution have been made into the bladder, in cystitis, and into suppurating cavities, with good effect, and salves of resorcinol have abated malignant and syphilitic ulcerations. A spray of a two-per-cent. solution has been used in whooping-cough; and a ten-per-cent. solution has been praised for local application to the throat in diphtheria. It is of service also in the treatment of seborrhea of the scalp (dandruff). Internally, resorcinol has been used for its antipyretic action, in which application the medicine presents the feature of a fair degree of safety and efficiency combined; but the action is evanescent and attended by disagreeable excitement and sweating. The dose of resorcinol for an antipyretic effect ranges from gr. xxx. to xlv. (2.0 to 3.0), best given in divided doses and administered, dry, in a wafer or capsule, or in solution in water, sweetened and aromatized. Constitutional effects are also asserted (Andeer) to be procurable, in diseases attended by an affection of the skin, by inunction of resorcinol in admixture with vaseline, in proportion of from five to eighty per cent. Andeer claims thus

to have produced striking amelioration in such diseases as smallpox, scarlet fever, measles, and leprosy, by inunctions, over the whole body, of resorcinol vaseline. Resorcinol has been used as an intestinal antiseptic, under a variety of conditions, in doses of one or two grains every two hours. EDWARD CURTIS.
R. J. E. SCOTT.

Respiration, Physiology of.—Respiration is the function by which living cells obtain oxygen and get rid of carbonic-acid gas. It is an essential factor in the existence of both animals and plants, being a necessary accompaniment of the chemical processes underlying life. In the higher animals respiration is a very complicated process, consisting of many stages, but in lower forms it is comparatively simple and may be studied to advantage.

COMPARATIVE.—*Protozoa.*—Simple one-celled organisms, like the ameba, live in a fluid medium, water, which surrounds them on all sides. From this surrounding medium the dissolved oxygen is absorbed by the general surface of the body, and distributed to all parts by diffusion or by currents set up by the contracting vacuoles, or by some unknown form of cell activity. The carbon dioxide is got rid of by a reverse process. This simple form of respiration is probably very similar to the process by which the cells of the higher animals obtain their supply of oxygen and return their carbon dioxide to the surrounding lymph, constituting the so-called "internal or tissue respiration."

Cœlenterata.—In this group each animal consists of a central cavity surrounded by two layers of cells. Oxygen is taken in to some extent by the external surface, but also by the central body cavity, which serves the double purpose of food absorption and respiration. This prepares us to find the lungs of higher animals having a common embryological origin with the organs of digestion, and suggests the close relationship of the two processes. The currents set up to and from the central cavity by the movements of the body wall and of the tentacles facilitate the respiratory processes by bringing fresh fluid with a new supply of oxygen within reach of the absorbing cells.

Worms.—In this heterogeneous division of the animal kingdom we find a circulating fluid or blood capable of carrying the oxygen from the surface of the body where it is absorbed, to the cells in the interior which have need of it. In some cases the blood contains a special substance, hemoglobin, with which the oxygen can enter into loose combination while being carried about. In the worms we find for the first time special organs of respiration. Sometimes these are little more than grooves or pits supplied with cilia to favor the renewal of the oxygen-containing medium. In other cases we find these pits becoming deeper so as to form ciliated ducts.

Insects.—In insects we find a system of tubes (tracheæ) adapted for air breathing. These are distributed through the body, and the renewal of the air within them is favored by movements of the legs and wings.

Higher Animals.—As we ascend the scale we find further developments of the organs of respiration, such as to offer the greatest respiratory surface in the smallest possible space. This is seen both in the gills of fishes and the lungs of air-breathing animals. The arrangements for the renewal of the oxygen-containing medium are elaborated and reach their highest development in the bony thorax of the higher vertebrates with their costal and diaphragmatic breathing. The blood-vascular system also becomes better adapted for taking up oxygen and carrying it rapidly all over the body.

The human embryo in its respiratory function, as in other things, passes through many of the stages represented in lower forms. The one-celled ovum, like the ameba, takes in oxygen by its general surface from the fluids which surround it in the uterus. As growth proceeds it develops a blood-vascular system, but for a time continues to take in its oxygen by the general surface of the surrounding membranes. When the placenta is formed, the fetus has a special organ of respiration, but obtains its supply like a fish from a fluid medium, the mother's blood. At birth the tying of the cord shuts off the placenta, and the consequent deficiency of oxygen stimulates the center in the medulla to initiate the first respiratory movements. The opening up of the lungs diminishes the pressure in the pulmonary vessels, and thus determines an increased blood supply to these organs. The foramen ovale closes and the adult condition is rapidly established.

THE ORGANS OF RESPIRATION.—These include the *air passages* leading into the lungs from outside and comprising the nose, pharynx, larynx, trachea, and bronchi; the *lungs* which contain the respiratory surfaces (air sacs or alveoli) in which the interchange of gases takes place, the divisions and ramifications of the bronchi leading down to the alveoli, and the supporting connective tissue in which run the blood and lymph vessels and the nerves; the *pleuræ* which cover the lungs and line the thoracic walls with a smooth slippery membrane facilitating movement; the *thoracic walls* which enclose the lungs and which are strong enough to protect them and yet mobile enough to be the medium through which the expansion of the lungs is effected; the *muscles of respiration*, including the diaphragm and the muscles acting upon the ribs; the *nervous mechanism* through which all the respiratory processes are initiated and regulated.

The *nose* serves a useful purpose in warming the inspired air and thus protecting the other air passages from too sudden changes of temperature. The *larynx* is especially concerned in speech and voice production. It also plays an important part in preventing dust particles and noxious gases from entering the lungs by the cough and spasm which these substances excite when they come in contact with its mucous membrane. The *trachea* and *bronchi* consist of tubes of fibrous and elastic tissue supported at regular intervals by incomplete rings of cartilage. The portion behind, where the cartilage is absent, is supplied with plain muscle tissue by which the tubes can be somewhat constricted. The mucous membrane consists of loose lymphoid tissue. It is supplied with mucous glands, which keep the surface moist, and is lined with ciliated columnar epithelium. The cilia carry the mucous secretion and inhaled dust particles up toward the larynx. The *lungs.* As the bronchi enter the lungs they divide and subdivide, forming the bronchial tubes, to the smallest of which the name bronchioles is applied. The structure of the trachea and bronchi is continued into the bronchial tubes with certain modifications. The cartilaginous rings are replaced by irregular plates of cartilage distributed at intervals around the tubes, and even these are not found in the very smallest bronchioles. The unstriped muscle becomes relatively more abundant as the size of the tubes diminishes and it forms a continuous layer of circular fibers. The musculature of the bronchioles may play quite an important part in regulating the local distribution of air within the lungs. It may also affect the ease with which air reaches individual parts in such a way as to influence very materially the intra-alveolar pressure. It is easy to see how the changes in intra-alveolar pressure may modify the distribution of blood so that the supposed lack of vasomotor nerves in the lungs may be largely compensated for by the action of the bronchial musculature. The epithelium changes from columnar to cubical, and in the smallest tubes mucous glands are not found. The lungs may be seen

to be divided into innumerable tiny sections known as lobules, of which each has a diameter of one to three centimeters. They are of pyramidal shape and are divided from one another by a little fibrous tissue. A bronchial tube entering such a lobule divides several times, forming tiny bronchioles. If we follow the bronchiole along we will find the epithelium changing from cubical to pavement, and we will see an occasional air sac or alveolus opening out from the side. These tubes supplied with alveoli are known as respiratory bronchioles. Each respiratory bronchiole ends in a dilated passage called an alveolar duct, into which open a number of infundibula. An infundibulum is a cone-shaped expansion with the apex toward the duct. Extending out from it are numerous hemispherical expansions known as air sacs or alveoli which very greatly increase the total surface.

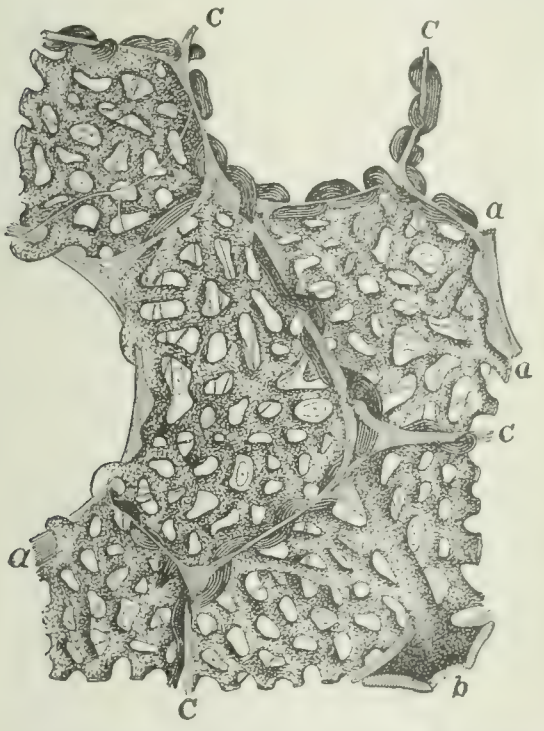


Fig. 4437.—Section of Injected Lung, Including Several Contiguous Alveoli. (F. E. Schultze.) (Highly magnified.) *a*, *a*, Free edges of alveoli: *c*, *c*, partitions between neighboring alveoli, seen in section; *b*, small arterial branch giving off capillaries to the alveoli. The looping of the vessels to either side of the partitions is well exhibited. Between the capillaries is seen the homogeneous alveolar wall with nuclei of connective-tissue corpuscles and elastic fibers. (Schaefer.)

The wall of an infundibulum consists of a thin basement membrane lined by epithelium, the so-called "respiratory epithelium." The cells composing this epithelium are of two kinds: non-nucleated platelets resting upon the blood capillaries and smaller nucleated cells between. Around the infundibula is spread out a network of capillaries so dense that the meshes are narrower than the vessels themselves. Between the air in the air sacs and the blood in the capillaries nothing intervenes but the two layers of epithelium belonging to the alveoli and the capillaries respectively. In some cases the capillary may be in contact with the epithelium of two contiguous alveoli (see Fig. 4437).

The capillaries distributed to the air sacs are from branches of the pulmonary artery. The walls of the bronchial tubes and the connective tissue of the lungs are supplied by the bronchial arteries belonging to the systemic circulation. The connective tissue which intervenes everywhere between the infundibula and under the pleura is rich in elastic tissue. The nerves of the lung come from the anterior and posterior pulmonary plexuses, which are formed by branches from the pneumogastric and sympathetic. The sympathetic fibers come off from the inferior cervical ganglion, annulus of Vieussens, and stellate ganglion, and can be traced back to the upper thoracic nerves.

Physical Relations of the Lungs to the Chest Wall and the External Atmosphere.—Before birth the lungs are solid organs; that is to say, the opposite walls of the alveoli and bronchial tubes are in contact, and form merely potential spaces communicating through the respiratory passages with the outside. At birth the thoracic cavity is enlarged by the action of the muscles of respiration. The additional space which results must be filled up as it is formed, for "nature abhors a vacuum." The only avenue through which anything can enter the thorax to fill it is through the respiratory passages, and so air enters, expanding the lungs and keeping them in contact with the receding chest wall. Throughout life the lungs continue to follow the movements of the chest wall. If the chest is enlarged, air enters the lungs, expanding them sufficiently to fill it up. In doing this the air has to overcome the elasticity of the lungs. During rest the air exerts upon the inside of the lungs the same pressure as upon the external surface of the body, 760 millimeters of mercury or fifteen pounds to the square inch. When the chest is suddenly expanded, as in inspiration, the air within the lungs is rarefied and the pressure within the lungs, *the intrapulmonary pressure* is diminished. During expiration the thorax diminishes in size, compressing the air in the lungs, and the intrapulmonary pressure rises. In either case movement of air in or out of the lungs takes place till the intrapulmonary pressure is again equal to atmospheric when equilibrium is established.

The pressure in the pleural cavity and in the mediastinum is known as the *intrathoracic pressure*. It is always less than atmospheric because the elasticity of the lungs tends to pull them away from the chest wall, and protects the latter from part of the intrapulmonary pressure. The more the chest is expanded the more is the elasticity of the lungs brought into play, and the more does intrathoracic pressure fall below atmospheric. The intrathoracic pressure is often spoken of as *negative*, meaning that it is less than atmospheric. The fact that it is so may be seen when an opening is made in the chest, as in this case air is drawn into the pleural sac and the lungs collapse. During ordinary breathing intrathoracic pressure varies from 758 to 752 millimeters of mercury, which is 2–10 millimeters below atmospheric. This is expressed by saying that there is a negative intrathoracic pressure of 2–10 millimeters. During forced inspiration, when the lungs are very much on the stretch, there may be a negative intrathoracic pressure of 30 or 40 millimeters.

Renewal of the air in the alveoli is effected by the movements of respiration supplemented by diffusion. The respiratory movements are primarily movements of the thoracic walls, which lead to changes in the capacity of the thorax and indirectly to expansion and contraction of the lungs. The size of the thorax can be increased or diminished in three directions—vertical, anteroposterior, and transverse. The vertical diameter can be increased by the descent of the arched diaphragm and by the backward and downward movement of the lower ribs. It can be diminished by the passive return of the diaphragm to its arched position of rest, assisted by the contraction of the abdominal muscles, which force the viscera up against the diaphragm and increase its arch.

The anteroposterior diameter is increased by the raising of the ribs from the resting position, in which they slant downward, to one in which they extend more directly forward, carrying the sternum with them. In quite breathing the upper end of the sternum acts as a fulcrum and the lower end is pushed out; but in very deep inspiration the upper end is also raised and extended forward. The anteroposterior diameter is diminished by the thorax returning to a position of rest as a result of gravity and elastic recoil.

The transverse diameter is increased by the outward and upward rotation of the ribs. Any tendency of the contracting diaphragm to draw in the lower ribs is overcome by the fact that the abdominal viscera are compressed by its descent and tend to press the ribs outward.

Muscles of Respiration.—In ordinary inspiration the vertical diameter is increased by the descent of the *diaphragm*, assisted by the *quadratus lumborum* and *serrati postici inferiores*, which fix the lower ribs. The anteroposterior and transverse diameters are increased by the *scaleni* and *serrati postici superiores*, which fix the two upper ribs and assist the elevation and eversion of the others, and by the *external intercostals* which raise the lower ribs. Both the *external and internal intercostals* by their contraction give strength to the intercostal spaces and enable them to withstand the atmospheric pressure. It used to be taught that expiration was largely passive being dependent on gravity and elastic recoil. The more recent teaching as expressed by Arthur Keith and others is that expiration, like practically all movements in the body, is dependant upon muscular action controlled and balanced by the nervous system. In varying degrees the forces of gravity and elastic recoil may favor and assist. In quiet expiration the chief muscles used are the abdominal muscles and the interosseous portion of the internal intercostals.

In forced inspiration a great number of muscles are called into play, first those having attachments to the ribs or sternum, and later a very great number which indirectly assist the enlargement of the chest or the opening up of the respiratory passages. Forced expiration is assisted by the action of the abdominal muscles, which press on the viscera and so push up the diaphragm, and also by those muscles of the abdomen and back which pull down the lower ribs.

Types of Respiration.—An infant breathes mostly with its diaphragm. Such breathing is spoken of as the *diaphragmatic* or *abdominal type*. In adults we find a difference in the manner of breathing between the male and female. In the male the movements of the abdomen and lower part of the thorax are more pronounced, forming the so-called *inferior costal type*, while in the female movements of the upper chest predominate, and we speak of the *superior costal type*. This difference in the sexes is not found in all races, and so is ascribed by some to the influence of dress, but others see in it an adaptation of woman for her sexual life, pregnancy, through natural selection.

The portions of the lungs which are expanded by the two chief types of respiration are the parts above the great fissure in the superior costal type, and the parts below the great fissure in the inferior costal type. Within the lobes, however, there are great differences in the expansion of different parts depending on the direction in which the chest is enlarged and on the number and size of the infundibula present in each section. The surfaces which undergo the greatest expansion are the diaphragmatic and the anterolateral. Expansion is less in the posterior parts of the lungs and especially in the posterior surface of the apex which is consequently the most frequent seat of tuberculosis.

The Quantity of Air Breathed.—During ordinary quiet breathing about 300 c.c. of air is taken into the lungs with each inspiration and expelled with each expiration. This is called the *tidal air*. By a forced inspiration an additional quantity, known as the *complemental air*, may be taken in. Its volume is about 1,700 c.c. The air that can be expelled by an effort after an ordinary expiration is the *supplemental air*, and measures about 1,500 c.c. The air remaining in the chest after the most powerful expiration is the *residual air*, amounting to about 1,000 c.c. The total quantity that can be taken in after a complete expiration or breathed out after the fullest inspiration is called the *vital capacity*, and includes the complemental, tidal, and supplemental air. It measures therefore in a typical case about 3,500 c.c. *Lung capacity* is the total quantity of air in the lungs after a forced inspiration, and is equal to the vital capacity plus the residual air, or about 4,500 c.c. All these quantities naturally vary very much in different individuals and under different conditions, but the above numbers may be taken as more or less typical.

The quantity of air breathed in any given case can be estimated by means of an instrument known as a spirometer

The Changes that Take Place in the Air.—In the lungs certain things are taken from the air and others added, as shown in the following table, in which the quantities are given in volumes per cent.:

	Inspired air.	Expired air.
Nitrogen	79.0	79.0
Oxygen	20.96	16.03
Carbonic acid	0.04	4.4
Aqueous vapor	Variable.	Saturated.
Argon, etc.	Traces.	Traces.

It is to be noted that the volume of oxygen lost, 4.93, is slightly greater than the volume of CO_2 added, 4.36, so that the total volume of the expired air is slightly less than that of the inspired air.

The expired air is warmed to the temperature of the body and is also fouled by organic emanations given off from the lungs and respiratory passages. The principles on which the analysis of expired air is carried out may be conveniently studied in the apparatus designed by Waller, which is one of the simplest and yet sufficiently accurate for most purposes.

In other methods the carbon dioxide is absorbed by soda, lime, or baryta water instead of by sodium hydrate, and arrangements may be made for passing the air through a chamber containing sulphuric acid for the arrest and estimation of the aqueous vapor.

Respiratory Quotient or Respiratory Coefficient.—As is shown in the table given above, the volume of oxygen absorbed is greater than the volume of carbon dioxide excreted. The relation of one to the other is expressed as $\frac{CO_2}{O_2}$ and is known as the respiratory quotient. If all the oxygen taken into the body reappeared in the expired air as CO_2, the volumes would be equal and the respiratory quotient $\frac{CO_2}{O_2}$ would be 1. Some of the oxygen, however, combines with hydrogen to form water, and is excreted as aqueous vapor by the lungs, or as water by the skin and kidneys, and thus does not leave the body as CO_2 at all, but as H_2O. The respiratory quotient varies with the relative proportions of carbon, hydrogen, and oxygen in the food. Carbohydrates contain in themselves just enough oxygen to satisfy all the hydrogen present, so that

only the oxidation of the carbon has to be provided for by the oxygen taken in by the lungs. Thus the presence of a large amount of carbohydrate in the diet tends to make the respiratory quotient approach 1. Fats and proteins, on the other hand, contain a relative excess of hydrogen, and require oxygen for combination with it, so that the CO_2 excreted represents only part of the oxygen absorbed and the respiratory quotient falls below 1.

Temporary variations in the respiratory quotient may be due on the one hand to oxygen being absorbed in excess and stored up as tissue oxygen, or on the other hand to tissue oxygen taken in long before being made use of for oxidizing some of the carbon. The former tends to lower the respiratory quotient and is seen during rest; the latter raises it and is seen in conditions of activity and quickened metabolism.

Ventilation.—The withdrawal of oxygen from the air and the addition of CO_2 and organic matters that takes place during respiration renders it vitiated or unfit to be breathed again. When a room has been breathed in until the amount of CO_2 has risen to 0.07 volume per cent., the air becomes more or less stuffy, although in very badly ventilated rooms the proportion may reach ten times this figure. The closeness or stuffiness is due principally to the organic emanations, of which some are of an odorous nature. This is shown by the fact that much larger quantities of CO_2 can be added to the air of a room in other ways without causing any inconvenience to the inmates. Air containing even as much as twenty-five per cent. of CO_2 can be breathed safely for a short time if there are no other impurities in it, and if it contain plenty of oxygen. An ordinary individual requires about 2,000 cubic feet of air per hour if the proportion of CO_2 is not to rise above 0.07 volume per cent. This may be supplied by allotting 1,000 cubic feet of space to each individual, and providing ventilating arrangements for renewing the air twice every hour. The smaller the space allotted to each individual the more frequently must the air be changed by ventilation.

The following table may be useful for ready reference on some of the points discussed above, although the exact numbers vary very much in different people. The proportions given in cubic centimeters and liters are somewhat less than those usually given, but are probably more correct than the larger quantities given in inches and feet.

Amount of	One breath.		Twenty-four hours.	
	Cu. in.	C.c.	Cu. ft.	Liters.
Air breathed	30	300	350	7,000
Oxygen absorbed	1.5	15	17.5	350
CO_2 excreted	1.3	13	15	300
Air rendered close (Proportion of CO_2 raised to 0.07 volume per cent.)	5,000	50,000	50,000	1,000,000

The Blood and Its Gases.—While the air on one side of the respiratory epithelium is being constantly changed by the movements of the chest and by diffusion, the blood on the other side is being changed by virtue of the circulation. The blood is brought in a venous condition by the pulmonary artery and its branches, and is carried away in an arterial condition by the pulmonary veins. The gases of the blood are the same qualitatively as those of the atmosphere, but are not present in the same proportions. The proportions naturally vary somewhat but the following are approximate in volumes per cent. of blood:

Blood.	O.	CO_2.	N.
Arterial	20	40	1–2
Venous	10	46	1–2

In considering the nature of the connection between the blood and its gases it is necessary for us to keep in mind the various constituents of blood and their power of taking in gases. The *plasma* may for our present purpose be considered as made up of water, salts, and proteins. *Water* is capable of holding a certain quantity of gas in solution, the exact amount depending on the nature and tension of the gases surrounding it, and on the temperature. If water be exposed to a mixture of gases it will absorb and hold in solution a quantity of each which will depend on the quantity of that particular gas in the mixture. Each gas present in a mixture exists at a certain tension, and exerts what is called a *partial pressure.* This partial pressure is not affected by the amount of any other gas that may be present. Thus a jar were half full of water and the rest of it occupied by air, the water would take up from the air a certain amount of nitrogen and a certain amount of oxygen. If now pure nitrogen were pumped into the jar without allowing any of the air already there to escape, the tension or partial pressure of the nitrogen in it would be increased and the water would take a proportionately large amount into solution. The tension or partial pressure of the oxygen would remain, however, what it was before and the water would not absorb any more. If now pure oxygen were pumped in, the partial pressure of oxygen in the jar would be increased and the water would take a proportionately larger amount of this gas into solution.

The nitrogen of the blood is held chiefly in simple solution in the water of the plasma. The oxygen and carbon dioxide, however, are present in much larger proportions than water could take into solution at the tension or partial pressure of these gases prevailing in either the lungs or the tissues. These gases must therefore be attached to the other constituents of the plasma or to the corpuscles. *The salts of plasma* include among others considerable quantities of sodium carbonate. This salt is capable of combining with carbonic acid gas to form sodium bicarbonate. There is reason to believe that the carbonic acid is principally held in the blood in this chemical combination. Sodium phosphate, another constituent of the plasma, may combine with carbonic acid too, forming sodium bicarbonate and sodium biphosphate. *The proteins* of the plasma, especially the globulins, are also claimed to have some power of combining with carbonic acid gas. *The corpuscles,* both red and white, may similarly carry a certain amount of CO_2 in combination with their salts and proteids.

The chief interest of the corpuscles for respiratory purposes, however, is connected with the colored proteid hemoglobin of the red corpuscles.

Hemoglobin makes up about ninety per cent. of the solids of the red corpuscles. It is a substance possessing a remarkable property of forming loose chemical combinations with various gases. As it exists in the blood it is combined with oxygen to form oxyhemoglobin. One molecule of hemoglobin can combine with one molecule of oxygen or one gram of hemoglobin can attach to itself 1.34 c.c. of oxygen. In arterial blood the hemoglobin is nearly saturated with oxygen, and in venous blood it still has some oxygen associated with it. Oxygen-free hemoglobin or reduced hemoglobin is not usually present in the body, but can be demonstrated in parts where the circulation has been stopped for from forty to 300 seconds (Vierordt).

There are a number of compounds and derivatives

of hemoglobin which can be most readily distinguished by the absorption bands in their spectra. In the article on *Blood* in another volume of this HANDBOOK, they are described in some detail, and their spectra are figured.

Oxyhemoglobin is the bright red substance which gives the color to arterial blood. In this compound the oxygen is present in a very loose chemical combination, and may be readily taken up by the tissues of the body or by reducing agents.

Methemoglobin is a brown substance formed by the action of oxidizing agents on oxyhemoglobin. It is found in the blood in cases of poisoning by chlorate of potash and similar substances. Methemoglobin is of no use for respiratory purposes, as the oxygen is too firmly united to be abstracted by the tissues, although it is readily taken up by strong reducing agents, such as ammonium sulphide, with the formation of hemoglobin (reduced).

Carbonic-oxide Hemoglobin.—If illuminating gas be inhaled the carbonic oxide which it contains unites with the hemoglobin of the blood in place of the oxygen by virtue of the fact that CO possesses the stronger affinity of the two for hemoglobin. This quite destroys the oxygen-carrying properties of the blood and results in death.

Other gases, such as NO, H_2S, etc., may also destroy the oxygen-carrying power of the blood by replacing the oxygen, or by otherwise changing the hemoglobin molecule.

Hematin.—Hemoglobin may be decomposed under the action of heat and acid or alkali into two parts, a proteid of unknown nature, usually referred to as globin, and a brown coloring matter rich in iron and designated hematin.

Hemochromogen, or reduced alkaline hematin, may be formed by the action of reducing agents on hematin, or by breaking up hemoglobin in the absence of oxygen. Hemochromogen has the same power of uniting with gases as hemoglobin has, and in fact has been shown to be able to attach to itself the same quantity (of CO) as the corresponding amount of hemoglobin. Hoppe-Seyler taught that hemochromogen existed as such in hemoglobin, and lent it its gas-carrying property. This is disputed, however, by Gamgee (Schaefer's "Textbook").

The protein part of the hemoglobin molecule is believed by many to be of the nature of a globulin. It is probable that the small quantity of CO_2 that can be carried by hemoglobin is attached to this protein part.

The Mercurial Pump.—The gases of the blood are obtained for analysis by subjecting the blood to the vacuum of a mercurial pump. One of the simplest and best is that of Leonard Hill. (See Fig. 4438.)

A is a reservoir filled with mercury which may be raised or lowered. By raising it and manipulating the various taps the whole apparatus is filled with mercury. By lowering it the blood chamber *F* is made a vacuum. *F* is separated from the apparatus, weighed, and partly filled with blood. It is then reattached and the gases are drawn off from the blood into the reservoir *B*. By raising and lowering *A* repeatedly with manipulation of the taps, the gases are all drawn off from the blood in *F* into the reservoir *B* and then forced over into the eudiometer tube *H*, where they are collected over mercury and measured.

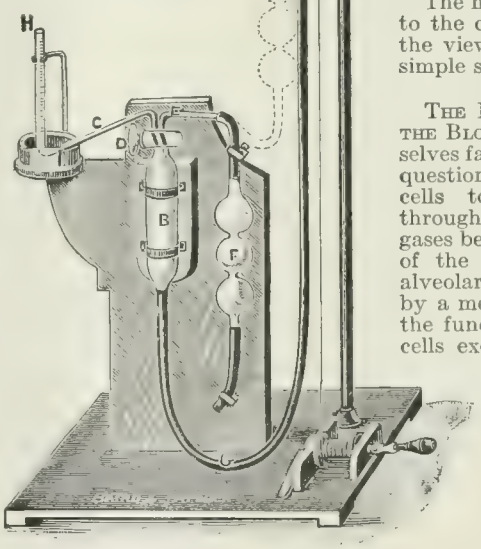


FIG. 4438.—Hill's Mercurial Gas Pump.

The amount of CO_2 is measured by inserting potassium hydrate which takes up the CO_2 to form a carbonate. The diminution which takes place in the total volume of gas is the amount of CO_2 which was present. The amount of oxygen can similarly be measured by using a solution of pyrogallic acid, which unites with it. The gas remaining unabsorbed is nitrogen.

Blood does not give off its oxygen in the mercurial pump in proportion to the diminution in the pressure as would be the case if it were in simple solution. On the contrary, very little comes off until a certain degree of vacuum is reached, and then large quantities are given off. This points to its being in loose chemical combination.

With regard to the CO_2, the fact that blood even when exposed freely to the air can retain an amount of CO_2 greatly in excess of what it could hold in simple solution proves that this gas too exists in chemical combination. Now if plasma be exposed to the mercury pump and the pressure sufficiently lowered, much of the CO_2 is given off, and must therefore be quite loosely combined. Another portion is not given off without the addition of an acid or hemoglobin (red corpuscles), which seem able to liberate it from some more stable compound.

The nitrogen is given off in proportion to the diminution in the pressure, and the view generally held is that it is in simple solution in the plasma.

THE INTERCHANGE OF GASES BETWEEN THE BLOOD AND AIR.—Here we find ourselves face to face with the fundamental question of the relation of epithelial cells to the processes taking place through them. Does the interchange of gases between the blood on the one side of the respiratory epithelium and the alveolar air on the other side take place by a mere process of diffusion, or does the functional activity of the epithelial cells exert some controlling or modifying influence? There is an increasing tendency to attribute importance to lining epithelium in the absorption and secretion of liquids and solids. This is seen in the change that has recently taken place in the teaching of the text-books with regard to intestinal absorption and the process of secretion. The fact that epithelium may also play an active part in the secretion of gases has been amply demonstrated by a number of investigators in connection with the secretion of gases in the swim bladder of fishes. Bohr has shown that this process is under nervous control.

With regard to the possibility of explaining the interchange of gases in the mammalian lung on a purely physical basis, it might be explained by the laws of simple diffusion and osmosis if the partial pressures on the two sides of the epithelium were always such as to favor the exchange that takes place. This question has been investigated as follows: First air is drawn off from the alveoli by one of the instruments devised for the purpose, of which *Pflüger's lung catheter* is the best known. Then this air is analyzed and the partial pressure of each gas in the alveoli can be calculated. Next the partial pressures of the gases in arterial and venous blood are estimated by some form of *aërotonometer* or *hemataërometer*, and a comparison of the results obtained from the alveolar air and the arterial and venous blood in any given case will show whether the partial pressures are favorable

to the interchange or not. The principle of the *aërotonometer* is as follows: It is an apparatus in which blood is brought into close relation with two gaseous mixtures, in one of which the CO_2 tension is above, while in the other it is below the anticipated tension of the blood. As blood flows through the apparatus an interchange of gases takes place between it and the gaseous mixtures contained. By analyzing the latter before and after, the tension of gases in the blood can be approximately determined.

Frederick gives the following as a typical result of such an investigation in a dog:

	External air.		Alveoli.		Arterial blood.		Tissues.
Tension of oxygen	20.95	>	18	>	14	>	0
	External air.		Alveoli.		Venous blood		Tissues.
Tension of carbon dioxide	0.03	<	2.8	<	3.81 5.4	<	5 0

In this case the tensions or partial pressures of the gases are such that oxygen would tend by mere diffusion to pass in from the air to the blood and CO_2 in the reverse direction.

Other workers, however, notably Bohr, and Haldane and Lorraine Smith, employing somewhat different methods, have obtained results which seem to show that oxygen may be taken in and CO_2 excreted even when the partial pressures are such as to oppose the process. If these experiments are reliable, we must look to some active secretory power of the respiratory epithelium for the explanation.

The late Dr. Wesley Mills maintained this view for many years, and his text-book, published in 1889, was one of the first to recognize it in the following terms: "The view expressed by some physiologists to the effect that diffusion explains the whole matter so far at least as carbonic anhydride is concerned, and that the epithelial cells of the lung have no share in the respiratory process, does not seem to be in harmony either with the facts of respiration, or with the laws of biology in general."

The Seat of the Oxidation which Occurs in the Body.—At the beginning of the last century physiologists were divided in opinion as to the principal seat of oxidative processes in the body. Some, who followed Black, believed that these processes took place exclusively in the lungs, while others, led by Le Grange, regarded the blood as the seat of these changes. During the past fifty years Pflüger and others have shown that neither of the old views was correct, but that oxidation is continually taking place in all the tissues, and that it varies to a great extent with their functional activity. It has been shown, moreover, that the taking up of oxygen and giving off of CO_2 do not necessarily run parallel, but that the former may be stored up in excess during rest as tissue oxygen, and may remain in some more or less stable combination until a time of functional activity, when a dissolution of the molecule occurs with the setting free of CO_2. Some of the facts on which these views are founded are the following: If the blood of a frog be replaced by saline solution, the animal may live for hours or days, and continue to take up oxygen and excrete CO_2 (Oertman). Bleeding, although diminishing the quantity of blood in the body, has no effect on the amount of gaseous interchange (Pembrey and Gürber). If a muscle be made to contract *in vacuo*, it will give off CO_2, derived from its tissue oxygen, in sufficient quantity to be determined (Hermann). If a solution of fresh blood be supplied to a frog's heart, the oxyhemoglobin will be reduced more quickly during activity than during rest (Yeo).

"The avidity of the different tissues for oxygen varies greatly, and the differences are doubtless expressions, broadly speaking, of the relative intensities of their respiratory processes" (Reichert).

Quinquaud records the following absorption capacities for 100 grams of different tissues submitted for three hours to a temperature of 38° C.:

	C.c.		C.c.
Muscle	23	Spleen	8.0
Heart	21	Lungs	7.2
Brain	12	Adipose tissue	6.0
Liver	10	Bone	5.0
Kidney	10	Blood	0.8

Internal or tissue respiration is the term applied to the interchange of gases between the blood and the tissues. The partial pressures of the gases in the tissues, lymph, and blood are said to be such as to favor the taking up of oxygen by the tissues, and the giving off of CO_2 in accordance with well-known physical laws, but this does not exclude participation of the endothelial and tissue cells in the process.

The activity of the cells is ascribed by many to the presence of intracellular ferments. Speaking generally these ferments have not been isolated, but their presence is assumed from the activities shown by the tissue juices. Some of these ferments have been given special names, notably reductase which is said to abstract oxygen from the tissue lymph and oxidase which determines the reactions between oxygen and various constituents of the cells.

Graphic Record of Respiratory Movements.—Innumerable devices have been employed for this purpose. Some, either because they require a cutting operation or for other reasons, are employed only on animals; and others may be used clinically on man. To the former category belong the *phrenograph*, by which the movements of the diaphragm are recorded by the use of a lever or rubber bag passed up between the liver and diaphragm and connected with a recording lever; various forms of sounds and cannulas, which can be passed into the pleural cavity or the esophagus and connected with a recording tambour to register the variations in intrathoracic pressure; a tracheal cannula or a nose cap from either of which the volume of air breathed can be recorded by the *aëroplethysmograph* of Gad, or the changes in intrapulmonary pressure can be registered by a Marey's tambour. In either case it is usual to have an air chamber between the animal and the recording apparatus, so that the same air will not be breathed over and over.

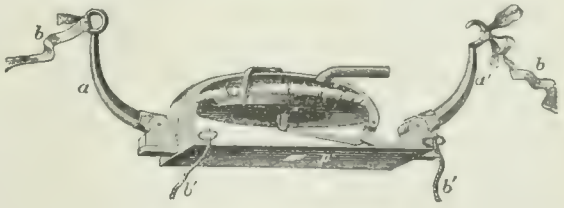


Fig. 4439.—Receiving Tambour of Marey's Pneumograph, New Form. (Langendorff.) *b,b*, Belt to go around chest; *b'*, *b'*, strings to suspend the instrument from the neck.

Among the methods which may be employed in man are the *pneumograph* or *stethograph*, in which a belt surrounding the chest is attached to some form of receiving tambour from which a rubber tube leads off to a recording tambour, and indicates the changes in the girth of the thorax. (See Fig. 4439.) In the *stethometer* of Burdon Sanderson the changes in the anteroposterior diameter of the chest are recorded.

Perhaps the simplest method of all is to connect a recording tambour through a piece of rubber tubing with a small funnel, and to press the latter into the episternal notch. A fair record of the respiration may be obtained in this way.

The curves obtained in these various ways differ in their details, but the tracing shown in Fig. 4440, and obtained with Marey's pneumograph, may be taken as a type.

As the figure shows, inspiration begins somewhat suddenly and advances rapidly, being followed immediately by expiration, which is carried out at first rapidly, but afterward more and more slowly.

Nervous Mechanism of Respiration.—The muscles of respiration act rhythmically under the influence of nervous impulses, which originate in the medulla oblongata and pass out by the motor nerves. The respiratory center in the medulla sends out these impulses as the result of a constant stimulus imparted to it by the blood. The explanation of the rhythmic action of the center under the constant stimulus of the blood is to be sought for in the fundamental properties of protoplasm. The action of the center is modified by impulses reaching it by afferent nerves, of which some are constantly in operation and others only act occasionally.

The Respiratory Center.—All the brain above the medulla may be removed without serious interference with the breathing. If the spinal cord be separated from the medulla all respiratory movements of the trunk cease, but some of the facial muscles, still in connection with the medulla through the cranial nerves, continue to exhibit movements of a respiratory character. Injury of the medulla in the lower part of the floor of the fourth ventricle (calamus scriptorius) is sufficient to cause cessation of respiration and death, all the rest of the nervous system being intact. These facts suffice to localize the respiratory center in the floor of the fourth ventricle, but the exact nerve cells which constitute it cannot be pointed out. From the fact that cessation of respiration has followed injury to different parts in the hands of different investigators, the respiratory center is probably made up of several separate groups of cells or nerve nuclei and bundles of connecting fibers.

If the medulla be carefully divided in the median line respiration continues; and if the pneumogastric nerve on one side be divided, the movements on that side will become slower than on the other, and we may have the two halves of the diaphragm contracting independently, each with its own rhythm. This shows that the respiratory center consists of two halves, each more or less complete in itself. Normally, however, they act in harmony, being coordinated through commissural fibers, which cross the median line from one side to the other.

From the fact that certain influences affect especially inspiration and others expiration, it seems logical to assume that the respiratory center is physiologically divided into an inspiratory and an expiratory center, but we cannot separate these anatomically at present.

Subsidiary Centers.—Stimulation of various parts of the brain gives rise to modification of the respiratory movements. This fact has led to a number of structures, among which are parts of the cerebral cortex, the tuber cinereum, the optic thalamus, the pons Varolii, and the anterior and posterior corpora quadrigemina, being dignified with the name of "*subsidiary respiratory centers.*" As will be shown later, a tonic inhibitory influence seems to be exerted on the respiratory center by the posterior corpora quadrigemina, but the other structures named are probably mere stations through which afferent impulses from the various sensory nerves may affect the respiratory center in the medulla. Brown-Séquard, Langendorff, Wertheimer, and others lay great stress on the fact that after separation of the spinal cord from the medulla in young animals a kind of respiration is carried on by the cord alone. It is very different in its character, however, from normal breathing, being "rapid and irregular" (Wertheimer), and in many cases it does not occur at all. One, therefore, feels disposed to look upon these so-called spinal centers for respiration as rather coordinating centers for the respiratory muscles, which usually perform their functions under the control of the respiratory center in the medulla. In some cases they seem to have retained a vestige of their original protoplasmic power of rhythmic activity.

The Influence of the Blood on the Respiratory Center.—If the amount of oxygen in the blood be diminished or the proportion of carbonic oxide become higher, there follows increased activity of the respiratory center. The respirations become deeper and often quicker, constituting the condition known as *hyperpnea.* Small variations in the amount of carbonic oxide have a greater effect than proportionate variations in the amount of oxygen and in ordinary life the augmentation of respiration accompanying muscular work is probably brought about through the stimulation of the respiratory center by the increase of the CO_2 in the blood. If the change in the blood be greater the respiratory movements become still more pronounced and additional muscles are called into play; this condition is known as *dyspnea.* Dyspnea may pass into the condition known as *asphyxia.*

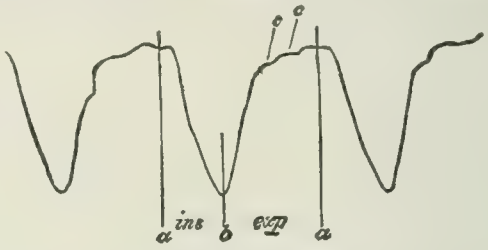


Fig. 4440.—Tracing of Thoracic Respiratory Movements obtained by means of Marey's Pneumograph. (Foster.) A whole respiratory phase is comprised between *a* and *a*; inspiration, during which the lever *descends*, extending from *a* to *b*, and expiration from *b* to *a*. The undulations at *c* are caused by the heart's beat.

The form of asphyxia caused by occlusion of the trachea and deprivation of oxygen is characterized by convulsions, followed by exhaustion and death. In asphyxia due to breathing an atmosphere in which carbonic acid gas is in excess, but where oxygen is not greatly deficient, the animal passes from dyspnea into a state of stupor, and dies without passing through the stage of convulsions. The condition of the blood affects the center directly, and not through the afferent nerves, as is shown by the so-called "cross circulation" experiment. In this experiment the neck vessels of two dogs are joined in such a way that the head of each is supplied from the carotid arteries of the other. The result is that the body of No. 1 and the brain of No. 2 receive the same blood and *vice versa.* If now the respiratory interchange of No. 1 be interfered with, the blood supplying his body will become venous, but his brain will continue to receive arterial blood from the other dog and his breathing will be unaffected. Dog No. 2, however, whose brain receives venous blood, will become dyspneic, although the rest of his body is receiving good arterial blood.

Certain substances, other than carbonic acid, are produced in the muscles during activity, substances which also increase the activity of the respiratory center. It has been shown that various acid substances have this effect, and the unknown substances formed in muscle are probably acid in nature.

The so-called automatic activity of the respiratory center is believed to depend on a stimulus received from the blood, but it is yet undetermined whether the most important factor in this stimulus is a deficiency of oxygen, the presence of carbonic acid, or the action of the acid products of metabolism, although much can be said in favor of the last named.

The Influence of Afferent Nerves.—There is only one of the cranial nerves which has a tonic influence on the respiratory center, as shown by a change in respiration when they are cut. This is the pneumogastric.

On cutting one vagus (pneumogastric) the breathing becomes slightly deeper and slower for a time. Later the effect may pass off and the breathing become normal again. If both vagi are cut, the deepening and slowing of the breathing is more pronounced and the effect is more lasting.

The effects of stimulating the central end of one vagus are differently described by different writers. Nearly all agree that weak stimulation frequently produces shallowing and quickening, so that the breathing becomes more or less like what it was before the nerves were cut. With stronger stimulation various results are obtained according to the way in which the experiment is carried out, being influenced by the employment of anesthetics and to some extent by the kind of stimulus used. This being the case, some writers believe that the pneumogastrics carry impulses which stimulate the respiratory center to increased activity; and others, among whom is the writer, believe that it carries principally inhibitory impulses.

The impulses which normally ascend the vagus, exercising a constant inhibitory influence on the respiratory center, are dependent upon the lung being distended, for Loewy has shown that opening the pleural cavity on one side so as to allow the lung to collapse has exactly the same effect on respiration as cutting the vagus on that side.

By rapidly inflating the lungs with a bellows the breathing may be entirely inhibited, the condition known as *apnea* being produced. The result follows, no matter whether air be used for inflation, or some neutral gas, such as hydrogen. If air be drawn out of the lungs, diminishing their distention, very deep inspirations result. Hering and Breuer, who obtained these results, and also Head, who repeated their experiments, endeavor to explain them on the assumption that there are two kinds of fibers in the vagus, of which one set brought into action by distention of the lung favors expiration, and another set acting when the lung is collapsed favors inspiration. Their results are far more simply explained in the light of Loewy's work, by saying that the moderate distention of the lung normally present causes weak inhibitory impulses to ascend the vagus, which control the respiratory center; increased distention gives rise to stronger impulses, which inhibit it altogether and produce a condition of apnea; while during collapse of the lung the center acts more powerfully in the absence of the usual inhibitory impulses.

In considering the effect of stimulating the fibers of the vagus directly we must remember that besides the respiratory fibers proper we can have passing up the vagus impulses of general sensibility and of pain, and these may cause changes in respiration through the sensorium like any other afferent nerve. The more completely we prevent the animal from feeling pain, the less likely are we to get pain effects and the more certain to see the direct action of the vagus on the respiratory center. If an animal be experimented on without being completely narcotized, artificial stimulation of the vagus may produce almost any imaginable effect on the breathing, either inspiratory spasm (gasp), expiratory spasm (cry), or inhibition. If, on the contrary, the animal be well anesthetized or decerebrated pain effects are eliminated and pure inhibition is nearly always seen, as shown by shallowing and quickening with weak stimulation, passing gradually, as the stimulus is increased in strength, into a state of complete inhibition or standstill in a position intermediate between inspiration and expiration. (See Fig. 4441.)

Even in unnarcotized animals the ascending constant current which stimulates without causing pain has almost always an inhibitory effect.

The other afferent nerves have no tonic action on the center, for cutting any of them does not produce any change in the breathing. In special emergencies any afferent nerve may carry impulses that modify the action of the center. If the nasal mucous membrane (fifth cranial nerve) be stimulated we get a *sneeze*, consisting of a gradual inspiration followed by a sudden spasmodic expiration through the nose. If the *glossopharyngeal* nerve be stimulated, as in swallowing, we get inhibition of respiration, which prevents food being drawn into the larynx. Certain kinds of stimuli applied to the mucous membrane of the pharynx and tonsils cause the complex act of vomiting in which the muscles of respiration play a part. Stimulation of the *laryngeal* nerves causes in some cases mere slowing of the breathing; but if the stimulus be strong, we see inhibition of inspiration and expiratory spasm or cough. Stimulation of the *splanchnics* inhibits respiration. Stimulation of the optic or auditory is said to increase inspiratory activity. Stimulation of other sensory nerves, such as the sciatic, produces in many cases one or more deep inspirations with weak stimulation, and a strong expiration or cry if the stimulation is strong; but the results are by no means uniform.

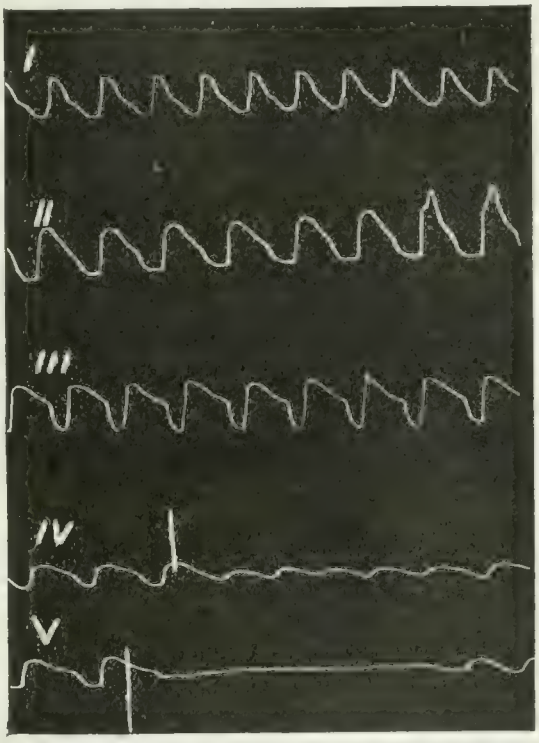


FIG. 4441.—Illustrates the Action of the Vagus on Respiration. Taken by the writer with an apparatus like that shown in Fig. 4439. *I*, Normal breathing of rabbit under ether; *II*, both vagi cut, respiration deeper and slower; *III*, cerebral hemispheres removed also; *IV*, weak stimulation of vagus opposite vertical line showing shallowing and quickening; *V*, stronger stimulation showing complete inhibition. Note: Downstrokes, inspiration; upstrokes, expiration.

The Influence of the Posterior Corpora Quadrigemina.—Removal of the brain in front of the posterior corpora quadrigemina has little effect on the breathing; but separation of these from the medulla has an effect just like bilateral section of the vagi; that is, the respiration becomes deep and slow. If the

vagi be cut as well and the animal has been protected from excessive hemorrhage the respiration becomes still deeper and very infrequent. Usually in this case inspiration and expiration are separated from each other by long pauses. Restoration of the respiration, to about its normal character, may be

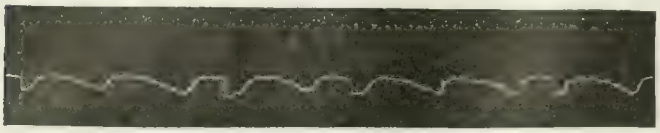


Fig. 4442.—Dog under Ether. Respiration recorded by connecting tracheal cannula with Marey's tambour. Downstroke, inspiration; upstroke, expiration. After one or two normal respirations there is a premature and abrupt inspiration.

effected by a well-chosen stimulus applied either to one of the vagi or to the corpora quadrigemina.

Cheyne-Stokes Breathing.—If the upper part of the medulla itself be injured the breathing is sometimes seen to take on a periodic character; that is to say,

Fig. 4443.—Dog under Ether. Pneumogastrics cut. Cerebral hemispheres removed. Note pairing of respirations.

the respirations occur in groups of three, four, five, or more, of which the first respiration in each group is the deepest (Markwald), and the groups are separated by intervals in which respiration is in abeyance. A similar kind of respiration is seen when a blood extravasation presses on the region of the alæ cinereæ

Fig. 4444.—Dog under Ether. Pneumogastrics cut. Upper end of one nerve stimulated. During stimulation of pneumogastric, respirations arranged themselves in groups of three.

near the respiratory center. These facts are interesting in connection with the so-called Cheyne-Stokes breathing occurring in various diseases of the brain, heart, and kidneys, which bears certain resemblances to this experimentally induced periodic breathing. (See article on *Dyspnea.*)

Fig. 4445.—Rabbit Etherized at 12 noon. Between noon and 2 P.M. four grains of morphine were given hypodermically. About 2.45 P.M. began having convulsions. At 3.15 P.M. the tracing in figure was taken and shows the respirations arranged in groups of four.

Other Forms of Respiratory Arrhythmia.—These have received very little notice but that a number of interesting forms occur the writer is certain. Some years ago the writer carried out a series of experiments on the nervous mechanism of respiration and among the tracings preserved are those shown in Figs. 4442, 4443, 4444, 4445. These tracings show occasional premature inspirations and also examples of the grouping of the respirations in twos, threes, and fours. The parallelism with cardiac extrasystoles is obvious and suggestive.

The Conditions under which the Respiratory Center Acts.—A rational interpretation of all the facts given would seem to be as follows:

1. The respiratory center is situated in the medulla, in the lower part of the floor of the fourth ventricle.

2. It receives a constant stimulus from the blood.

3. Acting alone it would expend all its energy by responding at long intervals with a very great respiratory effort.

4. It receives inhibitory impulses from the posterior corpora quadrigemina, and by the vagi nerves from the lungs which control its action and convert the deep infrequent respiratory acts into the shallower and consequently more frequent ones that we know as normal breathing.

5. In special cases the center may be influenced by impulses reaching it by other nerves.

The efferent nerves are the phrenics to the diaphragm, the intercostals, and the motor nerves to the other muscles of respiration. If the spinal cord be injured above the first dorsal vertebra the intercostal nerves and muscles are cut off from the center and thoracic respiration ceases. If the injury be as high as the fourth or fifth cervical vertebra the phrenic nerves and diaphragm are also cut off from the center and death ensues.

For the effect of breathing air at various pressures and air containing impurities see articles on *Air*, *Aërotherapeutics*, and *Caisson Disease.*

William S. Morrow.

References.—In preparing this article use has been made of the books of Schaefer, Mills, Foster, "American Text-book" (Reichert), Hall, Halliburton, Jeffrey Bell, Böhm and Davidoff, Quain's "Anatomy," Hermann's "Handbook" (Rosenthal), Langendorff's "Physiologische Graphik;" also of numerous journal articles and data from experiments performed by myself. Special acknowledgment must be made of assistance received from two papers by Max Lewandowsky in Du Bois-Reymond's Archives for 1896 on "Die Regulierung der Athmung."

Resuscitation.—The resuscitation of the apparently dead is a procedure in which the practitioner should be proficient and prepared to act promptly

and efficiently. He is generally called to act in public, and in this age of first-aid and amateur ambulance work, the layman is ever ready to criticise the slightest error or uncertainty. Unfortunately it is too often performed in an indefinite and careless manner, or with a hopelessness, as if to appease the popular demand rather than with an expectation of success. There is nothing empirical in the various methods of resuscitation. The many deaths from asphyxia have made it a subject of importance, and, as a result of the various inquiries, artificial respiration has been placed upon a scientific basis. We know exactly where it may be used and what it may accomplish.

The state of asphyxia may be due to a variety of causes, widely different from one another, but which may conveniently be collected into three groups. Those in which the entrance of air to the lungs is prevented, as in drowning, strangulation, choking, and hanging. Cases due to the inhalation of noxious gases, and cases due to paralysis of the nerve centers as in electric shocks, blows and by lightning. In the first group, the ill effects are due to the deprivation of oxygen and the accumulation of carbon dioxide in the system. There is at first a gasping for air which is rapidly overcome by the dulling of the senses and loss of consciousness. A slowing of the circulation, with engorged right heart and lungs and gradual paralysis of the vital centers, first of respiration and later of the heart. In drowning there may be much water in the stomach, but there is not any in the lungs, as it rarely passes beyond the bronchial tubes. The frothy fluid that is present in the vesicles and small tubes is the result of the straining efforts in the early stages and the secretion of fluid from the congested vessels. In the second group of cases there is, in addition to the ordinary carbon dioxide poisoning, the presence of other gases often of a powerful, poisonous character. Illuminating gas is the most common form met with in which the lethal carbon monoxide is abundantly present. This gas has a marked affinity for the hemoglobin, with which it combines firmly and is removed with great difficulty. In exposure to this gas, asphyxia is rapid, and unless quickly removed death is almost inevitable. Convalescence is always slow as even pure oxygen has little influence in renewing the poisoned blood. When chloroform and other anesthetic gases are the cause, an entirely new condition is present, the asphyxia being due to the direct action of the gas on the centers of respiration. There is an absence of carbonic oxide poisoning, and with the renewal of respiration the ill effects are overcome. In electric shock death is due to the direct paralyzing action of electricity on the central nervous system; if sufficiently severe its action is immediately fatal. If the shock is less severe the muscular system is thrown into a state of clonic spasm, which causes defective respiration and asphyxia. Its effect upon the heart is even more serious, giving rise to a state of "fibrillation," which when severe is always fatal.

It follows that a diagnosis of the patient's condition, if not absolutely necessary, is to be desired. Each case presents some points of difference, and much time and effort may be saved if the exact cause is known. That there may be a combination of causes is the point of greatest importance. The apparently drowned person may have received a blow and been rendered unconscious before falling into the water; a slight electric shock may be followed by a fall, with the same result, the effect of the fall being more severe than that of the electricty; with suffocation, whatever its cause, there may be a cerebral hemorrhage; or the subject of heart disease or apoplexy may fall into the water while in a state of unconsciousness. The necessity of distinguishing such complications is evident, more especially if questions of medicolegal interest should follow.

A question that arises and upon which fairly definite views should be held is as to how long a state of asphyxia may continue before actual death takes place or up to what interval of time may artificial respiration be commenced with hope of success? Another question is, when commenced how long should efforts be continued? No precise answer can be given to these questions, as each case has to be considered by itself, but it is generally conceded that when respiration is checked for four minutes, the patient is unconscious, and after a period of eight or ten minutes death has taken place. On the other hand, we know that after longer periods, in many instances, there remains sufficient vitality to restore life. The cause of the asphyxia has a decided bearing on the result. When there has simply been a deprivation of oxygen there is more probability of rescue than if carbon monoxide has been inhaled. There is always a surplus of oxygen in the tissues, which assists in maintaining life, and is more marked in the strong and robust than in the weak and anemic. A further explanation is, that there is a difference between apparent and somatic death. It is to this that resuscitation after long intervals is due, and when such possibilities are plainly recognized all efforts at restoration will be persisted in with energy and hopefulness. The remarkable work of many, notably that of Dr. Alexis Carrel, on the retention of vitality in tissues, and the length of time that the heart will react, demonstrates this most favorably. In nature the prolonged vitality of hibernating animals shows how long life may be retained with a minimum of action, also, the restoration of fishes which have been frozen for many hours. These facts and the many reports of recovery after long periods should encourage efforts to be made for at least one-half hour, the period generally allowed by life-saving bodies. If there is the faintest trace of heart beat or other evidence of life all efforts should be continued for an unlimited period, or for some time after they have ceased. The instructions issued by the National Electric Light Association to their employees requires two hours, without interruption. In most cases it would appear reasonable to give up all hope after one hour of persistent effort.

In all attempts at resuscitation the main object to be attained as early as possible is the restoration of the act of breathing and maintaining this until it can be carried on naturally. The place of first importance must be given to artificial respiration. To promote the alternate expansion and contraction of the lungs in a pure atmosphere is true to nature. It removes impure gases and introduces pure air, it favors the propulsion of blood to and from the heart, and relieves the engorged vessels. All other aids are secondary and must not be allowed to detract from an immediate start of whatever method is selected. The accessory details may be delegated to an assistant. They are also of importance and when promptly performed, add to a successful result. The environment should be made as favorable as possible. There must be an abundance of fresh air, particularly if there has been exposure to poisonous gases. Heat is essential to life and the body heat must be restored by the application of heat, removal of wet clothing, by rubbing and friction to the surface and extremities. Means to induce reflex respiratory effort should be resorted to, cold sprinkling of the face and chest, ammonia to the nostrils, and mustard sinapisms. If oxygen is available it should be provided as early as possible. The nasal passages and mouth must always be cleared of all foreign matter, and the operator should not neglect to favor the escape of water, that may have been drawn into the bronchial tubes, by placing the patient in a prone

position and elevating the body by traction over the stomach.

It was not until the latter half of the last century that there were introduced methods of artificial respiration depending upon the elasticity of the chest walls. Previous to this insufflation of the lungs by means of tubes and bellows was in vogue, with much benefit when properly used, but the injury caused to many lungs and other bad results from carelessness, had turned the profession and the public against their employment and some other means became necessary.

Marshall Hall Method.—In 1856 Dr. Marshall Hall[1] introduced his method and demonstrated the effectiveness of filling and emptying the lungs by what he termed the "Ready Method" as no appliances had to be provided. His investigations and work upon the subject were very thorough and to this day are an authority upon artificial respiration. Hall's method has been supplanted by the Silvester and Schäfer methods owing chiefly to its greater difficulty and the presence of an assistant being almost necessary. It, however, remains an effective and reliable method and may be resorted to with confidence if a variation from other methods is thought desirable. His directions are "Place the patient, with the face downward and one of the arms under the forehead, in which position the tongue will fall forward, leaving the entrance to the wind-pipe free. Turn the body very gently on the side and a little beyond, and then briskly on the face again. Repeat this movement about fifteen times a minute, occasionally varying the side. On each occasion that the body is placed on the face, make uniform and efficient pressure on the back and sides, removing the pressure immediately before turning the body to the side."

Silvester's Method.—Two years later Dr. Henry R. Silvester[2] introduced his method. He claimed that it was simpler and better, as the volume of air

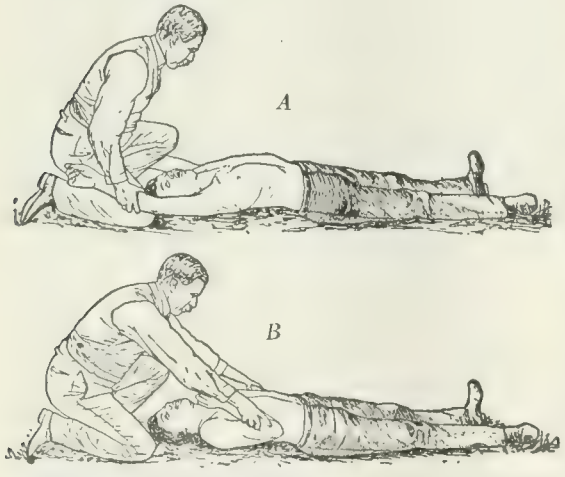


Fig. 4446.—Silvester's Method. *A*, First position, patient's arms extended to allow the entrance of air into the chest. *B*, Second position, patient's arms pressed against the sides of the chest to expel the air.

exchanged was greater. His object was to imitate the action of the respiratory muscles, by raising and lowering the arms at the rate of fifteen times a minute. The patient is placed upon his back and the movements are made slowly and deliberately. The directions are: "Standing at the patient's head, grasp the arms first above the elbows, and draw the arms steadily and gently upward above the head and keep them stretched upward for two seconds. Then turn down the patient's arms and press them gently and firmly against the sides of the chest." These rival methods caused a great deal of controversy. Each had its followers who praised their method and decried the other. The subject attracted so much attention that the Royal Medical and Surgical Society appointed a committee to inquire into the relative merits of the two methods. The work of this committee[3] was very thorough and their report is a valuable contribution to the subject of artificial respiration. The evidence and their conclusions were decidedly in favor of the Silvester method, and this method has continued in vogue to the present time.

Schäfer Method.—Since that time very many other methods have been proposed, nearly all being modifications of these two, but none met with general acceptance until Prof. E. A. Schäfer,[4] of Edinburgh, introduced his method in 1903. Its effectiveness has been proved and it is now recognized as the most satisfactory method we possess. In the prone

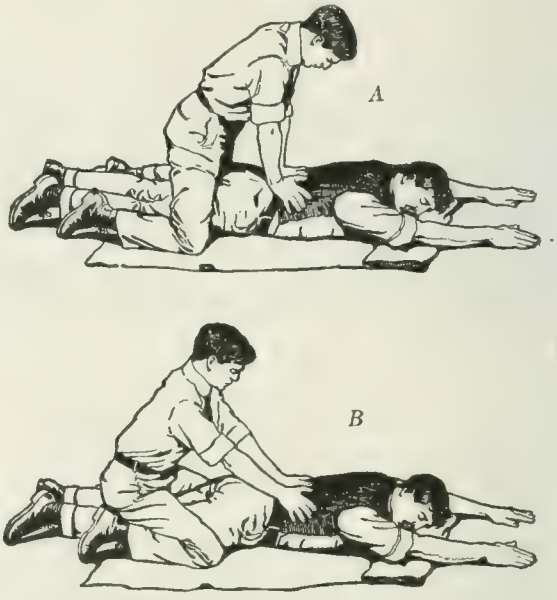


Fig. 4447 Schäfer's Method of Artificial Respiration. *A*, expiration, pressure on; *B*, inspiration, pressure off.

position the air passages are more free, fluids may escape readily and there is no danger of the tongue falling back to obstruct the larynx. It is simple to perform and less fatiguing when required to be persevered in for some time. He directs the patient to be placed in the prone position with a folded coat under the chest and arms extended. The operator kneels over the body with face toward the head, with hands flat over the lower ribs. Alternate pressure and relaxation is then made at the rate of twelve per minute, counting three during pressure and two during relaxation. The pressure expels air and much water if present, while during relaxation the natural elasticity of the walls as they regain their normal position allows of a freer inspiration of fresh air. The tongue should be drawn forward and the mouth cleaned before beginning.

Laborde's Method.—Among the many other methods suggested, one in particular is of much value and deserves special attention, as it introduces a new principle in resuscitation. It is that of Prof. Laborde,[5] presented to the Paris Academy of Medicine in 1892. The object of this method is to induce reflex action on the part of the diaphragm and lungs by traction on the tongue. He traces the im-

pulse through the glossopharyngeal and lingual nerves to the respiratory center, and thence to the phrenic and other respiratory nerves. The mode of applying this method is extremely simple. After the ordinary preliminary measures have been carried out the tongue is held deeply and drawn forcibly forward, about fifteen times to the minute. Two points are to be carefully observed, viz., to grasp the tongue deeply so that the whole organ is acted on and not the tip only, and to draw the tongue sharply and relax it suddenly and completely. As in all methods it must be conducted patiently for some time. During its performance other methods of exciting the reflex action may be attempted. The finger of the other hand may be placed in the pharynx, the mucous surfaces of the nose and fauces may be tickled, or ammonia and other volatile substances may be used. Laborde's method is particularly valuable in resuscitating newly born infants. In them the lungs have not acted, and some excitation is required to awaken the respiratory center. Silvester's and similar measures are not of much service in such cases, as the respiratory muscles are not properly developed, nor can the compression of the chest walls avail, as the lungs have not yet been inflated.

For the asphyxia of new-born infants, dependence must be placed on reflex excitation and insufflation. For the former we have Laborde's rhythmic traction of the tongue, slapping the surface of the body, etc., while at the same time an attempt may be made to compress the chest walls and to carry out Silvester's movements. To inflate the lungs, the most ready method is to breathe directly into the mouth of the child eighteen or twenty times a minute. To insure a proper passage of the air, the larynx is to be pressed upward and back, to close the esophagus, the tongue is to be drawn forward, and the nasal cavities are to be closed. Expiration is aided by pressing upon the chest walls. For insufflation catheters or rubber tubes may be introduced into the larynx, or some of the appliances that have been devised for forcing air into the lungs. If these latter are available they should be used immediately, but while awaiting their arrival the simpler means must be utilized without loss of time.

Schultze's Method.—Several special methods have been proposed for new-born infants as those of Silvester and Schäfer are not satisfactory. That most generally described is by Schultze which may be tried when other methods have not succeeded. The objections to it are, the large space required, and the danger of causing some internal injury by a too forcible flexion of the body. The infant being grasped so that the operator's thumbs rest loosely on the front of its chest, his forefingers enter the axillæ from behind and his fingers are spread over its back, while the head is supported by the hollows of his hands, he, standing a little astraddle and bending a little forward, holds it at arm's length hanging down. Without delay he, swinging his arms upward straight till they have passed the horizontal, flexes the elbows a little, and the momentum carries the child's pelvis and legs gently on and so compresses its abdomen, while the whole weight of its body presses the thorax against the operator's thumbs. The child is then swung downward again, and the pressure against chest wall and diaphragm relieved. It is advantageous to wrap the child loosely in a dry cloth.

Insufflation of the lungs is the most natural way to endeavor to restore suspended life, and was the method attempted from the earliest days of medicine to the middle of the last century, when the Hall and Silvester methods were introduced. It had advanced from the simple breathing into the nostrils, to numerous very serviceable instruments, combining laryngeal tube and bellows for alternately inflating and withdrawing the air in the lungs, the improvements in these instruments being traceable to those employed in sustaining life in animals, during experimental research. At this period opposition, which had been growing for some years, became very manifest and induced Hall to begin his investigations, and on the introduction of his method, the public were struck by its novelty and simplicity and artificial respiration at once replaced the older methods. Insufflation, however, was never discarded. Its importance and possibilities were recognized and continuous changes and improvements have been made in the required instruments. At first there was a difference of opinion as to the value of tracheotomy over the laryngeal tube, also much discussion about breathing into the lung or employing air forced into the lung. Later small conical tubes were made to fit into larynx, which were the forerunner of intubation for diphtheria and croup, and allowed of a new class of instrument to be made. On this continent the first carefully prepared report on instruments for insufflation was presented by Dr. I. R. Fell of Buffalo, at the Pan American Medical Congress at Washington in 1893. Later with the aid of Dr. O'Dwyer of New York, he perfected the Fell-O'Dwyer tube, which is in use in many hospitals at the present day. It consists of a foot bellows, connected by a long flexible rubber tube with the intubation attachment. The latter is of metal, is curved at the laryngeal end at a right angle, and has detachable conical tips, of various sizes to suit different ages, and designed to wedge in the larynx and prevent the escape of air alongside. The extra oral end has two branches, one to receive the tubing and admit the air from the bellows, the other to permit the escape of the air in expiration. The latter is stopped by the thumb of the operator during forced inspiration. This and many similar instruments have been introduced, but the difficulty in applying them properly, and, in some instances, their great expense, have prevented their general adoption. The many fatal accidents that occurred among workers about electric factories and electric light works, caused the National Electric Light Association to look upon the matter seriously, and they appointed a committee of twelve, with representatives from the American Medical Association and the American Institute of Electrical Engineers, to inquire into the methods of resuscitation, and suggest such measures as might lessen the number of deaths. The work of this committee was very thorough and a valuable report was presented in 1913. They reported strongly in favor of the Schäfer method over the Silvester, but found that the exchange of air in artificial methods was not sufficient in many instances and advised "that mechanical devices assuring more efficient respiration than can be assured by manual methods are desirable." The instruments they examined and reported upon were the pulmotor and one devised by one of the members of the committee, Dr. Meltzer.

Pulmotor.—This instrument has been in use for many years and has been supplied to many corporations and hospitals where death is liable and all immediate measures for life-saving should be at hand. It is carried in a box the size of an ordinary suit-case. It consists of a mouth-piece connected with the case by rubber tubing. In the case the appliance works automatically, pumping in and exhausting the air in the lungs. There is also a tank of oxygen which may be connected and replaces the air to the extent of forty per cent. The committee did not report favorably on this instrument. The automatic pump in the early instrument frequently failed to continue its work. The suction force was liable to draw the soft tissues and block the exit, or cause collapse of the walls of the bronchioles. They

concluded that, when there is no respiratory effort, the pulmotor should be used only when regulated by hand. It should not be used longer than five or six minutes, and should be alternated with the Schäfer method.

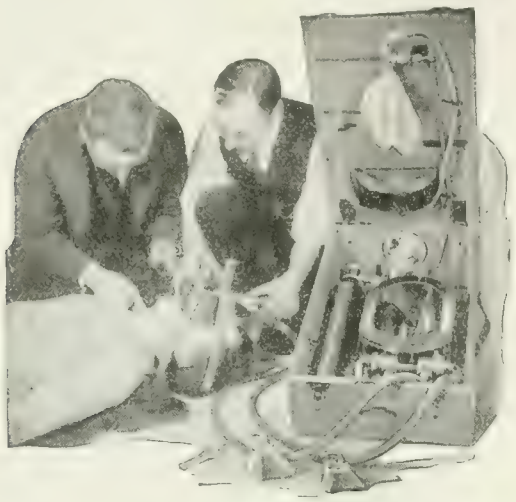


Fig. 4448.—The Pulmotor.

Recently there has been introduced a new design which obviates the objection to the automatic pump by replacing it with one worked by hand. To it is attached a regulating valve which allows of any degree of pressure that is desired. The manufacturers are the Draeger Oxygen Apparatus Co., Pittsburgh, Pa.

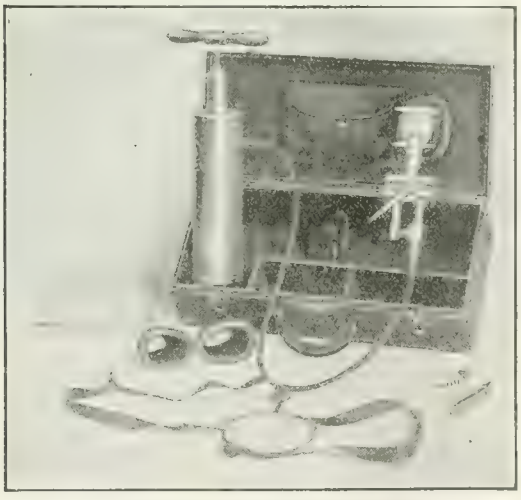


Fig. 4449 The New Model Pulmotor.

Meltzer's Mechanical Method.—This is similar to the pulmotor except in two important points. Instead of the automatic device, the inspiration and expiration are controlled by a foot bellows, and the degree of force may be regulated by a special attachment. The other change is in the mask which also has a tube attached for insertion into the pharynx to prevent the air escaping through the nostrils or into the stomach. The committee reported upon this apparatus as follows: Its positive action is determined by the operator and not left to a mechanism which may fail to operate. It is free from sucking action during expiration. It embodies, in a form which can be used by laymen, a method of artificial respiration which has been employed for many years and is known to be effective and free from danger.

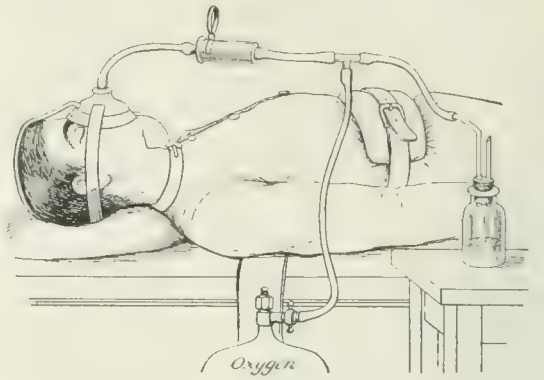


Fig. 4450.—Meltzer's Device for Artificial Respiration. A pharyngeal tube may be used in place of the mask and when air alone is to be used a foot-bellows is substituted for the oxygen tank. Pressure is made upon the abdomen to increase blood pressure and prevent the air from entering the stomach.

Lungmotor.—This instrument is constructed by the Life Saving Devices Company, Chicago, as an improvement upon the Meltzer machine. It is furnished with a hand pump in place of the foot bellows, and its pharyngeal tube is of soft rubber and of a more approved shape. The working is the same as that of the Meltzer apparatus.

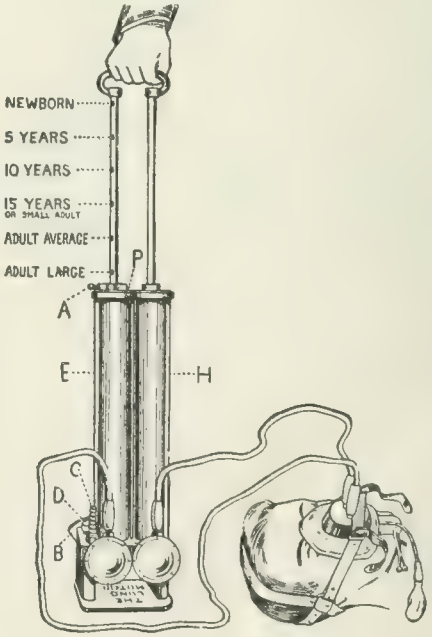


Fig. 4451.—The Lung Motor.

Oxygen is an invaluable adjunct to artificial respiration, and when available, should always be employed. The blood and tissues absorb oxygen readily and retain a surplus amount, which remains in reserve. Experimental work has shown that when it is absorbed, carbon dioxide may be present without ill effect, in percentages that otherwise would be poisonous. When the hemoglobin has absorbed carbon oxides, especially the monoxide, the air

inhaled has practically no effect on the blood, but a supply of oxygen gradually restores the blood to a healthier condition. It is particularly valuable in asphyxia due to the inhalation of illuminating and other poisonous gases. Oxygen also lessens the acidity of the blood that arises during asphyxia and minimizes the danger of acidosis. It may be administered subcutaneously. As much as one pint may be injected into the soft tissues causing a swelling as large as a foot-ball. This is rapidly absorbed and aids the inhalations.

Electricity.—Very little is definitely known as to the value of electricity in asphyxia. It would require to be used with caution, as a fibrillation of the heart might be present and the condition be aggravated. Faradization has been proposed as a means of contracting the diaphragm, as an aid to other efforts to inflate the lungs. One electrode is placed over the right phrenic nerve, just astride the carotid artery, while the other is placed over the lower ribs. The left side is avoided in order not to interfere with the heart's action. When used with artificial respiration the current should be applied regularly during the elevation of the arms, and cut off as soon as the arms begin to descend. The abdominal electrode should not be placed too low for fear of contracting the abdominal muscles instead of the diaphragm.

Bleeding and subcutaneous and intravenous injections of saline solution with or without adrenalin, have been advised as valuable aids where there is evidence of slight action of the heart, to stimulate its action and favor the return of circulation.

In all attempts at resuscitation it is quite evident that one method must not be followed to the exclusion of others. No one of them precludes the employment of others, but rather there is every reason to expect a greater benefit from their combined or alternate use. The only precaution required is that they should be carefully and regularly conducted, and that the various efforts to promote inspiration and expiration should coincide. Beaumont Small.

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Retina, Diseases of.—The retina is seldom affected by disease which is limited to itself alone, or even to the eye alone, but most often lesions of the retina are part of a general disease and are frequently of assistance in the diagnosis of the latter. The diseases most apt to produce serious retinal complications are, diseases of the kidneys, syphilis, diabetes, septicemia, and leukemia. Among ocular affections choroiditis and optic neuritis almost always lead to retinal changes, the former because of the close anatomical relationship of the choroid and retina, and the latter on account of the interference of the retinal blood supply produced by the swelling of the disc. Both choroiditis and optic neuritis, however, are usually in turn dependent upon some general disease.

Vascular Disturbances of the Retina. *Pulsation of the retinal veins* on the disc is frequently seen under normal conditions, and can readily be produced by a slight pressure of the finger upon the eye. It is particularly associated with increased intraocular tension from any cause. According to Donders it is due to the changes in arterial tension being communicated to the veins through the vitreous humor. True transmitted venous pulsation has been seen in valvular heart disease, arteriosclerosis, and anemia, but never under normal conditions.

Pulsation of the retinal arteries is always pathological, and indicates either an increase in intraocular tension or decrease in the arterial pressure. It may occur in glaucoma, anemia, syncope, senile arteriosclerosis, aneurysm of the arch of the aorta, aortic insufficiency, and Basedow's disease. It may also result from compression of the central artery by tumors of the nerve or orbit.

Hyperemia of the retina may be either arterial or venous in nature. The general redness of the fundus depends to such a great extent upon the degree of pigmentation of the choroid, and the tortuosity of the vessels varies so much under normal conditions, that it is impossible to diagnose retinal hyperemia unless the disc is also reddened. *Arterial hyperemia* manifests itself by distention and tortuosity of the arteries which sometimes lie in anteroposterior planes so that they project toward the observer. It is common in meningitis, and may be noted in Basedow's disease, plethora, and neurasthenia. Strangely enough, it may result from excessive loss of blood or from chlorosis, and in the former case it may be so intense as to give rise to retinal hemorrhages. *Venous hyperemia* is characterized by dilatation and tortuosity of the veins, which appear darker than normal, and is always associated with hyperemia of the disc. It is not infrequently accompanied by retinal hemorrhages. The arteries may show no change, or they may be narrowed owing to the same obstruction which is producing stasis in the veins. In general, venous hyperemia is due to some hindrance to the outflow of venous blood from the eye, as, for instance, to compression of the central vein in optic neuritis or glaucoma. Sometimes the obstruction lies in the orbit, as in cases of tenonitis, orbital tumor, and orbital cellulitis, or even in the cranial cavity, as in intracranial tumors, thrombosis of the cavernous sinus, and meningitis. Rarely it is a part of a general venous stasis due to valvular heart disease. A few cases of particularly exaggerated venous congestion have been seen associated with congenital heart disease, the condition then being spoken of as *cyanosis retinæ*.

Obstruction of the central retinal vein produces the ophthalmoscopic picture known as *hemorrhagic retinitis* or *retinal apoplexy*. The veins are engorged and tortuous and the retina covered with hemorrhages. The disc is never swollen, but is hyperemic and its outline is somewhat blurred owing to the edema of the surrounding retina. The veins on the disc cannot be emptied by pressure on the eye. The condition is generally supposed to be due to thrombosis of the central vein, but the researches of the writer prove conclusively that it is almost invariably due to obliterative endophlebitis. The obstruction is almost always within or just behind the lamina cribrosa. It occurs in individuals affected with general angiosclerosis, and hence most often between the ages of sixty to seventy. Both eyes are almost never affected at the same time, but occasionally the second eye becomes affected several years afterward. The obstruction comes on suddenly, without prodromal symptoms, and though vision is at once much diminished, complete blindness is not produced until later. Evidently a very small lumen in the central vein suffices to maintain the retinal function until the final stoppage takes place. In some cases only a branch of the central vein is involved, at least at first, the disturbance then being confined to a limited portion of the retina. The intraocular pressure is not increased at once, but a large percentage of these cases ultimately develop glaucoma, the *hemorrhagic glaucoma* of von Graefe, within three weeks to two months after the obstruction of the vein. This

type of glaucoma is not usually amenable to treatment and the pain is so great that removal of the eye is generally necessary. The prognosis in regard to life in cases of obstruction of the central vein is better than might be expected. Nephritis is not often a prominent complication, and many of the patients live for years. This may be due to the fact that the general vascular disease affects chiefly the veins also in the other organs of the body (Plate L, Fig. 1).

Thrombosis of the central retinal vein, although, as just stated, not the usual cause of obstruction of this vessel, does undoubtedly occur in exceptional cases, but only as a result of sepsis. The writer recently saw such a case due to chronic streptococcus infection, the organisms being recovered from the blood. The source of the infection was an unsuspected sinusitis of the ethmoid cells. There had been recurring attacks of iritis and thrombophlebitis of the lower extremities for five years. Clinical cases of thrombosis of the central vein due to influenza have also been described.

Anemia of the Retina.—All degrees of this occur up to the complete cessation of the retinal circulation. Incomplete retinal anemia may be either chronic or acute; in the former case it is usually dependent upon chronic general anemia, either primary or secondary, and is not associated with any disturbance of vision, while in the latter it most often results from excessive loss of blood and frequently produces permanent blindness. It is rather remarkable that instead of anemia, loss of blood may give rise to retinal hyperemia and hemorrhages. Incomplete retinal anemia is also an accompaniment and no doubt often the cause of retinal atrophy, and is constantly seen as the result of optic atrophy. Ophthalmoscopic examination in incomplete anemia shows constricted arteries, dark veins, pallor of the disc, and sometimes arterial pulsation. As a matter of fact, however, unless the changes are quite marked, the condition is apt to be overlooked.

Ischemia, or complete anemia of the retina, is usually due to obstruction of the central artery, and may be the result of endarteritis, embolism, primary thrombosis, spasm of the muscle walls of the artery, hemorrhage into the optic sheath, direct injury to the artery within the nerve, or to pressure exerted upon the artery by a neoplasm.

Obstruction of the central retinal artery is most commonly due to obliterative endarteritis, although embolism is the diagnosis almost always made. Even in cases examined anatomically this mistake has undoubtedly often been made, due to the fact that the tissue filling the lumen may degenerate so that its real nature is not easily determined. Obliterative endarteritis usually occurs in elderly persons having general arteriosclerosis. The retinal vessels of the affected as well as of the unaffected eye are, as a rule, highly sclerotic. Often there are prodromal attacks of obscuration of vision. These are possibly due to spasm of the diseased vessel, but more likely to temporary reductions in the general blood pressure diminishing the blood flow through the narrowed lumen. When the obstruction becomes complete, sudden blindness ensues (Plate L, Fig. 2).

Embolism of the Central Retinal Artery.—This usually occurs in younger persons having old or recent endocarditis or other evident sources for emboli. It is said to occur more frequently in the left eye. Blindness comes on suddenly, usually without prodromal symptoms. The embolus may be carried to a branch of the central artery, the anemia then involving only a portion of the retina. If the embolus is infected, suppurative panophthalmitis usually results.

Thrombosis of the central retinal artery, if it occurs at all, is certainly rare. *Hemorrhage into the sheath of the optic nerve* has never been demonstrated by an anatomical examination to be a primary cause of obstruction in the central artery, but it occurs as a result of trauma to the eye or from a hemorrhage at the base of the brain.

Spasm of the Muscle Walls of the Central Artery.—In migraine attacks of temporary blindness not infrequently occur, and naturally enough have been attributed to spasm of the central artery. The visual symptoms usually associated with migraine, however, are probably central in origin. Wagenmann observed one of these attacks ophthalmoscopically, and saw the retina become markedly anemic and then return to its normal condition within an interval of about ten minutes. Six months later a similar attack occurred in this case, and resulted in permanent blindness with the ophthalmoscopic picture ordinarily considered characteristic of embolism. The condition may occur also unassociated with definite migraine.

Quinine Amblyopia.—Quinine in large doses may also cause constriction of the retinal arteries, which may be seen with the ophthalmoscope. There is great impairment of vision together with contraction of the visual field. In some cases there is complete blindness, and a cherry-red spot has even been seen in the macula. Central vision is ultimately recovered, sometimes, however, only after many months, but the peripheral field is apt to remain contracted. Parsons holds that the retinal anemia is due to the withdrawal of blood to the abdominal veins. Other drugs acting similarly to quinine are salicylic acid, filix mas, oil of wintergreen, cocaine, ergot, acetanilide, adrenalin, nitrobenzol, and chlorate of potassium.

In ischemia of the retina, no matter what the cause of the shutting off of the blood supply, the changes produced are always much the same. The disc is pale; the arteries are so much reduced in caliber that they can be followed only for a short distance, and interrupted columns of blood may be seen in them. If the case is seen early, a to-and-fro motion of the blood may be observed, such as is seen in the vessels of a frog's web when the circulation is beginning to stop. The veins are also contracted, but to a much less degree, and pulsation may still be brought out in them by pressure on the globe. The retina soon becomes opaque, first near the vessels, the opacity being most marked around the macular region. But the most striking as well as the most characteristic feature of retinal ischemia is a cherry-red spot about one-third the diameter of the disc, which makes its appearance in the center of the macula. This spot is not invariably present, however. The explanation usually given for its occurrence, which was first offered by von Graefe, is that it is due to the dark choroid showing through the thin fovea, the general white opacity of the rest of the surrounding retina, rendering it unduly conspicuous. A later theory is that the spot is due to a hemorrhage, but in the vast majority of cases the explanation of von Graefe undoubtedly holds true. In exceptional cases, however, the appearance of the spot suggests a hemorrhage, and the following observation proves that a localized hemorrhage in the macula can result from complete obstruction of the central artery. There was enucleated and submitted to the writer for examination on old glaucomatous eye upon which an opticociliary neurotomy had been performed ten days previously, the optic nerve and with it the artery and vein being severed close to the globe. On macroscopic examination there presented itself a sharply defined red spot in the center of the macula, and on microscopic examination this proved to be a hemorrhage, the only one in the retina. The retina was almost completely necrotic, and there were marked proliferation and migration of the cells of the pigment layer. The source of the hemorrhage was no doubt the cilioretinal vessels.

In a number of cases of arterial obstruction, due to endarteritis or embolism, the circulation after a time has been seen to return. This has possibly been due to the breaking up of an embolus, or more likely to

EXPLANATION OF

PLATE L.

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Fig. 1.—Hemorrhagic Retinitis, due to obstruction of the central retinal vein. (From Noyes: "Diseases of the Eye," Wood's Library of Standard Authors, 1881.)

Fig. 2.—Ischemia of the Retina, due to obstruction of the central retinal artery. (From Noyes: *Op. cit.*)

Fig. 3.—Commotio Retinæ. (From Noyes: *Op. cit.*)

Fig. 4.—Albuminuric Retinitis. (From Noyes: "Diseases of the Eye," 1890.)

Fig. 5.—Albuminuric Retinitis at an Advanced Stage. (From Stellwag's "Diseases of the Eye," Translation of Hackley and Roosa, 1868.)

Fig. 6.—Separation of the Retina. (From Stellwag.)

Diseases of the Retina.

the establishment of a collateral circulation through the cilio-retinal vessels or circle of Zinn. Sometimes the direction of the circulation is reversed. The return of the circulation gives rise to numerous hemorrhages, most of them in the macular region, and no doubt due to the injury to the vessels produced by the cessation of the flow of blood. The final picture is that of atrophy of the retina and optic nerve.

As a result of ischemia of the retina, vision is almost instantaneously lost. Occasionally a part of the visual field may remain intact for a while, but later it also becomes blind. It is said that in some instances the macula is sufficiently well nourished by the cilio-retinal vessels to prevent impairment of central vision. If the circulation returns quickly, as in migraine, vision is completely restored, but in total embolism it is almost always permanently destroyed. In rare cases glaucoma later ensues.

Treatment of Retinal Anemia.—If the anemia is very marked, lowering the head at intervals during the day may be practised. The acute retinal anemia resulting from excessive loss of blood should be combated by saline infusions and general supportive treatment. Inhalations of amyl nitrite are of value in spasm of the central artery. In embolism, paracentesis of the cornea, iridectomy, and massage of the cornea with the purpose of dislodging the embolus, have been recommended.

Retinal Hemorrhages.—Aside from trauma, which is of course a frequent cause, hemorrhages into the retina may occur as the result of a general disease, less commonly as the result of disease confined to the eye alone. The recurring retinal hemorrhages of young people are probably due to tuberculosis (see below). As already noted, retinal hemorrhages are especially abundant after obstruction of the central vein from any cause, and the intense hyperemia resulting from suffocation is also likely to produce them. Their occurrence as an after-effect of embolism has already been referred to. The retinal hemorrhages that occur as the result of general disease are dependent either upon alterations in the retinal vessels, associated in most cases also with high arterial pressure, or upon changes in the character of the blood itself. Thus they are seen with comparative frequency in general arteriosclerosis, Bright's disease, gout, diabetes, anemia, leukemia, purpura, and scurvy. When such predisposing factors are present the immediate cause is often violent exertion, such as coughing or straining at stool. Retinal hemorrhages also occur as the result of menstrual disturbances, sometimes apparently as one of the manifestations of vicarious menstruation. They frequently occur in new-born infants as the result of excessive pressure on the head during delivery, but they are quickly absorbed without leaving any macroscopic changes. In this way no doubt many obscure cases of congenital amblyopia are produced. Among other general causes may be mentioned poisons, especially lead and phosphorus, jaundice, pregnancy and parturition, malarial fever, septicemia, and pyemia.

Retinal hemorrhages vary greatly in regard to size, shape, number, and position. When few in number they are usually situated not far from the disc or near the macula. They occur in any of the retinal layers that contain blood-vessels, but most frequently in the nerve fiber layer where they assume a characteristic striated "flame-like" shape. Owing to the radial arrangement of the fibers around the disc, hemorrhages in its neighborhood tend to take the form of red radii. The extravasations of blood may break through the retina into the vitreous humor producing vitreous opacities, or they may force their way between the retina and choroid. Sometimes the blood collects beneath the hyaloid membrane, forming the *subhyaloid hemorrhage*. This most frequently occurs in the macular region, appearing as a sharply defined dark red disc. When recent, retinal hemorrhages are bright red in color, but they soon become darker, often almost black. The blood is absorbed rapidly, especially when the hemorrhage is small, but white spots in many cases are left to mark their sites. The white spots are due to necrosis and may contain fat globules and cholesterin crystals. They may finally disappear or they may remain permanently, not infrequently becoming more or less pigmented, owing to the migration of cells of the pigment layer into them. It is believed that the pigment striæ, known from their resemblance to obliterated vessels as *angioid streaks in the retina*, are due to metamorphosis of capillary retinal hemorrhages.

The disturbance of vision produced by retinal hemorrhages obviously depends upon their size and position, and of course is particularly great when one of the hemorrhages occupies the macula. Sometimes there is metamorphopsia, less often photopsia. Even small hemorrhages may produce a temporary clouding of vision if they break through the retina into the vitreous humor. The prognosis is favorable when they are small and the tendency to relapses can be successfully overcome. The subhyaloid hemorrhages which occur at the macula are usually absorbed and vision is completely restored. When the hemorrhages are dependent upon a general disease the treatment must necessarily be directed chiefly toward the latter. The application of cool compresses to the eyes, the administration of mercurial inunctions or potassium iodide to favor the absorption of the effused blood, leeching, purging, and the production of diaphoresis by pilocarpine have all been advised, but are probably valueless.

Phlebectasia retinæ is a name given to a rare condition in which the retinal veins show dilatations and constrictions, sometimes producing a decided beaded appearance. In some cases it is probably due to vasomotor disturbances. Schöbl describes a case in which the condition was also present in the conjunctival veins and was evidently dependent upon suppression of the menses, the phenomenon disappearing when the menstrual flow was reëstablished.

Retinal aneurysms are of very rare occurrence, but they have been seen in the living subject and also in enucleated eyes. Most frequently they are multiple, miliary in size, and situated on the smaller retinal arteries; but sometimes a single large aneurysm may form on one of the large arteries. An arterio-venous aneurysm has been known to occur as the result of an injury. Treatment is of no avail.

Von Hippel's Disease, Angiogliomatosis Retinæ.—In this unusual disease the retina contains areas consisting of proliferating capillaries and neuroglia. Ophthalmoscopically the areas appear as round or fusiform reddish spots which vary in size up to three disc diameters. They occur along distended and tortuous retinal vessels, and may be associated with old or recent hemorrhages. The disease begins in early life, is apt to be bilateral, and ultimately leads to complete blindness.

Sclerosis of the retinal vessels probably always occurs where there is general arteriosclerosis, but the alterations in the retinal vessels may not be sufficiently obvious to attract attention on ophthalmoscopic examination. Both the veins and the arteries may show white borders, tortuosity, and sometimes constrictions and spindle-shaped thickenings. The light streaks in the centers of the arteries are abnormally bright, and the veins are apt to be markedly constricted at the points where they are crossed by arteries. In marked cases the arteries may appear as thin white threads, "silver wire arteries." Often, however, the first evidence of disease of the retinal vessels is the occurrence of retinal hemorrhages. An important cause of sclerosis of the retinal arteries is syphilis. Vision is unaffected for a long time.

Retinitis.—This term strictly should signify inflammation of the retina, but as a matter of fact most

of the retinal conditions to which it is applied are not of an inflammatory nature, but are due either to degenerative or to atrophic changes, or they are dependent upon edema and hemorrhage. When retinitis occurs in association with neuritis the condition is spoken of as neuroretinitis. In not a few cases retinitis is secondary to optic neuritis, the swelling of the disc interfering to such an extent with the venous outgo as to lead to edema and hemorrhage. The chief varieties of retinitis are as follows:

Suppurative Retinitis.—This most commonly occurs as the result of penetrating wounds of the globe or following operations, particularly those for the removal of cataracts, and almost always results in or forms a part of a general panophthalmitis. It is usually due to microorganisms which have been introduced into the eye, most often to pneumococci, but a comparatively mild form of it can be produced by chemical irritation due to the disintegration of a foreign body, especially if the latter contains copper. The condition may also be metastatic in origin, particularly in puerperal septicemia and in the acute infectious diseases of children. In these metastatic cases the inflammation may be confined throughout to the vitreous chamber, and thus, in children, it may result in one of the conditions which gives the clinical picture known as *pseudo-glioma*. Contrary to what has been generally believed, in panophthalmitis it is the retina, not the choroid, from which the purulent exudation mainly arises. The choroid seems to play the part of an abscess wall, and is congested, more or less edematous, and infiltrated with lymphoid and plasma cells. In the cases diagnosed clinically as metastatic choroiditis the condition is usually that of metastatic retinitis. If seen sufficiently early, the retina in these cases is found to be hazy and covered with hemorrhages, but the vitreous humor soon becomes so cloudy that the later stages of the process cannot be followed. Suppurative retinitis from any cause may pursue either an acute or a chronic course, and ultimately results in phthisis bulbi. The treatment is that suitable for panophthalmitis, and is of little avail.

Retinitis Septica (Roth).—In pyemia and septicemia the retina frequently shows hemorrhages and white spots not unlike those seen in albuminuric retinitis. There are no signs of active inflammation and no pain. Vision is not much affected and the prognosis is favorable so far as the eye is concerned. Roth believed the condition was not due to the presence of microorganisms in the retina, but to toxic substances circulating in the blood produced by the septic processes elsewhere. Recent observations go to show that the hemorrhages are due to the lodgment of septic emboli in the retinal vessels in spite of the mild course pursued by the affection.

Retinitis Simplex, Serous Retinitis, Retinal Edema.—Under certain conditions not understood, the retina becomes hyperemic and shows a haziness evidently due to edema, which either may be diffuse or may occur in circumscribed patches. Vision may be considerably reduced and there may be megalopsia, micropsia, and metamorphopsia. Under complete rest the condition entirely disappears. A special variety known as *commotio retinæ* is due to a blow upon the eye. This also clears up, usually in about three days, with complete restoration of vision. (Plate L, Fig. 3.)

Albuminuric Retinitis.—In some cases of Bright's disease the retina shows changes which are met with under almost no other conditions, and which therefore may be regarded as practically characteristic of renal disease. Such plainly marked cases of albuminuric retinitis, as they are named, occur in only about seven per cent. of patients suffering from Bright's disease. On the other hand, if carefully searched for, less characteristic retinal changes—such, for instance, as alterations in the vessels and hemorrhages—will be found sooner or later in probably one-fourth of these patients. Typical albuminuric retinitis may occur in any form of renal disease, whether acute or chronic, but it is met with by far the most frequently in chronic interstitial nephritis and least often in amyloid disease of the kidneys. While the retinal affection appears only in cases of renal disease which have lasted some time, yet not infrequently it is by means of the ophthalmoscope that the serious condition of the kidneys is first discovered. The most characteristic feature of the affection is the presence of a "star-shaped figure in the macula," consisting of a greater or less number of white striæ which radiate from the center of the macula, frequently, however, without completely encircling it. The fovea is usually not involved and stands out as a clear red spot. Other changes almost always present are hemorrhages, edema, and irregular white patches of various sizes. The latter have ill-defined edges and are situated in the inner layers of the retina, often obscuring the vessels that cross them. In early cases, sclerosis of the retinal vessels may not be noticeable; in advanced cases it usually reaches an extreme degree. Optic neuritis is commonly present, though not at the outset, and in some cases is the most prominent feature. In other cases hemorrhages predominate, while in still others the most striking change is that due to edema. The condition is rarely limited to one eye, though the appearances may be quite different in the two eyes. Thus in one eye the principal change may consist in the star-shaped figure about the macula, while in the other this may be absent and the retina covered with hemorrhages. If at any time there has been severe optic neuritis the retina and optic nerve ultimately undergo atrophy. Rarely the retina shows folds or even complete separation, the latter most often in the albuminuria of pregnancy. (Plate L, Figs. 4 and 5.)

The retinal condition most likely to be mistaken for albuminuric retinitis is that which results from a high grade of optic neuritis, especially that associated with brain tumor. In this the star-shaped figure may be present in a perfectly typical form. In such cases, however, sight is almost always lost, whereas in albuminuric retinitis complete loss of vision rarely occurs. It should be remembered, too, that a high grade of optic neuritis does not occur in Bright's disease except in advanced cases in which the diagnosis is plain. Finally, renal disease could be excluded in most cases by a microscopic examination of the urine. In lead poisoning, too, the retina may present appearances identical with those seen in albuminuric retinitis (*saturnine retinitis*), but it is not certain that they are not due in reality to kidney lesions produced by the lead.

Anatomically the most striking changes found in albuminuric retinitis are general edema and localized infiltrations of the layer of Henley with serum, fibrin, and hyaline material. There is little doubt that it is to the fibrin and hyaline that the ophthalmoscopic picture is chiefly due. The serum often extends between the rods and cones and pigment epithelium, producing localized flat separations of the retina. In the nerve-fiber layer, so-called varicose nerve fibers frequently occur. Proliferation and migration of the cells of the pigment epithelium occur in the later stages. Hemorrhages in various stages of disintegration are usually seen. Formerly, it was supposed that the white spots were due to fat, but it is now known that fat is not deposited in sufficient quantity to account for them. Recent observers, however, have found that lipoids, similar to those in the kidneys, occur in small quantities in the retina. The star-shaped figure is said to owe its form to the radial arrangement of the fibers of Henley about the macula, but it seems to the writer more likely that its form is determined by the radial arrangement of the vessels in the region. The cause of the retinal changes is not definitely known. They have been attributed to changes in the

retinal vessels, but as a matter of fact may occur while the vessels are apparently normal. A more probable suggestion is that they are due to the altered condition of the blood. Cushing and Bordley have advanced the view that they are due to a low-grade but long-continued edema of the retina resulting from increased intracranial pressure. Their evidence, however, is not perfectly conclusive. The optic neuritis that occurs in the later stages is almost without doubt due to increased intracranial pressure.

The disturbance of vision usually is slight when compared to the extensive retinal changes, and in the milder forms vision may be entirely unaffected. The fact that the fovea centralis is but seldom affected accounts for the almost constant preservation of central vision. Complete blindness is rare, and when it occurs it is usually the result of secondary atrophy of the optic nerve and retina or is due to separation of the latter. It should be remembered, however, that in Bright's disease, whether or not there is retinitis, attacks of blindness, *uremic amaurosis*, may come on within a few hours as the result of uremic poisoning, though they are more common in acute nephritis than in the chronic forms of renal disease. Here the blindness in all probability is due to the action of the uremic poison upon the brain itself, the pupils in most cases still reacting to light. It is associated with other uremic symptoms and disappears when the uremia is overcome.

The prognosis of albuminuric retinitis depends chiefly upon that of the renal disease, and since the retinal affection occurs only in advanced stages of the latter, it is almost always bad. Conversely, the prognosis of the renal disease, and hence the prognosis in regard to life, is particularly bad when albuminuric retinitis has made its appearance. The prognosis in regard to sight is of little importance, because the patients seldom live long enough for the visual disturbance to become of serious moment, death usually occurring well within a year, rarely later than two years, after the discovery of the retinal disorder. The nephritis associated with pregnancy is an important exception to this rule, complete recovery being of frequent occurrence after it. Recovery also sometimes follows the nephritis which accompanies the acute infectious diseases. In these cases the retinal disease ceases to progress, and many of the retinal alterations disappear. The star figure at the macula, however, seldom entirely disappears.

Aside from the measures usually employed in severe cases of nephritis there is no treatment that will benefit the retinal disease in any way. It sometimes happens, however, that the retinitis may undergo decided improvement under treatment directed toward the kidneys and yet death ensue in the usual short time. In the albuminuric retinitis of pregnancy, especially if it appears early, the induction of abortion is advisable.

Diabetic Retinitis, Glycosuric Retinitis.—This affection is certainly rare, though just how rare is not definitely known. It is a late manifestation of the general disease, and according to Hirschberg it is always present in diabetes which has existed for twelve years. In some instances the retinal changes are no doubt due, in part at least, to an accompanying interstitial nephritis; but there is no question that in typical cases they differ decidedly from those seen in typical albuminuric retinitis. The affection is probably confined to diabetes mellitus cases claimed to have been due to diabetes insipidus may have been due to brain tumor.

In the form of retinitis most characteristic of diabetes, *central punctate retinitis of Hirschberg*, the retina shows great numbers of small bright shining spots, sometimes irregular in shape, which are most numerous near the disc and in the macular region, without, however, having a stellate arrangement. Scattered more generally over the fundus there are many punctate hemorrhages. Neither the retina nor the disc shows evidences of edema, and the retinal vessels are apparently normal. Larger white spots are also occasionally seen. Sometimes in diabetes the white spots are entirely absent and the retina shows only various kinds of hemorrhages. This condition is the *hemorrhagic diabetic retinitis* of Hirschberg. In diabetic albuminuric retinitis the changes characteristic of nephritis are associated with those of diabetic retinitis. Albuminuric retinitis may also occur alone in diabetic patients. In the *lipemia retinalis* of young diabetics, the color of the retinal vessels may be markedly altered due to the fatty condition of the blood.

Diabetic retinitis is always sooner or later binocular. Vision is apt to be considerably impaired, especially central vision, and there may be contraction of the peripheral field. It is difficult to say in a given case, however, whether or not the disturbance of vision is due to the retinal changes, since amblyopia is common in diabetes due to retro-bulbar neuritis or optic atrophy. In some cases the disturbance of vision is very slight. Not infrequently vitreous opacities due to hemorrhages occur and may produce total blindness, and glaucoma secondary to hemorrhage is also met with. Total blindness, however, is rare in diabetic retinitis. The prognosis of the retinal affection is bad, the latter seldom showing improvement under treatment, and occurring as it does in the later stages of the general disease, diabetic retinitis is of evil significance in regard to the duration of life. This is particularly true of the hemorrhagic form, since a tendency toward hemorrhage on the part of the cerebral vessels is indicated. The treatment is that suitable for the general disease.

Leukemic Retinitis.—In all severe cases of leukemia the retina presents an abnormal appearance, but actual retinitis is relatively uncommon. The fundus is apt to appear light yellow in color owing to the altered color of the blood in the choroidal vessels, but where the choroid is highly pigmented this may not be noted. The arteries are pale and sometimes small; the veins are dilated, frequently tortuous, and their walls may appear thickened owing to infiltration with white cells. Retinal hemorrhages are extremely common, in fact, they are the most constant ocular lesion met with in leukemia. In addition to these changes other lesions sufficiently marked to warrant the name of retinitis sometimes occur. These are confined almost entirely to the spleno-myelogenous type of leukemia, and consist of haziness of the retina and the presence of white spots with red borders. The latter are most numerous at the periphery and in the macular region, and are due to collections of white cells in the centers of hemorrhages. Though not often seen, they are highly characteristic of leukemia. Other white spots, due to degeneration, also occur. The disc may be practically unaffected, or it may be greatly swollen owing to edema and to infiltration with cells. Both eyes are almost always affected, though in different degrees. The impairment of vision depends upon the position and number of the white patches and hemorrhages; a hemorrhage in the macular region will of course cause loss of central vision. This may be of the subhyaloid variety, however, and afterward clear up. A large hemorrhage into the vitreous humor may cause permanent loss of sight and in some cases glaucoma. Albuminuric retinitis may occur as a complication. The prognosis is hopeless as regards both the general and the local affection.

Tuberculous Retinitis.—As in the case of the brain, the retina is remarkably resistant to tuberculosis. Only three cases of miliary tuberculosis, and no cases of large solitary tubercle or extensive retinal tuberculosis of any kind are known. In rare cases the retina has been secondarily affected by extension from a process in the uvea or optic disc. In 1909,

Axenfeld and Stock suggested on clinical grounds that the recurring retinal hemorrhages of young people were due to tuberculosis. In some of these cases, there occur in addition to the hemorrhages, small round gray spots along or near the veins. The condition has been termed by Igersheimer *periphlebitis retinalis adolescentium*. Fleischer, in 1914, examined anatomically an eye showing this retinal condition, and found that the white spots were small tubercles. There was also tuberculosis of the anterior part of the eye involving particularly the iris and filtration angle. He concluded that the retinal condition was not due to direct blood metastases, but that the infection spread from the anterior part of the eye by way of the perivascular lymph spaces of the retina. He assumed that in other cases this anterior tuberculosis was present but was not obvious clinically. If this view is correct, it harmonizes with the writer's contention that chronic ocular tuberculosis is due to bacilli secreted into the aqueous humor from the ciliary body. Although in these cases of retinal tuberculosis there must obviously be a tuberculous focus elsewhere in the body, it is never of a fatal type.

Retinitis with Massive Exudation (Coats).—This is a rare disease, occurring in young people otherwise apparently normal, that is probably primarily hemorrhagic in nature. Possibly it is an exaggerated form of tuberculous periphlebitis retinalis just described. It is characterized by the presence in the retina of large white or yellowish masses, often associated with hemorrhages and cholesterine crystals. Frequently the eye is finally lost from secondary glaucoma. Microscopic examinations that have been made show that the masses are due to disintegrating hemorrhages in the outer retinal layers. No evidences of tuberculosis have been found, possibly owing to the late stages in which the examinations have been made.

Syphilitic Retinitis is far less common than syphilitic chorioretinitis (see vol. iii., p. 64), but still it does occur. It is met with in both acquired and congenital syphilis, though in the latter only the final stages are seen. In the acquired form it may develop four to six months after the primary infection. The retina shows a grayish-white opacity which is most marked near the vessels, and along the latter small white spots are frequently seen. The vessels themselves are apparently not much affected. Dust-like opacities are almost always present in the posterior part of the vitreous humor, and may persist after the retinal affection is cured. Hemorrhages are rare. Microscopically the important changes found have been diffuse round-cell infiltration of the retina, endarteritis of its vessels, and nodular collections of round cells in the choroid. No distinct gummatous formations have been observed in the retina. Proliferation and migration of the cells of the pigment epithelium have been noted. An early subjective symptom of the disease is a constant shimmering of light. Visual acuity is much reduced and there is frequently night blindness. Ring scotomata are sometimes detected. The retina and with it the optic nerve ultimately may undergo atrophy. The prognosis and treatment are similar to those of syphilitic chorioretinitis.

Relapsing Syphilitic Central Retinitis.—This is an extremely rare affection, first described by von Graefe, characterized by repeated sudden attacks of marked impairment of vision. At first the vision returns to normal during the intervals, but finally it becomes permanently impaired. The retina shows slight dimness in the macula around which fine dots are frequently seen, and in the later stages of the disease pigmentary changes occur in the macular region. Reduction in central visual acuity usually persists even after prolonged antisyphilitic treatment, owing to the structural alterations in the retina.

Retinochorioiditis Juxtapapillaris (Jensen).—This is a rare affection occurring in otherwise healthy young adults, in which a single oval white infiltrate, about the size of the disc, appears in the retina at the disc margin. The infiltrate becomes absorbed in the course of a few months, ultimately leaving a pigmented spot and a permanent sector-shaped scotoma. Recurrences sometimes take place after a year or two. Central vision is seldom permanently impaired.

Retinitis Proliferans (Manz.).—In this disease masses of connective tissue arise from the retina and extend out into the vitreous humor. They are usually attached near the disc, rarely directly to the latter. There is little doubt that the condition is brought about through the organization of retinal hemorrhages. The progress of the disease is slow, but it usually leads to total blindness. Iridocyclitis or separation of the retina may occur, and the globe finally undergoes atrophic changes. It is said that mercurial inunctions and potassium iodide are of benefit.

Retinitis Circinata (Fuchs), a very rare disease, always occurring in elderly persons, is characterized by the presence of a number of small white spots situated around the macula in the form of a more or less complete circle, with a diameter two or three times that of the disc. Within the circle, but not quite reaching its circumference, the macula shows a grayish opacity. The white spots lie deeper than the retinal vessels and sometimes are slightly pigmented. Small retinal hemorrhages occasionally occur, especially in cases of long standing. Along with these changes there are diminution in central vision, limitation of the visual field, and a small central scotoma. Vision gradually becomes more and more defective, but absolute blindness does not occur. The affection may be either monocular or binocular and is now believed to be due to arteriosclerosis. According to Fuchs, the spots sometimes disappear, but the disease is not benefited by treatment.

Senile Macular Disease.—In old people not infrequently the macula shows yellowish spots and irregular pigmentation. Both eyes are usually affected, and vision is much impaired. The condition is probably due to sclerosis of the capillary layer of the choroid behind the macula with resulting proliferative changes in the pigment epithelium.

Retinitis Striata (Nagel), another very rare affection of the retina, owes its name to the presence in the retina of gray stripes situated in front of the pigment layer, but behind the vessels. The stripes vary in width, but may be three or four times as wide as a vein. They may run from the disc-like radii, or they may have no special arrangement. In addition to these striæ the retina may show pigmentary changes. The disease appears at an early age, runs a chronic course, and although there is some reduction in visual acuity, blindness does not generally result. The etiology and pathology of the affection are unknown, though some observers hold the view that the stripes are due to metamorphosis of hemorrhages, as in the case of angioid streaks in the retina. L. Caspar maintains that they are the result of a retinal separation that has undergone spontaneous cure. Treatment is of no avail.

Retinitis from Exposure to Bright Light, Eclipse Blindness.—The only lesion of the retina produced by light is that due to exposure to the sun or other extremely intense light source, such as the arc of a powerful electric circuit. The condition most commonly results from viewing a solar eclipse without suitable protection to the eyes, hence the name. There is produced a minute central scotoma, which may or may not persist, and later on pigmentary changes may be seen in the macula. Experimental investigations, made by the writer and Louis Bell, confirm the view that the condition is due to the conversion of the intense light into heat by the pigment epithelium and choroid.

Alleged Danger to the Retina from Ultra-violet Light.—

Within recent years, much has been written about the possibility of danger to the retina from exposure to ultra-violet light. This has caused much apprehension, owing to the fact that modern sources, of artificial light are known to give off rays of relatively short wave lengths. After a careful experimental investigation, the writer and Louis Bell have found that the retina is not in the slightest danger of injury from ultra-violet light of any source, the lens completely preventing all abiotic rays from reaching the retina.

Snow blindness, which results from long exposure of the eyes to the brilliant light reflected from large expanses of snow, is not dependent, as might be thought, upon retinal changes, but it is due to the photophobia and blepharospasm resulting from a peculiar form of conjunctivitis.

Retinal atrophy is the final outcome of embolism of the central artery, thrombosis of the central vein, and of the severe form of retinitis. It also occurs as the result of separation of the retina and in the late stages of glaucoma. It is characterized particularly by marked thinning of the vessels, which sometimes become almost invisible, and by secondary atrophy of the disc. Pigmentary changes not infrequently take place in the retina. Retinal atrophy may also be due to siderosis (*q.v.*). The following are apparently idiopathic forms of retinal atrophy.

Retinitis Pigmentosa.—(See Chorioretinitis pigmentosa, vol. iii., p. 49.)

Retinitis Punctata Albescens (Mooren).—In this affection the retina is studded over with numerous small white spots which are most numerous around the disc and in the macula; the fovea, however, usually escapes. The course and visual symptoms are the same as in retinitis pigmentosa. In fact, transition forms between the two conditions are now known to occur, and they are believed to be different forms of the same disease.

Amaurotic Family Idiocy (Tay).—In this very rare disease the retina presents an appearance as striking as it is characteristic. There is a grayish-white patch in the macular region, about twice the size of the disc, the center of which is occupied by a small red spot similar to that seen in obstruction of the central artery. Otherwise the fundus appears normal. The disease makes its appearance within the first year of life, both eyes being affected in the same way and the child showing marked symptoms of idiocy. It occurs almost exclusively in children of Hebrew parentage, usually attacking several children of the same family. Optic atrophy followed by blindness gradually ensues, and death inevitably occurs within a very short time, most often before the child reaches the age of two years. Anatomically the chief lesion found is an extensive degeneration of the cells of the cerebral cortex. Holden found similar degeneration of the large ganglion cells of the retina, which gives the explanation of the ophthalmoscopic picture since these cells are absent in the fovea and most numerous in the macula surrounding it. The writer has confirmed Holden's findings in an eye removed immediately after death and hence free from postmortem changes.

Macular-cerebral Degeneration (Oatman).—In this also very rare disease there is atrophy and pigmentation of the macula in both eyes, and imbecility of greater or less degree. The affection does not begin until the age of about six or seven years. Like amaurotic idiocy it is a familial disease, but unlike the latter it does not occur among Hebrews and does not lead to early death or complete blindness. Another rare form of hereditary macular disease has been described by Best.

Separation of the Retina, Amotio Retinæ.—In enucleated eyes, the inner portion of the retina separates from the pigment layer with the greatest ease, and indeed it is a difficult matter to obtain histological specimens with the two layers *in situ*. Notwithstanding this fact, however, separation of the retina, though not rare, seldom occurs except under conditions which in themselves are of a most serious nature. Thus the most common conditions which lead to it are advanced myopia, severe injuries, especially if accompanied by loss of vitreous humor, iridocyclitis, choroiditis, intraocular tumors, and hemorrhage. Idiopathic separation does occur, however, and is most common in youth and in old age. An important though uncommon cause for retinal separation is albuminuric retinitis, especially that associated with pregnancy. (Plate L, Fig. 6.)

The large majority of separations are found below, though in many cases they no doubt started elsewhere and sank downward, the retina becoming reapplied at the site of the original separation. Localized separations at the macula are rare. The best ophthalmoscopic view of a retinal separation is to be obtained by the indirect method, though it is advisable also to make use of the direct method, holding the instrument some distance from the eye of the patient. In large separations the retina can often be seen by oblique illumination alone without the aid of an ophthalmoscope. The retina, if the separation is recent, projects forward as a tremulous, translucent, gray membrane, showing a greater or less number of folds over which the blood-vessels are seen to take a tortuous course. The latter lose their light streaks and appear smaller and also much darker than normal owing to the reflection of light from the choroid behind. Ordinarily, if the media are clear the condition is readily recognized, but when the separation is flat and extensive the diagnosis is sometimes difficult. If the separation continues to increase, as is usual, it ultimately becomes total, the retina remaining attached at the disc and ora serrata only, and forming a plaited funnel behind the lens. Most often, however, it cannot be seen with the ophthalmoscope at this stage owing to lenticular or vitreous opacities. In the case of intraocular tumors, distinction should be made between an actual separation of the retina and the lifting up of the latter, due to the growth of the tumor beneath it. While the retina is attached to the tumor it is of course not tremulous, shows no folds, and the color of the tumor may be recognized through it. Even very small tumors, however, may early cause complete separation of the retina.

The apparent color of the separated retina depends upon that of the subretinal fluid; if the latter is tinged with blood, the retina takes on a greenish color. Owing to degenerative changes, the retina very soon becomes opaque, but it finally becomes translucent again when atrophy sets in. Quite frequently ruptures can be detected in separated retinæ.

The tension of the eye as a rule is diminished and the anterior chamber is deep. Where the separation is due to an intraocular growth, the tension is almost always increased, or at least not diminished, a fact of great diagnostic importance. Liquefaction of the vitreous humor in association with vitreous opacities is common, and in old cases cataract and a low grade of iritis are apt to occur.

The separated retina frequently is edematous and shows hyperplasia. Calcification, more rarely ossification, may occur, and cholesterin crystals may form in it. Pigmentary changes and hemorrhages are not often seen. Rarely cysts are formed. The blood-vessels remain pervious for a considerable length of time, but many of them finally show sclerosis. The nervous elements of the retina atrophy, and the layer of rods and cones soon undergoes maceration.

The manner in which separation of the retina is brought about is apparent in a large number of cases, but in an equally large number it is a matter of dispute. Cyclitis produces separation by the contraction of exudates that have been poured in the vitreous

chamber. The writer has found that in this way metastatic cyclitis is a common cause for separations of the retina in children. Choroiditis may produce it in a similar manner, or by giving rise to subretinal exudate. Traumatic separations are produced in several ways. When occurring immediately or soon after an injury or operation they are usually due to hemorrhage or to the loss of vitreous humor. In other cases the retina is ruptured by the injury and the vitreous humor passes behind it through the rupture. The separations that occur some time after the injury are due to the traumatic cyclitis and choroiditis that have been set up. Foreign bodies in the vitreous chamber may cause separation of the retina if they produce a severe inflammatory reaction; but, on the other hand, they may remain attached to the retina for years without separation resulting. Finally, spontaneous subretinal hemorrhages from any cause, glaucoma for instance, may produce separation of the retina.

To explain other cases of separation a number of theories have been advanced. In myopia it seems clear that the elongation of the eyeball plays the chief rôle, but the exact way in which it does so is not certainly known. Iwanoff found that in myopic eyes the vitreous body became separated from the retina posteriorly, and that the preretinal space thus formed was filled with serum; but he failed to explain satisfactorily how this led to retinal separation. Leber and Nordensen maintain that in the large majority of cases retinal separation is due to a fibrillar condition of the vitreous body leading to its shrinkage and hence to traction upon the retina. The peculiar condition of the vitreous body is said to be dependent upon a chronic choroiditis. Suddenly developing separations, according to this theory, are due to rupture of the retina resulting from the traction. Raehlman, however, has called attention to the fact that the fibrillar condition of the vitreous body may be secondary to the separation, and that separations may occur when the vitreous body is perfectly fluid. He holds the view that a process of diffusion plays the most important part in the production of retinal separations. It seems to the writer that the cause of idiopathic separations may be an opposite one to that of glaucoma, the intraocular pressure being insufficient to hold the retina in place when the eye is subjected to the jarring of ordinary life.

Among the early subjective symptoms of retinal separation are photopsia, chromatopsia, and metamorphopsia, followed by the appearance of a dark cloud which obscures part of the visual field and produces a positive scotoma. Vision at the macula is maintained so long as the separation has not involved this region, but it is apt to be impaired in any case. The separated retina may retain light perception for a short time, and if it soon becomes readapted, it may completely resume its function. Thus the macula may be separated at first and then become reapplied and regain its function as the separation sinks lower down. But the prognosis in retinal separations is very unfavorable, though in rare instances a spontaneous cure has resulted. Small separations occurring after an injury or as the result of albuminuric retinitis of pregnancy offer the best prognosis. Usually the separation increases until it is complete and there is absolute blindness.

The treatment of retinal separation has hitherto been highly unsatisfactory. Temporary success has sometimes followed prolonged rest in bed combined with the administration of diaphoretics, diuretics, and purgatives. Subconjunctival injections of salt solution have been generally abandoned. Many surgical measures have been tried, but with indifferent success; scleral puncture, withdrawing the subretinal fluid by means of a syringe, injecting irritants with the purpose of setting up an adhesive inflammation, and recently, trephining the sclera, have all been recommended. Others have not obtained the remarkable results claimed by Deutschmann with his special method of incising the retina.

Recently, Mueller's operation, first described over twelve years ago, has begun to attract general attention, and a number of successful results have been reported after its use. It consists in excising a crescentic piece of sclera about twelve millimeters by 2.5 millimeters in size from the equator of the globe on the outer side, and suturing the opening. The purpose of the operation is to reduce the size of the globe, and it is therefore especially indicated in myopic cases.

Subretinal Cysticercus.—The cysticercus has been found as a parasite within or beneath the retina, but the condition is an extremely rare one, especially in this country. At first the retinal separation produced is localized over the parasite, and the movements of the latter can sometimes be observed under it. The vitreous humor soon becomes cloudy and the retinal separation becomes total, producing complete blindness, and the eye finally undergoes atrophic changes. Sometimes the parasite works its way through the retina into the vitreous humor. Drugs given with the object of killing the parasite have always proved ineffectual. When the attempt is made sufficiently early, the entozoon may be successfully removed by operation with preservation of sight.

Tumors of the Retina. (See vol. iv., p. 297.)

Frederick Herman Verhoeff.

Retzius, Anders Adolf.—A leading pioneer in craniometrical research. He was born in Stockholm, Sweden, in 1796. He devised a system of comparing various dimensions of the skull, and constructed a classification of skulls which is based upon this system. He died in 1860.

Retzius' name is associated with a number of anatomical structures, namely: R.'s fibers in Deiters' cells; R.'s gyrus, the gyrus intralimbicus; R.'s space, or cavum Retzii, in the anterior abdominal wall; R.'s veins in the wall of the intestine discharging ultimately into the vena cava, etc. A. H. B.

Reverdin, Jacques Louis.—A distinguished Swiss surgeon, who flourished during the second half of the nineteenth century. He was born at Frontenex, near Geneva, Aug. 28, 1842. He received his doctor's degree at Paris, and was awarded (1871) the Civiale Prize for his thesis on the subject of internal urethrotomy. In 1872 he settled permanently in Geneva as a practitioner of surgery, and in 1876 was appointed Professor of External Pathology and of Operative Medicine. He died in 1908.

Of his sixty or more published writings the following deserve to receive special mention: "Mémoire sur les causes de la gravité particulière des anthrax et des furoncles de la face," in *Archives générales*, 1870; "Mémoire sur la greffe épidermique," *ibid.*, 1872 (awarded the Amussat Prize); and "Des opérations de cure radicale des hernies," 1881. A. H. B.

Reversion.—Reversion is a special case of heredity, and the term is usually applied somewhat loosely to include all cases in which the offspring does not resemble the immediate parents, but exhibits correlation with a more remote ancestor, or group of ancestors. Pearson (1900) has sought to give greater precision to the use of the term. He distinguishes (1) regression, (2) reversion, and (3) atavism.

If we take any pair of characters, as, for example, the lengths of the thumbs of the right and left hands of the same person or the statures of father and son, and construct a correlation table from a sufficiently large number of cases, it will be found that for any

given dimension in one group (the "subject," *e.g.* length of right thumb or stature of father) the dimensions of the associated characters in the other group (the "relative," *e.g.* length of left thumb or stature of son) will be on the average nearer the general average of the whole population. This is *regression*, and is a general phenomenon of correlation when the correlation is not perfect, as is almost always the case (see article *Heredity*, Table I and Fig. 3135). In fact, it is a purely statistical result. Correlation between the price of wheat and the amount of rainfall will show regression just as well as correlations between parents and offspring.

Reversion, in the strict sense of Pearson, is a departure from the peculiarity of the parents toward the peculiarity of some particular ancestor. From the many recorded cases we may select for illustration one cited by Darwin. This is the case of a black bull in Kincardinshire, the son of a black cow with white legs, white belly, and part of the tail white. In 1870 a calf was born which was the great-great-great-grandchild of the bull and had the same very peculiar markings as the bull's mother, all the intermediate ancestors of this calf having been black like the bull himself.

Atavism (Lat. *atavus*, an ancestor) in the strict sense, is a return to the peculiarity of the ancestral form of the species. As this ancestral form is generally unknown, the explanation of an unusual variation as due to atavism is in most cases merely conjectural. For example, the dark stripes that appear sometimes upon the back, shoulders, and legs of horses have been attributed to atavism by Darwin, Ewart, and others; the presence of these stripes being regarded as evidence of a striped ancestry when considered in connection with the coloring of other species of the genus Equus, like the zebra, quagga, etc. Another example of atavism is the occasional appearance of supernumerary mammæ and teats in women and in men. In women they have been observed to produce milk. These are regarded as atavistic because in the Lemuroidea, the lowest group of Primates, there are, in addition to the well-developed functional mammæ on the pectoral region, rudimentary teats upon the abdomen and groin. They thus approach the condition found in dogs and pigs, while in the apes and man there is normally but a single pair of mammæ.

Sometimes it is difficult to determine whether a given unusual variation is a case of atavism or a sport. For example, it is known that the ancestors of the horses had three toes, and it is probable that the ancestors of the modern cats and dogs had five digits on all four feet, but dissections in some cases have shown, and it is probably true in most cases, that when polydactylism occurs in these animals the phenomenon is similar to polydactylism in man, which is certainly a sport and not atavistic.

Darwin showed that the crossing of distinct breeds of animals may result in the appearance of atavistic characters. For example, in his experiments with pigeons he found that when he crossed two distinct breeds, even when they showed no trace of blue color or of bars on the wings, the mongrel offspring would frequently exhibit some of the blue color or traces of the wing bars of *Columba livia*, the wild rock pigeon, which species he regarded as the ancestral form of the domestic pigeon. More striking results were obtained by again crossing the mongrels, the best case was the result of pairing a mongrel female barb-fantail with a mongrel male barb spot, neither of which mongrels had the least blue about them. The offspring exhibited the general blue color and every characteristic mark of the wild rock pigeon.

Similar, but less striking, results were obtained by Staples-Browne (1908) in the second generation from a cross between white fantail and black barb pigeons. He obtained the blue color but not the wing bars of the wild rock pigeon.

From the study of more favorable material Castle (1913) has demonstrated that these phenomena of atavism may be explained by the applications of Mendelian principles. Ordinarily when a red guinea-pig is mated with a black one all the offspring are black, and if these are in turn mated with reds, both black young and red ones are obtained. But occasionally Castle obtained from such crosses the agouti color, characteristic of the native Peruvian races of guinea-pigs. Examination of his records showed that all such individuals were descended from a single red male. Agouti animals have black hairs with red or yellow tips. Carefully conducted breeding experiments showed that the agouti color depends on the presence in one animal of three independent Mendelian factors (see article *Heredity*). The red male had the factors for the red color and the agouti pattern, but the pattern was invisible because there was no black pigment in his hair. But when he was mated with a black female, the three necessary factors were united in the offspring, and the agouti color appeared. In general when by the crossing of different domestic races offspring showing an atavistic character are produced, the result may be regarded as due to a recombination of hereditary factors which had become separated in different individuals during the process of domestication. ROBERT PAYNE BIGELOW.

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Reynolds, John Russell.—Born at Romsey, Hampshire, England, in 1828. He studied medicine at the University College Hospital in London, practised for a short time in Leeds, and then in 1852, after receiving his doctor's degree, he settled in the metropolis as a general practitioner. In 1859 he was made Assistant Physician, and in 1862 Physician and Clinical Professor, in the University College Hospital. Among the various honors conferred upon him in later years the following may here be enumerated: in 1878 he was made Physician of the Royal Household, and the title of Baronet was conferred upon him probably soon afterward; in 1893 he was chosen President of the Royal College of Physicians, and in 1895 President of the British Medical Association. He died on May 29, 1896.

Of Reynolds' more important writings the following deserve to receive special mention: "An Essay on Vertigo;" "Diagnosis of Diseases of the Brain, Spinal Cord, Nerves, and their Appendages," London, 1855; "Epilepsy: its Symptoms, Treatment, etc.," 1861; "Disturbances of the Nervous System dependent on Gout," in *British Med. Journal*, 1877; and a "System of Medicine." A. H. B.

Rhabditis.—A genus of small round-worms, Family, *Anguillulidæ*, with accessory pieces to the two male spicules, and without lateral ridges. A somewhat doubtful species, *R. niellyi*, has been known to cause a papular eruption. There are many free-living species. See *Nematoda*. A. S. P.

Rhatany. *See Krameria.*

Rhazes, Abou-Beckr Mohammed Ben Zacharia.—Born in Persia about the year 860 of the Christian era. Already at the early age of forty Rhazes was looked upon as the most skilful physician of the century in which he lived. He was entrusted

first with the management of the hospital at Bagdad, and then with that of the hospital at Djondisabour. In his old age he became blind, but he was not willing that any attempt should be made to restore his eyesight. "I have no special wish to recover the power of vision; I have seen enough of the world to be thoroughly disgusted with it and hate it." He died when he was far advanced in years.

Of all the numerous treatises which he wrote—on philosophy, on medicine, on alchemy, and on history—only two larger works and a few short ones relating to medicine have come down to our time.

His chief work bears the title: "Liber Elhavi, seu totum continentis Bubikir Zacharie Errasis filii, traducti ex arab. in latin. per Mag. Ferragium medicum Salerni, etc.," Brescia, 1486. This work is often spoken of as simply the *Continens* of Rhazes.

A. H. B.

Rheum.—Rhubarb. The dried rhizome of *Rheum officinale* Baill., *Rheum palmatum* L., and the variety *tanguticum*, Maxim., or probably of other species of *Rheum* (fam. *Polygonaceæ*), grown in China or Thibet, deprived of most of the cork and carefully dried.

The general features of the rhubarb plant are well illustrated by the common garden pie-plants, *R. rhaponticum*, etc. There are twenty or more species, all from southern and central Asia. Both of the above-named species have been introduced to cultivation in Europe, and have produced a drug identical in its essential features with Chinese rhubarb. The second named has not been cultivated upon a commercial scale, but *R. officinale* is quite extensively so cultivated in England. The product is smaller, retains more of its bark, is more spongy, and less esteemed than the Chinese product.

The underground portion consists of a short, thick, erect rhizome, which gives off several thick roots. These are dug in the autumn and the rhizomes and roots preserved separately, the former constituting the most and the more highly esteemed portions of the drug. They are two or three times as large as the roots. The outer corky bark layer is removed and the pieces are dried, mostly by being suspended upon strings passed through perforations made for the purpose.

Description.—Rhubarb occurs mostly either in unevenly barrel-shaped pieces—from two to five inches in length and one-third to two-thirds as thick, the ends truncated, the surface showing the angular markings left by peeling, though these are more or less rounded off—or in longitudinal halves or slices of such barrel-shaped pieces. Usually the pieces are perforated by a rather large hole. The surface is of a bright light yellow and covered with a fine powder, which should consist of the rhubarb substance, but is sometimes powdered curcuma. That which has been kiln dried or "high dried" possesses a surface roughened with broad ridges, separated by broad grooves, the latter frequently discolored to appear smudgy or blackish. Such rhubarb is very prone to be dark colored and spongy or hollow internally. The federal regulations forbid that more than fifteen per cent. of the pieces should show this defect. The surface of high-dried rhubarb is less powdery. Underneath this superficial powder the surface of rhubarb is found reticulated, the oblong or lozenge-shaped ends of the reddish-brown or deep yellow-brown medullary rays being separated by intersecting bands of a grayish-white parenchymatic tissue. The fracture is irregular but not at all fibrous, and of a grayish-red color. Upon transverse section the larger (rhizome) pieces show, near the periphery, a nearly continuous circle of pretty stellate fibrovascular bundles, these being wanting in the root pieces. Upon this transverse view the direction of the medullary rays is seen to be very irregular, less so toward the periphery. Rhubarb possesses a peculiar fine aroma, which, however, becomes coarse, heavy, and a little empyreumatic in the high-dried form. When chewed it produces a very gritty effect between the teeth, is mucilaginous, colors the saliva yellow, and imparts a bitter, astringent, and somewhat aromatic taste.

Powdered rhubarb is frequently adulterated, more especially with turmeric or curcuma. This may be recognized under the microscope by its large solitary, oval starch grains, and by the fact that the particles quickly impart a deep yellow color to a colorless volatile oil close to their margins, when placed in contact with it.

Constituents.—From a therapeutic point of view most of the constituents which have been isolated from rhubarb are unimportant. An active substance which has been extracted (usually to the extent of from three to five per cent.) is "cathartic acid," common to a number of important purgative drugs. In doses of from three to five grains it produces the general purgative effects of rhubarb. It is, however, not a simple substance. The resinous constituents remaining after the extraction of the crystalline bodies named below appear also to be quite active. This resinous body has been separated into portions respectively called pheoretin, aporetin, and erythroretin. No one, however, has seriously proposed the substitution of the use of any one constituent of rhubarb for the entire substance or its preparations.

The three constituents which have attracted the most attention from a chemical standpoint, though the second only appears to have any activity, are chrysophanic acid (not an acid however), emodin, and rhein. They are successively, in the order named, oxidation products from some original body which has not been determined, thus: Chrysophanic acid, $C_{15}H_8O_2.(OH)_2$; emodin, $C_{15}H_7O_2.(OH)_2$; rhein, $C_{15}H_6O_2.(OH)_4$. Rheotannic acid is a glucoside yielding rheumic acid. There exist also an unstudied bitter principle, an odorous oil, also a derivative product, about two-thirds of one per cent. of fat, starch, and calcium oxalate, the last reaching to a fourth, or possibly more, of the weight of the drug.

History and Varieties.—Rhubarb has been used in China from the remotest ages (2700 B.C., Flückiger), and possible references to it are found in the earliest European books on medicine. As early as the seventh century of our era, there can be no doubt of its occurrence in Europe, and by the tenth or eleventh it was well known and highly valued.

For about a hundred years previous to 1860 the Russian Government monopolized the rhubarb trade between Siberia and the Chinese provinces, and established an exceedingly strict inspection of all the roots exported that way, condemning and destroying all but those which were absolutely perfect. In this way an exceptionally fine quality was obtained, and exported, after its long hard journey, from Moscow. Curiously, in England and this country the old and entirely inappropriate name "Turkey rhubarb" was given to this variety. Since 1860 this inspection has been discontinued, and this grade of rhubarb has entirely disappeared from English and American commerce.

The great bulk of the present commercial product is known as Canton rhubarb, though this name also has ceased to be descriptive. Shensi rhubarb is preferred to Canton, and a specially fine variety is that known as Tze-chuen. The round pieces are in general preferred to the flat and the natural to the high dried. For household use, rhubarb is frequently cut into pretty little forms, fingers, crescents, stars, etc.

Action and Use.—When chewed, rhubarb stimulates the saliva. In small doses, in the stomach, it seems to act as a digestive stimulant; in larger ones

it appears to be a simple purgative, hastening along the contents of the bowels by increased peristalsis, carrying the liquid contents of the small intestine rapidly down, to soften and force along the more solid mass in the colon and rectum. Intestinal secretion is supposed to be less stimulated by it than by salines or the cathartic resins. Its coloring matters are absorbed, and may tinge the milk and urine.

Rhubarb is mild and fairly certain in its action; it produces comparatively little pain, no depression in moderate doses, and its action is not prolonged. The tannin in it is credited with producing some constipation after its use, but the simple emptying of the bowels without irritation of the mucous membrane would be enough to explain this result. Rhubarb is given in almost all conditions in which simply emptying the bowels is desired.

Administration.—Rhubarb is offered by the Pharmacopœia in a great variety of forms; it is also found in a good many of the popular proprietary laxative mixtures. It makes a fine, deep yellow powder which is sometimes given, but not often, on account of its very nauseous taste. Two or three decigrams (gr. iij. to v.), once or twice a day, would be a very mild tonic-laxative dose; a single dose of gr. xv. (1.0) is mildly, while one of 2 gr. xxx. (2.0) would be severely, cathartic. Rhubarb in substance is frequently taken by chewing and swallowing a piece of the root as large as a pea or a bean, once a day or so, preferably after eating; the taste, when the drug is used in this way, being less nauseous than that of the powder. The tonic, almost carminative, action of rhubarb upon digestion, has led to its being widely used in this way. The following are the preparations of the United States Pharmacopœia:

Extract, of about 300 per cent. strength; fluid extract; tincture, containing 20 per cent. of rhubarb 10 of glycerin and 2 of cardamom; aromatic tincture, the same amounts of rhubarb and glycerin, 4 per cent. each of cassia-cinnamon and cloves, and 2 per cent. of nutmeg; compound powder, 25 per cent. of rhubarb, 65 per cent. of magnesia, and 10 per cent. of ginger; compound pills, each containing 0.13 gram powdered rhubarb, 0.1 gram purified aloes, 0.06 gram powdered myrrh, and 0.005 c.c. oil of peppermint. From the fluid extract is prepared the syrup, of 10 per cent. strength, with 1 per cent. potassium carbonate, and a little spirit of cinnamon; also the mixture of rhubarb and soda, containing 3.5 per cent. each of sodium bicarbonate and spirit of peppermint, 1.5 per cent. fluid extract of rhubarb, 35 per cent. glycerin, and a little fluid extract of ipecac. The aromatic syrup is made of 15 per cent. of the aromatic tincture, with 85 per cent. of syrup. The sweet tincture, 10 per cent. each of rhubarb and glycerin, 4 per cent. each of liquorice and anise, and 1 per cent. of cardamom; and the pills, each containing 0.2 gram of powdered rhubarb and 0.06 gram of soap, are no longer official.

Allied Plants.—The genus contains about twenty species, most of whose roots have qualities similar to the above. Several of these, *R. rhaponticum*, and others, are cultivated in Austria and elsewhere in Europe for this purpose, and the European product is trimmed and prepared so as closely to imitate the Chinese. It can generally be told by its duller color, more spongy texture, absence of gritty crystals when chewed, and the more regular arrangement of its medullary rays; the stellate spots are absent. It is very inferior to genuine rhubarb.

Henry H. Rusby.

Rheumatic Fever.—Acute rheumatic fever has been defined as an acute, infectious, febrile, non-contagious disease, characterized chiefly by acute inflammation of the synovial membranes and adjacent tissues of the joints of the extremities and a marked tendency toward involvement of the heart. There can be no question of the propriety of classifying acute rheumatic fever as a definite clinical entity but the developments in the bacteriological studies of this disease during the past few years have produced a grave doubt as to whether it is in reality a separate disease. It has long been recognized that there is a close relationship between rheumatism, both acute and chronic, and endocarditis, tonsillitis, chorea, erythema nodosum, and certain other conditions. In 1900, Poynton and Paine isolated an organism which they called the *Diplococcus rheumaticus* and which they believed was the cause of rheumatic fever. This was a member of the streptococcus group and could not be distinguished either morphologically or culturally from the ordinary streptococcus. Very recently Rosenow has carried out a large number of studies with members of the streptococcus group and has apparently been able to show that under proper conditions transmutations occur among the members of this group. Furthermore, he has demonstrated that strains of these organisms may exhibit remarkable affinities for certain tissues or organs. The focus of infection or place of entrance into the body is usually the tonsil or a tooth socket. With his special technique and precautions he has been able to reproduce in animals the lesions found in patients by inoculating the animal with a culture made from the tonsils or teeth, and cultures from the lesion in the animal have yielded a streptococcus. The results have been remarkably constant in a very large series of conditions among which are rheumatism, muscular rheumatism, endocarditis, gastric ulcer, appendicitis, herpes zoster, erythema nodosum, chorea, and cholecystitis. His theory is that in the tonsil transmutations take place whereby there are developed strains of streptococci which have special affinities. From time to time certain of these organisms reach the blood stream and under certain conditions of susceptibility, attack the organ for which they have an affinity and produce their lesion. If one accepts this view rheumatism becomes a single manifestation of an almost universal process and cannot be accepted as a separate disease. It must be admitted that, as yet, Rosenow's work has not found widespread corroboration but it is being reproduced in a few laboratories and in no place has it been disproved by any one using his technique. It is perhaps, therefore, more correct to say that acute rheumatic fever is an infectious disease due to a member of the streptococcus group which has a special affinity for the synovial membranes of the joints of the extremities, a slightly less affinity for the endocardium, myocardium, and pericardium and a distinctly less marked affinity for the tonsils, the muscles, and the nervous system. The reader is referred to Rosenow's original papers for a complete discussion of the subject and a detailed description of his experiments.

Acute rheumatic fever occurs chiefly in the temperate zone and is rarely seen in the tropics. It is most common in the cool damp months of the year and its incidence is largely influenced by exposure to cold and dampness. It is rare in children under five years and practically does not occur in infancy. It is uncommon after the age of forty-five, the so-called rheumatic manifestations which occur at this time of life being usually due to the presence of some other disease. The largest proportion of cases occur between the ages of twenty and thirty-five. It is endemic but at times shows a prevalence which might be classed as epidemic. It is doubtful whether heredity plays any part in the disease. It cannot be insisted upon too strongly that uric acid has no relation to rheumatic fever, an idea that is very strongly fixed in the minds of the laity and also of only too many members of the medical profession. Fatigue and trauma seem to play some part, at times, in the determination of an attack

of the disease. One attack of rheumatism does not confer upon the sufferer any immunity against further infection. Indeed, in many instances, it seems to predispose the patient to future attacks.

Pathology.—The tissue changes of rheumatic fever are not pathognomonic of that disease. There are hyperemia and swelling of the synovial membranes of the affected joints and effusion of fluid into the joint cavity. The fluid is turbid and contains some leucocytes and a few flakes of fibrin, but rarely goes on to the formation of pus. Cultures made from the fluid during the first two or three days may yield streptococci, later they are usually sterile. At times there is extension of the inflammation into the tissues surrounding the joints. The complications in the heart, pericardium, pleura, muscles, etc., are not accompanied by pathognomonic pathologic changes.

Symptoms.—The onset may be sudden or gradual. There may or may not be premonitory symptoms of an indefinite sort. Nor infrequently an attack is preceded by a tonsillitis. The onset may be so sudden that the patient is waked from sleep by the pain in the affected joint. There is a rapid development of pain, swelling and redness in one of the joints of the extremities, usually one of the larger joints. This is accompanied by a rise in temperature which may reach 103° or 104°. On examination the joint is seen to be swollen, dusky red, and held fixed in one position. Active and passive motion is very painful and the joint is hot and exquisitely tender so that the patient is often unable to bear the weight of the bedclothes upon it. There may be more or less edema about the joint and there is an increase in the amount of fluid in the joint. There is apt to be a profuse secretion of a highly acid sweat which may drench the bedclothes. After a few days the temperature falls and the local symptoms clear up only to recur in another joint. In this way several of the joints may be affected in succession. The tongue is coated and the urine concentrated and highly acid in reaction. The vertebral and sternoclavicular joints are rarely affected. In other cases the symptoms are much milder. There is a gradual onset of pain and stiffness in one or more of the larger joints or occasionally the fingers. This is accompanied by very little in the way of local signs though there may be some swelling and tenderness. The trouble moves from joint to joint in a much more deliberate fashion. The patient is often not confined to bed though he may be unable to do his regular work. In the acute form of the disease the joints return to a completely normal condition after the subsidence of the attack. In the more chronic form, certain permanent changes take place after a time, developing into what is known as chronic rheumatoid arthritis, or even arthritis deformans. Generally a certain amount of anemia develops during the course of the disease and when the pain is severe there is more or less exhaustion. These general effects seem to depend upon the severity of the attack. There is also apt to be weakness of the limb affected.

Course.—A simple, uncomplicated attack of acute rheumatic fever may be recovered from in a week or two and the patient remain well though usually requiring a fairly long period of convalescence before returning to his original strength. This is, however, not the general rule. Most patients suffer from recurrences or relapses of varying severity and do not become entirely well for a period of several months. In some instances the condition becomes chronic and the patient never really recovers. In the presence of complications the course is affected depending upon their severity.

Complications.—The essential lesion of acute rheumatic fever, the joint inflammation, is the least important and the least dangerous manifestation of this infection. The complications constitute the really important phase of the disease. The most serious complications are those which affect the heart. Endocarditis, myocarditis, and pericarditis may occur singly or together. They are seen most frequently in young patients and here also they have the gravest prognosis. It is said that from sixty to eighty per cent. of children with rheumatism develop an endocarditis. The onset is often insiduous and is easily missed if special care is not taken to discover it. Changes in the pulse and temperature have much significance when they occur in the course of this disease. The heart may not suffer much permanent damage but generally there is more or less injury to one of the valves and the patient becomes a sufferer from chronic cardiac valvular disease. Pericarditis is also most frequent in children and is not infrequently followed by the development of an adherent pericardium. The immediate prognosis of these conditions is good though the patients are handicapped throughout the remainder of their lives. There is probably more or less myocarditis present in all cases in which the heart is involved. Pleurisy with effusion may occur. The skin may be involved in the infection. Erythema multiforme, erythema nodosum and purpura are well recognized complications and herpes zoster has been shown to result from a similar infection. An acute parenchymatous nephritis is described as a rare complication but it does occur as a complication of acute tonsillitis and is probably more frequent in rheumatism than has been recognized. Hyperpyrexia and chorea are evidences of involvement of the nervous system in the infectious process. Neuritis is not very infrequent while a true meningitis is comparatively rare. Rheumatic iritis is one of the graver complications.

The muscles are affected in two ways. There is always an atrophy when, as a result of joint pain, any set of muscles are not used for an appreciable length of time. In addition there occurs a real myositis due to infection with the same type of streptococcus. This perhaps does not often occur as a real complication but it is a very frequent manifestation of so-called rheumatism. Depending upon the location it may be known as torticollis, lumbago, or merely rheumatism, but the essential factor is the same in all instances. There is an inflammation of the muscle which may later go on to the production of fibrous tissue. There is pain of varying severity which is apt to be more or less inconstant and to shift from one muscle to another. This is a particularly chronic and intractable form of the disease. The patients may be kept miserable for long periods of time. The severity of the pain is apt to be influenced by the weather, temperature, and other barometric changes and one attack predisposes to succeeding ones. This form of rheumatism is apt to occur in older individuals and may be very difficult of diagnosis.

Prognosis.—The prognosis of the attack of rheumatic fever is favorable. Under proper treatment the mortality is very low. In the presence of complications the conditions are changed and the prognosis depends upon numerous factors. The cardiac conditions are of course most apt to prove fatal and cases of hyperpyrexia have an especially bad reputation. In the chronic forms of the disease the prognosis for life is good and generally there is a favorable outlook for relief from the immediate attack, but there is also a great probability that the disease will recur perhaps repeatedly, and a permanent cure is not often to be hoped for.

Diagnosis.—In the typical instances of acute rheumatic fever there is little difficulty in the diagnosis. It is important to remember, however, that joint inflammation may be a part of the picture of any infec-

tion. Scarlet fever (in which the organism causing the complications is probably a streptococcus), typhoid fever, gonorrhea, pneumonia, and gout may be the underlying disease in doubtful cases. Gonorrheal arthritis is usually monarticular and the diagnosis may generally be made with the help of the complement fixation test. Osteomyelitis is an important condition to differentiate since it demands prompt surgical intervention. The swelling extends further from the joint than in rheumatism and there is usually a much higher leucocytosis and polynucleosis. The Roentgen ray examination is an important aid to diagnosis both here and in the presence of tuberculosis of a joint. Syphilis should be diagnosed with the aid of the history, the Wassermann reaction and the presence of other syphilitic lesions. In hysteria and neurosis there is no fever. It should be remembered that rheumatism practically does not occur in infants and that infantile scurvy should be thought of in cases which present painful joints. Joint swelling and pain may be present in the course of serum sickness.

Treatment.—Prophylactic treatment is of great importance. Care should be taken of the teeth so that they shall not become foci of infection. Dead teeth should be so filled that pockets do not form about the roots, or should be removed. The tonsils are so frequently the source of this infection that they deserve special attention. It certainly is not justifiable to advise the removal of all tonsils. But if they become infected or are the seat of recurring attacks of inflammation they are probably better dispensed with. If in addition, the patient has already had "rheumatic" manifestations it is wisest to remove them thoroughly. Tonsillectomy should not be performed while these organs are acutely inflamed because of the danger of producing a general septicemia.

Salicylic acid and its salts play such an important part in the treatment of rheumatic fever that they have been acclaimed as true specifics. This is not wholly justified. There is no doubt that they relieve the pain and exert a certain influence upon the joint process but it cannot be said that they actually bring about a cure. Nevertheless they are the only preparations on which one can place any reliance in the treatment of the disease. Salicylic acid itself is rarely given. The salts most in use are sodium salicylate, acetyl salicylic acid (aspirin), phenyl salicylate (salol), methyl salicylate (oil of wintergreen), salicyl salicylic acid (diplosal), acetparaminosalol (salophen), and methylene citryl salicylic acid (novaspirin). There are a large number of these preparations on the market, the aim in each case being to produce a combination which will not have the irritating and disagreeable properties of the salicylate radical but will nevertheless be effective in treatment. Some of them are very successful. In the use of the salicylates they must be administered in full doses until the full effect of the drug is obtained. Thus of the sodium salicylate, 120 grains are given daily, combined with twice that amount of sodium bicarbonate to avoid irritating effects, until the patient begins to feel the first symptoms of salicylism, usually a ringing in the ears. The dose is then reduced to about 40 or 60 grains a day and continued for a week or more after the subsidence of the symptoms. If the irritating effects of the sodium salicylate are such that it cannot be continued one may substitute aspirin (90 to 100 grains) or diplosal (60 to 70 grains). Salol should be used cautiously because of the danger of phenol poisoning. If necessary sodium salicylate can be given per rectum or intravenously. The latter method affords a comparatively easy way to produce a saturation of the system in a very short period of time and with no ill effects upon the stomach. Research has shown that there is no particular advantage to be obtained by the use of salicylate preparations made from the natural oil of wintergreen.

It is important that the patient be put to bed and kept quiet. The diet should be ample but of simple food and easily digestible. The bowels should be kept open by the free use of the saline cathartics and enemata. The inflamed joints should be kept warm by wrapping them in cotton and it is a general practice to moisten the cotton with methyl salicylate which at least acts as a mild counterirritant. In those patients who are unable to take salicylic acid in any form, one can administer acetanilid, phenacetin, or antipyrin for the relief of pain. The administration of alkalies, which was once considered as a standard method of treatment of rheumatism, is believed now not to be of very much value. Hyperpyrexia should be treated by cold baths or cold packs.

Muscular rheumatism is also treated with the salicylates though it is usually not necessary to administer them so intensively. In addition various forms of physical therapy are at times of assistance. Baking, steam and electric light baths, cold douches, and massage are forms often employed with a favorable effect that is at least temporary. Some of the forms of electrotherapy have been highly recommended and seem to be of great benefit in some cases. Counterirritation with the actual cautery will occasionally give relief when everything else fails.

Cardiac complications are of the first importance. They should be watched for carefully and the patient should be kept absolutely quiet if any appear. If the heart becomes involved the patient should be kept in bed for two months at least and then allowed to get about very cautiously and slowly provided the cardiac symptoms have subsided. There is no objection to the use of digitalis should there be signs of cardiac decompensation. The appearance of heart trouble is not an indication for stopping the salicylates as was once believed.

Since it has been recognized that acute rheumatic fever is an infection there has been a rather liberal use of vaccines in its treatment. When an organism can be recovered from the blood it, of course, should be used for the making of the vaccine. When blood cultures are sterile and cultures are made from the tonsil or tooth socket it is extremely difficult to determine which of the many organisms recovered is the causative one. The complement fixation test which has been recommended for this purpose is not a reliable test, evidently, and one must proceed by chance unless he has access to the materials so that Rosenow's technique can be followed. A streptococcus isolated from the inflamed joint of a rabbit which had been inoculated with material from a tonsil is probably the organism at fault and is preferable for making an autogenous vaccine. Stock vaccines are probably of little value in the majority of instances. The so-called phylacogens have no good theoretical basis for their use and they may prove dangerous. When vaccines are used the dosage should be cautiously regulated. Fifty or one hundred million is sufficient for the first dose. In the absence of any reaction such as chill, fever, or exacerbation of joint symptoms the dose can be doubled each time and given daily until some reaction occurs. A dose should be selected which is not large enough to give a reaction and then administered about once a week. The technique of the administration of vaccine is that of any hypodermic medication.

The use of radium, either intravenously or by the drinking of radioactive water, is said to have been followed by striking relief in some of the more chronic cases.

Ralph G. Stillman.

Rheumatin is the salicylate of saloquinine, and represents a large percentage of the salicylic radical in combination with quinine. It occurs in white acicular crystals, which are colorless and tasteless, and but sparingly soluble in water. Overlach finds its action practically specific in acute rheumatism,

without any digestive disturbances, and distinct from that of a mixture of quinine and salicylic acid. Pieper found it valuable in trigeminal neuralgia as well as in rheumatism. The dose is fifteen grains (1.0) three or four times a day.

W. A. Bastedo.
R. J. E. Scott.

Rheumatism, Chronic Articular.—Definition.—A chronic affection, characterized by stiff and painful joints.

Etiology.—Like rheumatoid arthritis (*q.v.*) chronic rheumatism is often the result of a persistent toxemia due to a chronic focal infection. The disease, according to continental writers, is a frequent sequel of acute rheumatism, but in North America it is more commonly independent of antecedent acute or subacute attacks. It occurs most frequently after the middle period of life, especially among those who, in addition to contending with the hardships of poverty, must engage in occupations of a laborious character which involve exposure to cold and dampness, such as day laborers, farmers, hunters, washerwomen, and the like.

Pathology.—The cavity of the joint is not infrequently dry. The synovial membrane and its villi are thickened and injected, and adhesions may form between the opposing surfaces. The articular cartilages are distorted, perhaps eroded and partly absorbed in cases of long duration. The capsule and ligaments of the joint and the tendon sheaths adjacent to the affected articulation are thickened. Atrophy of the muscles in the vicinity of a chronically rheumatic joint is by no means uncommon, especially when single large articulations (knee, shoulder, hip) are involved. Atrophy from disuse is likely to occur if the joint becomes ankylosed. Peripheral neuritis and pressure from exudation on the muscles themselves or their nutrient vessels have also been designated as factors in the muscular wasting.

Symptoms.—The conspicuous symptoms are pain and stiffness in the affected joint. Most commonly the onset is slow and insidious. The pain usually becomes more severe during rainy weather, particularly in the variable climatic conditions of spring and autumn. The stiffness is most marked in the morning and after rest, and lessens after exercise. The pain is apt to be increased by movement, and is often very troublesome at night. The affected joints may be tender upon palpation, but swelling, if present, is usually slight. The inflammation is rarely of sufficient intensity to cause redness of the joint. The course of the disease is as a rule afebrile, but if many joints participate in an exacerbation there may be a slight and transient rise of temperature. The disease may be monarticular, involving a single large joint, the knee, shoulder, or hip in particular, but generally a number of joints, both large and small, are implicated. The joints, if the disease is of some duration, are likely to creak or grate when moved, because of the dryness and roughness of the articular surfaces. In cases of long standing the joints are enlarged and distorted, the mobility is decreased in varying degrees, and they may become completely ankylosed. Muscular atrophy takes place, and the patient may, in the severest cases, become bedridden. The joint changes when established are usually persistent, and do not shift from one articulation to another as in rheumatic fever. In mild cases the general health may remain wellnigh unimpaired, but in the severer and more painful cases gastric disturbances, emaciation, anemia, and neuralgias may be present with varying intensity. Other complications are not common, but chronic endocarditis, with resultant valvular defects, may be associated with the joint changes.

Diagnosis.—Chronic articular rheumatism may require to be differentiated from chronic articular gout and arthritis deformans, although in the majority of cases the diagnosis is easily made.

Gout is more apt to affect the smaller joints. There is usually a history of acute attacks involving the great toe-joint, tophi if found are distinctive, and the evidences of arteriosclerosis and granular kidney are much more common in gout than in chronic rheumatism.

It is difficult, and readily may be impossible to distinguish between arthritis deformans and chronic rheumatism in the early stages. In more advanced cases the former presents greater deformity of the joints, while rheumatism tends rather to ankylosis with comparatively slight alteration in shape, and moreover is likely to attack a larger number of articulations than arthritis deformans. It is proper to state that by some writers arthritis deformans is regarded as an advanced stage of chronic rheumatism.

Prognosis.—The presence of chronic rheumatism is, as a rule, not incompatible with a long life, but it is essentially a chronic ailment, and the majority of cases are obstinately resistant to all therapeutic measures. In exceptional cases great improvement or apparent cure may take place; in many the disability and pain may be much relieved; in some the disease may seriously affect many joints and render the patient helpless.

Treatment.—Any local infection (teeth, tonsils, nasal sinuses, etc.) should, if possible, be radically treated. If circumstances permit, the patient should live or at least spend the winter months in a warm, equable, dry climate, such as that of Southern California or the South of Europe. Otherwise the utmost care should be taken to shield the subject from dampness, cold, and bad weather by good shelter and warm clothing. The digestive functions should be maintained in good order, enemata and laxatives being employed when they are required. The diet should be regulated so that it is digestible and ample in order to keep the nutrition of the body at its best. Moderate exercise should be taken when possible. A daily cold sponge followed by a good towelling is usually helpful, and those who find that the sponging disagrees with them should employ the dry friction alone.

Local treatment is of prime importance. Counter-irritation should always be used, by means of stimulating liniments or by painting with tincture of iodine; by the application of a series of small blisters; or by "striping" the painful joint with the Paquelin cautery, or, what answers as well, with a glass rod, the end of which has been heated in an alcohol flame. The application of ichthyol and iodine, salicylic acid (gr. xxx. to ℥i.), or belladonna ointments, is at times of much service. Systematic massage and passive movements are useful, especially for the prevention of ankylosis and atrophy, and for the lessening of swelling and stiffness. Electrical treatment may or may not be of service, but is always worth a trial.

Hydriatic measures of various kinds should not be omitted. At home a hot bath at night often mitigates pain and secures a more restful sleep; so also do hot fomentations of the painful joints. Or, finally, the affected joint may be wrapped in three or four thicknesses of linen wrung out of cold water and covered with flannel and oiled silk or, in lieu of the latter, thick brown paper.

Complete and systematic hydriatic measures, including also the hot-air treatment (baking the affected joints) generally require a daily visit to, or, if practicable, a stay of some duration in, an establishment provided with the necessary apparatus and trained attendants, particularly in the sanatoria which avail

themselves of natural medicinal and thermal waters. Among the latter are the Hot Springs of Arkansas and Virginia, Richfield Springs of New York State, Banff on the Canadian Pacific Railway in the Rocky Mountains, Mt. Clemens in Michigan, and Santa Rosalia in Mexico. Here and in Europe a variety of baths—Turkish, Roman, sand, mud, and peat—have been employed. Thorough and persistent hydrotherapeutic treatment usually secures great relief, and even in obstinate cases a permanent cure is sometimes obtained.

Medicinal treatment is not very satisfactory. As a rule the administration of iron, quinine, strychnine, arsenic, and other reconstructives is helpful; so also is a course of cod-liver oil, mixed fats, or extra butter and cream in the dietary. Iodides, guaiacum, colchicum, alkalies, and bichloride of mercury, are occasionally useful. The salicylates are unquestionably beneficial during marked or subacute exacerbations.

GLENTWORTH R. BUTLER.

Rheumatoid Arthritis.—(*Synonyms:* Rheumatic gout; arthritis deformans; chronic rheumatic arthritis; rheumatic joint; osteoarthritis.)

DEFINITION.—A chronic and progressive disease of the joints characterized by deforming changes in the synovial membranes, cartilages, and bone, with periarticular bony outgrowths which interfere to a greater or lesser extent with the mobility of the affected articulations.

ETIOLOGY.—As a rule the disease develops between thirty and fifty years of age, although it may occur in children under twelve. It exists with preponderating frequency in women, from one-half to four-fifths of the cases occurring in this sex, especially at the time of the menopause. Sterility and uterine or ovarian disease apparently predispose. There is in some cases a family history of a tendency to gouty or other disease of the joints, or to tuberculosis of the lungs; and two or more cases may occur in the same family. Worry, grief, mental shock or overwork, exposure to cold and dampness, insufficient diet, and local traumatisms appear at times to be exciting causes. There are two theories as to the essential cause of the disease; one, that it is of nervous origin; the other, that it is a chronic infection. According to the former theory the disease is akin to the arthropathies of nervous origin. Thus the joint changes in arthritis deformans are very similar to those which may occur as a result of locomotor ataxia, syringomyelia, hemiplegia, and injuries of nerve trunks. The not infrequent presence of neurotrophic phenomena, such as marked muscular atrophy, glossy skin, and alterations in the nails and bones, is of some significance; so also is the occurrence of numbness, tingling, and severe pain, involving special nerves or nerve trunks. Moreover, the joint lesions are usually symmetrical.

There can scarcely be a doubt that in many instances the disease is due to a long-continued toxemia from a chronic focal infection. The most common of these infections are pyorrhea alveolaris (Riggs' disease), chronic tooth abscesses, and chronically infected tonsils. Less common are infections of the nasal sinuses; chronic cholecystitis, appendicitis, and salpingitis; and chronic toxemias of intestinal origin.

PATHOLOGY (OR MORBID ANATOMY).—The morbid changes begin in the cartilages of the affected joints, which after proliferating become softened and, especially in the center and at the points of greatest pressure, are absorbed or worn away. The exposed articular bone surfaces become smooth and ivory-like (eburnated). The proliferating cartilages and synovial membranes at the border of the joint form an irregular fringe of nodules and polypoid bodies which ossify (osteophytes) and interfere more or less seriously with the mobility of the joint. The ends of the bones may become enlarged, and the ligaments are greatly thickened. Complete ankylosis is not infrequent, due principally to the locking of the joints by the osteophytic growths (Haygarth's nodosities) and the thickened ligaments. In elderly persons and in cases of long duration the articular ends of the bones may undergo wasting, so that the head of the humerus, or of the femur (morbus coxæ senilis), may practically disappear, causing partial dislocations and false joints. The affected articulations are more or less misshapen and the deformity may reach an extreme grade. When the hand is affected the fingers frequently bend laterally toward the ulnar side. The great toe is deflected toward the outer border of the foot. The vertebræ when diseased may be completely ankylosed by bony outgrowths, and the spinal column thus consolidated. Atrophy of the muscles about the joint, sometimes of extreme degree, is of common occurrence.

SYMPTOMS.—Five varieties of the disease are recognized—the general progressive form, the monarticular form, the vertebral form, the form affecting children, and Heberden's nodes.

The *general progressive* form may be acute or chronic. The *acute* outbreak occurs especially in young women in connection with parturition and lactation, or in older women at the menopause; it is occasionally observed in children. The symptoms resemble those of rheumatic fever. A number of joints become swollen, seldom reddened, and there is a moderate rise of temperature. The subjects become anemic, low-spirited, and lose flesh and strength. In some instances the disease may greatly improve, only to renew its onset under the influence of further child-bearing or nursing.

The *chronic* variety is that which is observed in the majority of the cases. As a rule one or two joints, usually of the hands, are first involved; then those of the knees and feet and other articulations; finally, in the severest cases, all the articulations may be implicated. The involvement is usually symmetrical. The earliest symptoms are slight swelling in or about the joints, and pain on movement with impaired mobility. There may or may not be effusion into the joint. The pain may be extremely severe and continuous, or slight and variable. It is usually worse at night and during the exacerbations. The disease progresses irregularly, days or weeks of improvement alternating with renewals of pain, swelling, and stiffness. Slowly the joints become deformed by ligamentous thickening and the formation of bony outgrowths. The mobility of the joint decreases and creaking or grating is felt or heard upon motion. In the end the joint may be completely immobile, owing to the checking action of the osteophytes and the fibrous thickening of the capsular ligaments. The disused muscles waste away, and when contractured may give rise to persistent flexion of the affected members. In the worst cases the patient is bedridden and almost if not quite helpless. In one case under observation practically every joint in the body was ankylosed; even the lower jaw was wellnigh immovable. Tingling, numbness, glossy or pigmented skin, onychia, rapid muscular atrophy, and increased reflexes have been observed. Anemia and gastrointestinal disturbances are not uncommon, especially during the exacerbations of the disease. The heart is not often involved, but in one personal case, that of a young woman, there were advanced arteriosclerosis and an aneurysmal dilatation of the aorta.

The *monarticular* form affects especially the hip, knee, or shoulder, occurs mainly in old people, and

not infrequently is an apparent sequel to an injury. The pathological changes are similar to those of the chronic general form, and the muscles early undergo atrophy. When affecting the hip the disease constitutes the morbus coxæ senilis, the anatomical alterations of which have been described.

The *vertebral* form, spondylitis deformans, is a progressive rigidity of the spine, due to ankylosis of the vertebræ. Two types are described. The first is the so-called spondylitis rhizomelica (Strümpell-Marie), which attacks men only at or beyond middle age. It begins usually in the hip-joints, which become ankylosed, the process subsequently extending to the spine and shoulder-joints, very rarely to the knee-joints. The spine becomes rigid, the ribs flexed, and there is some kyphosis. The dorsal and gluteal muscles are atrophied and exostoses are found upon the vertebræ and sacral bones. There is but little pain attending the process. In the second (Bechterew-Marie) type the disease begins in the spine, which becomes ankylosed and kyphotic, the shoulders stoop, the head is lowered and carried forward, and there is much intercostal pain, with anesthesia, muscular atrophy, and other signs of involvement of the roots of the spinal nerves. The hip- and shoulder-joints are slightly if at all affected. The disease is often hereditary. There is little doubt that both types are forms of arthritis deformans, and are not, as formerly supposed, independent diseases.

Heberden's nodes, knobby enlargements of the proximal ends of the terminal phalanges of the fingers, are much more common in women than in men; they begin, as a rule, between thirty and forty years of age. They are regarded as indicative of a long life, but it has been stated that cancer occurs with undue frequency in women who have such nodosities. While the nodes are forming the affected joints may be tender and swollen, perhaps slightly reddened. Exacerbations may be excited by dietary errors, or slight accidental traumatisms; but in most instances the attacks alternate with periods of quiescence without apparent cause. Fortunately, those who develop Heberden's nodes seldom have the larger joints affected.

The *juvenile form* occurs more frequently in girls than in boys and, as a rule, before the second dentition. While the disease may be a replica of that affecting grown persons, the most important class of cases differ in many respects from the adult affection. The onset may be acute, with fever, possibly with chills, but generally the first symptom is a slight stiffness in one or two joints, others slowly becoming affected. There is no crepitus in the affected joints, and the main anatomical change is a general thickening of the periarticular tissues and enlargement of the joint with little or no alterations in the bones. The mobility of the joint is impaired, perhaps totally destroyed. There may be marked atrophy of the muscles. The most interesting feature of the malady is a general and marked swelling of the lymph glands, occurring especially in the cases attended by fever and increasing with the latter. The spleen also is enlarged and palpable. Profuse perspirations are rather common. The heart is rarely affected. The subjects are anemic, weak, and ill-developed.

Diagnosis.—In the early stages it is always difficult and frequently impossible to distinguish arthritis deformans from chronic rheumatism. When the disease is well developed the diagnosis is seldom in doubt. The peculiar joint deformities in advanced cases are quite characteristic. The more acute cases may be mistaken for rheumatic fever, but the slighter fever, the lesser pain, redness, and swelling, and the usual absence of cardiac complications separate it from the latter. From gout arthritis deformans is distinguished by the absence of chalky deposits and, usually, of cardiorenal disease, as well as by the fact that gout usually attacks the metatarsophalangeal joint of the great toe.

Prognosis.—In a majority of cases the progress of the disease is arrested, leaving several joints more or less crippled. In other cases the disease advances irregularly, with periods of quiescence, and persists throughout the life of the patient. A few become helpless and bedridden. As a rule, the milder forms of the disease are not incompatible with fair health and a long life, but the disability may be very great.

Treatment.—It is of prime importance to maintain the general health at its highest point. Plenty of fresh air, daily cool or cold sponging followed by vigorous toweling, well-ventilated sleeping-rooms, ample hours for sleep, daily exercise according to ability, laxatives and digestive tonics when needed, and a liberal dietary of meat, eggs, milk, butter, wine and malt liquors, should be considered essentials.

Focal infections (see Etiology) must be carefully sought, and treated as radically as surgical or medical means permit, in order to prevent the continuance of an existing toxemia.

Local treatment embraces cold or hot compresses covered with oiled silk, and left on for two or three hours at a time, massage carefully given and long continued, persistent hot-air treatment (baking), small and repeated blisters, "striping" from time to time with the thermocautery, friction with ointments containing iodine and ichthyol, systematic passive movements, and even the forcible breaking of adhesions in selected cases.

Hydriatic treatment should be begun early and is of great value. At home a nightly plain hot bath, hot Nauheim bath, or hot-air bath may be employed. If the patient is able he should go to a hydriatic establishment in connection with a natural thermal or medicinal water, such as the Hot Springs of Virginia or Arkansas, Mt. Clemens in Michigan, Richfield Springs of New York, Green Sulphur of Florida, or Sharon Springs; Bath in England; Baden, Wiesbaden, Aix-les-bains, Carlsbad, Gastein, Homburg, or Wildbad on the continent of Europe, or the sand baths, mud baths, and peat baths of various localities.

Electricity may be employed, but its effects are uncertain.

Medicinal treatment is at times very helpful. Iron, arsenic, and cod-liver oil in full doses are the remedies that are especially indicated. Iodide of potassium (five to ten grains) or the syrup of the iodide of iron (ten to twenty minims) three times daily is especially useful if there is much periarticular thickening. In the acute polyarticular attacks the salicylates are unquestionably of great value.

Glentworth R. Butler.

Rhigolene.—Of the products of the fractional distillation of petroleum the lightest is obtainable as a fluid by condensation, and consists mainly of the paraffin *butane*, a body gaseous under ordinary conditions. This condensed distillate is termed *cymogene*. The distillate of next higher boiling-point boils at about 18° C. (64.4° F.). Such distillate consists largely of the fluid paraffin *pentane* ("amylic hydride"), C_5H_{12}, and is the substance commonly known as *rhigolene*. Rhigolene is a colorless, mobile fluid of slight and not unpleasant odor and taste; very light, very inflammable, and, as its boiling-point predicates, very volatile. It mixes in all proportions with common (ethylic) ether. Rhigolene was proposed by B. W. Richardson as a substitute for ether for the production of local anesthesia by freezing, after his method. Because of the low boiling-point of rhigolene—lower than that of ether—the cold produced by the evaporation of a spray of rhigolene is very intense and very rapidly attained. Richardson observed an area of skin become hard, white, and in-

sensible at the expiration of *two seconds* after beginning the driving upon it of a rhigolene spray. But such very rapid freezing found to be undesirable, because the intense cooling of the superficial frozen area prevents the abstraction of heat from below, and so limits unduly the depth to which the anesthesia can be carried. Hence Richardson proposed a mixture of rhigolene and anhydrous ether in equal parts. Rhigolene dissolves camphor, spermaceti, and iodine, and has been used as a solvent of those bodies for use for local applications. A rhigolene solution of camphor and spermaceti together Richardson found to make an excellent conjoint cooling anodyne and healing application to burns. The vapor of rhigolene, inhaled after the manner of vapor of chloroform, is readily taken, and produces general anesthesia with great rapidity. But in this application rhigolene has shown itself dangerous, and has never come into practical use.

EDWARD CURTIS.
R. J. E. SCOTT.

Rhinitis.—Rhinitis is an inflammatory affection of the mucous lining of the nasal cavities in which both the subjective and objective symptoms vary according to the chronicity and cause of the disease.

The primary cause may be irritation due to physical or chemical substances in the inspired air. It may be overwork thrown on the intranasal membranes from an environment of an unhygienic condition of air as to temperature, moisture, or percentage of carbon dioxide gas, or it may be due to conditions of life necessitating sudden and marked changes in the temperature, moisture, etc., of the respired air. The results on the membranes of overwork is often seen in persons having one obstructed nostril in which case the unobstructed nostril does all the work and presents at different ages all the stages of an inflammatory process in a mucous membrane, from hypertrophy to atrophy. Again the cause may be found in certain diseases in which the changes in the rhinitic membranes are but the local manifestations of the general disease. The diseases in which this symptom occurs are, notably, influenza, tuberculosis, syphilis, and the so-called disease of childhood, etc., and because of the severity of the local inflammation or its extension to the accessory cavities of the nose or to the middle ear, it may become one of the most trying and dangerous complications of those diseases. This is especially so in influenza, scarlet fever, and measles.

Inasmuch as this symptomatic rhinitis is considered under the headings of the various diseases in which it occurs, the writer will content himself with warning against a too vigorous treatment of the noses of young children sick from any of the above-named diseases. Spraying, douching, or swabbing of the nose of a crying and struggling child is a dangerous procedure. The most rational and absolutely safe procedure in these cases is the application of negative pressure or suction which may be done as follows:

To a stop-cocked tube passing through the cork of a vacuum bottle is attached a rubber tube into the other end of which is inserted a medicine dropper, the rubber cap of which has been perforated so as to leave an opening about one-eighth inch in diameter. The perforated end of the rubber bulb having been placed in one nostril of the child to be treated while the other nostril of the child is closed by the finger of the physician or nurse, the stop cock in the tube leading to the vacuum bottle is opened. Because of the crying of the child the nasopharynx is closed off from the oropharynx and a suction is exerted through the nose and accessory cavities of the child and any secretions in these parts will be seen passing through the glass tube toward the vacuum bottle. An ordinary aspirating apparatus fills all requirements for the above treatment.

CLASSIFICATION.—The various forms of rhinitis may be classified as follows:

- Rhinitis
  - I. According to cause
    - 1. Primary
      - *a* Diseases: grippe, diphtheria, measles, scarlet fever, syphilis
      - *b.* Local germ activity (membranous rhinitis)
    - 2. Secondary or Symptomatic of
      - *c.* Toxemia: Autointoxication; Non-autointoxication: Vasomotor
      - *d.* Occupational
  - II. According to chronicity
    - 1. Acute
    - 2. Subacute
    - 3. Chronic
      - *a* According to condition of membrane: *a.* Simple catarrhal; *b.* Hypertrophic; *c.* Atrophic: Simple Ozena
      - *b.* According to secretion: *a.* Catarrhal; *b* Mucopurulent; *c.* Purulent
  - III. According to location
    - 1. Unilateral
    - 2. Bilateral: *a.* Anterior; *b* Posterior

By primary rhinitis is meant that form of disease which exists in the nose of one who says he has a cold in the head or that he is catarrhal. It may be acute or chronic.

ACUTE RHINITIS.—*Synonyms:* Cold in the head, acute catarrh, coryza.

Etiology.—Taking cold or the development of a simple acute rhinitis is as a rule quite a complex process. That is, there are predisposing factors and exciting factors and whereas it is generally only the exciting factors that are recognized by the one who develops the disease, it can safely be said that the predisposing factors are more responsible for the disease. The predisposing factors may be local in the nose or due to conditions in remote parts of the body. Not infrequently both local and general conditions are present in the same individual. Such persons are "always taking cold" or "catch cold very easily." The local condition may be the presence of adenoid growths in the vault of the pharynx or some faulty construction of the nose which may be congenital or acquired. This applies especially to the nasal septum. Other structures of the nose (the turbinated bones) may take on characteristics through repeated attacks of colds which render the possessor more liable to relapse.

Predisposing Causes.—Of the general predisposing factors the more important are covered by the terms rheumatic and gouty diathesis, which to me means the result of the improper working of the gastrointestinal tract, which again may be due to lack of proper bodily exercise, or errors of diet as to either amount or kind. The improper use of alcoholic beverages conduces to the same end.

Exciting Causes.—The exciting causes are as well known to the laity as to the profession. They are: living in poorly ventilated places, exposure to draught, especially when overheated, wetting of one's feet, the breathing of air containing irritating substances either chemical or mechanical, going suddenly from a warm into a cold atmosphere without proper attention to change of clothing, etc.

One in no way predisposed may subject himself to any or all of the above exciting causes without experiencing the first symptom of a cold; whereas one predisposed will develop the disease when subjected to any one of them. In fact so slight a thing may be

the exciting cause that one may be absolutely unable to say what it was.

Pathology.—Because of the peculiar arrangement of the vascular supply of the mucous membrane of the nose, an engorgement of that membrane results in the closing up of the glandular necks and mouths (Zuckerkandl). Consequently the nose in the early stage of rhinitic inflammation is obstructed and dry. It is probably at this stage of the disease that just the train of symptoms that are to follow is determined by the action of the particular organisms which happen at the time to be present in the nose. Any of the common disease-producing germs may be present in a pure or a mixed culture. Following the engorgement or as the result thereof, a transfusion of serum from the blood-vessels takes place, which gradually thickens or becomes more mucoid as the glands begin unloading. This form of secretion is followed by a secretion of mucopurulent character. The tendency of the disease is to recovery which shows itself by the gradual lessening of the discharge.

Symptoms.—On account of the engorgement and closing of the mouths of the glands there is a sense of stuffiness and dryness of the nose, accompanied by a smarting and burning in the upper and posterior parts of the nasal passages, especially felt on inspiration. Coughing and sneezing follow, and are in some cases annoying symptoms. The accessory sinuses are generally involved which causes symptoms in the head varying from a general heavy and full feeling to severe pains located somewhat according to which of the sinuses are most involved. The eyes are suffused, and such constitutional symptoms as fever, chilliness, and a general malaise may be present. In patients of good constitution and resistance the disease is self-limiting, recovery taking place according to the severity and character of the infection in from one to two weeks.

Prognosis.—The prognosis is good, but the sequelæ and complications, such as bronchitis, pneumonia, sinuitis, and ear troubles, should be borne in mind.

Treatment.—The great majority of cases go untreated or at least receive only such treatment as the sufferer or his friends have used before or have heard of as having been used. As a matter of fact, however, the disease, on account of its potentiality for evil should be respected and a regular and systematic treatment instituted, by which means the disease, if taken in its incipiency, may generally be aborted or, if taken later, may be shortened and the chances of annoying sequelæ and complications much reduced.

Abortive Treatment.—If the patient is seen during the period of vascular engorgement and glandular inhibition, the writer's plan is as follows: The patient is put in bed after a hot foot bath. Tincture of aconite in one-drop doses is administered every fifteen or twenty minutes for from three to four hours; ten grains of Dover's powder is given with the first dose of aconite, and hot water bottles may or may not be placed under the bed coverings. In from five to six hours the patient is in a profuse perspiration when an alcohol sponge bath is given, and body and bed linen are changed. This treatment reduces the blood pressure, thereby opening up the mouths of the glands, and at the same time the reflex excitability of the nervous system is greatly reduced. All the aching and pains cease and temperature is lowered, gradually becoming normal, after the administration of a laxative dose of calomel or castor oil, in from six to ten hours after the alcohol bath. The patient is kept in bed for from twenty-four to thirty-six hours and in his room twenty-four hours longer. Some catarrhal secretion may continue for a few days but the disease or infective process has as a rule been broken. Complete recovery is hastened by the administration of such tonic treatment as is suggested by the apparent needs of the case. The tonics used singly or in combination are strychnine, iron, cod-liver oil, Russell's emulsion, etc. Local treatment of the nose by spray or inhalation is instituted if the secretion is abundant or annoying.

Treatment of an Established Attack.—If the case be not seen until the catarrhal stage of the disease, the treatment is first general, second local. Stomach and bowels are put in as good condition as possible; diet is restricted, especially as to nitrogenous foods, and one of the so-called tonics is administered. When the following local treatment is instituted: The nose is douched with a warm physiological saline solution, which may or may not be followed by the spraying of the nose with a solution of one of the organic silver salts. The insufflation of powders containing morphine or the spraying of the nose with cocaine and adrenalin solutions is mentioned to be condemned, except in such cases as show marked sinus involvement, when the spraying of the nose with a two per cent. solution of cocaine in a 1–5,000 solution of adrenalin chloride will serve to contract the tissues about the ostia of the various sinuses, thereby facilitating drainage from these cavities, relieving pain, and shortening the duration of the disease.

The administration of the well-known rhinitis and coryza tablets, containing morphine, atropine, etc., is contraindicated both theoretically and practically, as by their administration we close up the glands at a time when the effort should be to open them and allow them to excrete.

Whether it be a patient just relieved of his first cold or whether it be one who consults us on account of repeated colds or a chronic condition, we should carefully examine the patient for predisposing causes. If there is a malformation of the nose it should be corrected. If the attack is due to diet or to stomach or bowel disorders these must be corrected and a diet instituted. I have known persons who took cold on slightest prevocation to become almost cold proof by proper attention to diet and bowels. Exercise, proper ventilation of living apartments, bathing, and clothing are all matters to be looked into and regulated by the physician.

Chronic Rhinitis.—*Synonyms:* Catarrh, chronic catarrh.

Etiology.—The causes of a chronic rhinitis are the same as the predisposing causes of acute rhinitis and the chronic condition results from the uninterrupted working of these causes. The chronic disease results from repeated attacks of the acute, or the condition may have been chronic from the beginning; that is to say, no evidence can be adduced that the patient has ever been free from catarrh.

Chronic rhinitis may be classified either from the condition of the membrane, especially that covering the turbinated bones, or according to the character of the nasal discharge. According to condition of the membrane a chronic rhinitis may be simple, catarrhal, hypertrophic, or atrophic; according to character of the nasal discharge a chronic rhinitis may be catarrhal (mucus discharge), purulent (pus discharge), or mucopurulent (a mixed pus and mucus discharge). Probably also it may be well to classify chronic rhinitis according to cause, as inflammatory, vasomotor, etc.

Chronic Catarrhal Rhinitis.—As few noses are free from architectural defects and as few people live in and breathe for any appreciable portion of their lives an air approximately ideal as to hygienic conditions, chronic catarrh is an almost universal disease.

Pathology.—The mucous membrane is chronically congested, causing a low-grade inflammatory process. The glands are enlarged and about them is a cellular infiltration giving rise to a somewhat thickened membrane.

Symptoms.—The subjective symptoms depend not only upon the severity of the disease but upon the temperament of the patient and the local nerve ex-

citability. The symptoms may be confined to the annoyance of the nasal secretion which demands a constant clearing of the head by blowing or hawking from the nose; or, if there is great nerve excitability there may be frequent sneezing and coughing which also in turn seem to make worse the discharge.

Prognosis.—Relief may be promised but the patient should be made to know that amelioration is all that can be expected.

Treatment.—The treatment consists in the regulation of life habits as to diet, clothing, care of bowels, ventilation, etc.; the correction of nasal deformity, and the teaching of a proper nasal toilet.

Hypertrophic Rhinitis.—*Etiology.*—For the production of a hypertrophic rhinitis we must add to the already mentioned predisposing causes of chronic catarrhal rhinitis, irritation. It is quite conceivable that considerable hypertrophy of the membranes covering the turbinated bones, especially the inferior, may be produced by a long-continued overfunctioning of the membrane, caused by the breathing of vitiated air, but more often and I think practically all hypertrophy of a degree to demand surgical interference is produced by irritation of the membrane from without. The irritating agent may be chemical or physical and air-borne, or it may be and most frequently is due to the contact of the membrane with the retained secretions of the nose itself. This retention may be due to structural deformity of the nose or it may be due to the frequent tumefaction of the membrane which takes place during acute exacerbations of a chronic catarrhal rhinitis, or, to vasomotor disturbances. The hypertrophy may be limited to certain areas of the nose or it may be general; that is, one not infrequently sees the disease limited to the posterior ends of the turbinated bones and the membrane covering the posterior end of the septum; in which case there will be hypertrophy also of the lymphoid tissues of the nasopharynx. This condition of affairs the writer believes to be due to the irritation caused by the impact of expired air vitiated by the gaseous emanations from a disordered stomach. When free drainage from the accessory sinuses is interfered with hypertrophy takes place in the region of the middle turbinates and the tuberculum septi.

Pathology.—The pathology of hypertrophic rhinitis is that of the earlier stages of cirrhosis.

Symptoms.—The symptoms of hypertrophic rhinitis as such arise from obstruction. Hypertrophy of the inferior turbinated bones may be so great as not only to block respiration but lying on the floor of the nose and in contact with the septum they prevent proper drainage either forward or backward of the nasal secretions. Hypertrophy of either end leads to the same result but to a lesser degree. Hypertrophy of the middle turbinated bones seldom blocks respiration, but it blocks drainage from the accessory sinuses of the nose, causes a sensation of pressure in the region of the nasal and lacrymal bones, and conduces to frequent frontal headaches.

Treatment.—The principle underlying the treatment of hypertrophic rhinitis is the removal of structures obstructing respiration and the establishment of good drainage from the accessory cavities of the nose and the nose itself.

If there is a predisposing deformity it should be corrected; after which attention should be directed to the hypertrophy itself. It should be borne in mind that when the irritation is relieved by the establishment of drainage, the hypertrophic process ceases to be active; in fact a retrograde process sets up, therefore surgical measures should be as conservative as possible. All hypertrophic tissue should not be removed—only such as interferes with drainage. Even if there is some obstruction to respiration it will probably be relieved by the retrograde process set up, the obstruction to drainage having been removed. A patient thus relieved will probably continue to be chronically catarrhal and should be so treated.

As has been stated the hypertrophy is confined to certain parts of the nose. Hypertrophy of the posterior ends of the turbinated bodies may be removed by scissors or snare; the cold wire snare is most in favor. Hemorrhage has been reported from this operation, and its possible occurrence should be borne in mind; it may be almost certainly prevented by taking plenty of time in drawing the wire loop of the snare slowly through the growth into the cannula. By taking from one-half to three-fourths of an hour for the operation, I have been able to do practically a bloodless operation. A light, straight Sajous' snare that can be left in the nose after the growth has been seized is the best. There is no pain after the first tightening of the loop about the growth. The screw by which the loop is drawn into the cannula may be turned every four or five minutes and should be left at rest whenever the tightening causes pain.

Hypertrophy which involves the whole of the inferior turbinal is generally sufficiently relieved by trimming or cutting off the lower edge of that body so as to establish free drainage along the floor of the nose. This may be done by scissors or snare or by their combined use. Cauterization, chemical or electric, once in vogue is now happily seldom used.

Hypertrophy of the middle turbinated bones is, as a rule, confined to either the anterior or posterior ends. The anterior tip when hypertrophied interferes with drainage from the accessory sinuses and should be removed. This is best done by biting out a piece of the bone high up at its attachment by means of a cutting forceps. This having been done, the wire loop of a snare is thrown over the end of the bone, the end of the cannula being pushed into the notch just made and the wire loop, drawn into the cannula.

The after-treatment consists in keeping the nose clean which is best accomplished by means of a nasal douche.

Atrophic Rhinitis.—This is the bête noire of rhinologists, happily less frequently seen to-day than but a few years ago—a monument, if a negative thing may be a monument, to rhinological work. I have no figures at hand but from my observation in a large clinic I should say that when we see one case of atrophic rhinitis and ozena to-day we saw twenty-five cases twenty years ago.

Etiology.—Volumes have been written on the etiology in which many theories have been advanced. The reader who would and does not know these various theories is referred to the special works on rhinology. I shall here state my own theory and conclusions derived from observation and study during the last twenty-five years.

1. The atrophic membrane is essentially, pathologically considered, such a membrane as is seen in the late stage of a cirrhotic process.

2. One cannot conceive of this condition without believing that there existed at some time previously an earlier stage in which there was hypertrophy whether recognized or not.

3. An inferior turbinated bone which does not functionate does not erect or swell and therefore at no time fills the nose so as to suggest hypertrophy, as does the functionating bone whose covering is undergoing hypertrophy.

4. An inferior turbinated bone which is covered by a mucopurulent secretion whether moist or dry does not functionate, at least does not do so well, and the degree of functioning depends upon the thickness and character of the secretion which covers it.

5. The irritation resulting from the constant coating of a mucopurulent secretion causes a hypertrophic process in the membrane whether functioning or not and therefore

6. Hypertrophy of the membrane may take place

without being apparent on ordinary rhinoscopic observation.

7. Many children suffer from a chronic rhinitis with probable involvement of the ethmoid cells, whose noses are full of secretion of a mucopurulent character which prevents a proper functioning of the turbinated bones and yet is a source of a constant irritation to the rhinitic membrane.

8. With a certain rate of secretion in conjunction with a certain amount of air through the nose, all moisture is taken from the secretions, they become dry and form crusts that rest upon the membrane.

If the above propositions are true, we should not be surprised to see occasionally in the noses of young men and women the well-known picture of atrophic rhinitis in which the membrane over the inferior turbinated may be when brought to view either smooth or hob-nailed in appearance and drawn tightly down over a small bony framework. In the worst cases the whole interior of the nose is lined by a thick scab formed by the drying out of secretions, and on account of the retention of these scabs in the nose there develops the characteristic odor of ozena. This odor is probably due to the growth under the scab formation of the *Bacillus fœtidus*. That this disease is so comparatively infrequent at the present time is due to the greater attention paid to the catarrhal condition of children, to the early removal of adenoids, as well as to the better general handling of children as regards not only diet, etc., but the various diseases of childhood.

Symptoms.—Patients suffering from *simple atrophic rhinitis*, while their nasal passages are extremely wide and open, not infrequently complain of inability to breathe through the nose; there is an apparent inhibition of the sensory nerves supplying the mucous lining of the nose. I have spoken of simple atrophic rhinitis because we do see the disease without the crust formations or the characteristic odor of ozena, although most rhinologists consider ozena to be an atrophic rhinitis. Patients with *ozena* complain of the odor or if they do not themselves sense the odor they have been told of the foul breath and seek relief. They may also complain of the obstructed nasal respiration which may be due to the blocking of the nose by the scabbing or the nerve inhibition above referred to. Not infrequently the patient is brought by a parent while yet too young to seek relief independently. In such cases the parent complains of the foul and sickening odor or the scab formation.

Treatment.—Prophylaxis is the best treatment. Children who show symptoms of chronic rhinitis or who are subject to acute attacks or are subject to colds should be carefully examined not only as to the condition of their upper respiratory tract but as to their general condition, and whatever is found to be wrong should be corrected as far as possible. Careful attention should be paid to the noses of children who are convalescent from the exanthematous diseases and diphtheria to see that there is no left-over effect in the nose or its accessory sinuses or to the end that if such left-over effects be found they may be properly treated. To the extent that the above procedures are carried out, we may almost hope for the eradication of this dread disease.

Only in the early stages of the disease, while it is still confined to the membrane can one hope for a curative treatment, and this will depend upon one's ability to find and remove the cause. If a unilateral atrophy exists it may be due largely to a deviated septum, in which case the atrophy will be found in the more open nostril. The treatment consists in a submucous resection of the septum which opens up for use the previously obstructed nostril. The previously open and diseased side of the nose should now be plugged lightly with absorbent cotton (a plan suggested by Grenville MacDonald) which serves not only to institute a certain rest for the diseased membrane but, impeding the flow of air through that nostril, prevents the drying out of the secretions and consequent scab formations. The nose should be cleansed by the douche once or twice daily and the cotton then reinserted. If the disease is bilateral and due, as it frequently is, to chronic disease of the accessory sinuses, this sinus disease (see *Sinuses, Accessory Nasal*) should be treated to the end that the discharge from these cavities be stopped or lessened, when a toilet treatment of the nasal mucous membranes may be instituted—this will consist in cleansing the nose by douche or spray by one of the recognized solutions put up for the purpose. The nasal chambers having been cleaned a nebula of oil should be thrown into the nose for the purpose of covering the membrane with a coating of oil which tends for a time at least to protect the membrane from irritation as well as preventing or retarding functioning work of the membrane and therefore conducing to a rest cure of an overworked or irritated membrane. Autogenous vaccines may be used as an aid in the elimination of the nasal and accessory sinus discharges. The treatment of a well-established case of atrophic rhinitis can be but palliative, and the key note of such treatment is cleanliness. This demands for a considerable time the daily attention of the physician as the scabby nose of a sufferer from atrophic rhinitis can be cleansed only by the use of forceps, swabs, and douches. In extreme cases of bilateral atrophic rhinitis all intranasal surgery is contraindicated, unless possibly it is evident that some of the accessory sinuses are responsible for a large amount of the secretion in the nasal passages. And even then it is a question, if the turbinates are largely resorbed, whether surgery is not entirely contraindicated—whether it is not better to depend entirely upon the cleansing process; I have never known a case in which this cleansing process has been instituted and faithfully carried out that has not been improved and so improved that the careful patient has become able to care for his or her own nose in such a way as not to be a nuisance to self or an annoyance to friends. Weak solutions of peroxide of hydrogen may be used by the patient as a spray to be followed by a saline douche. The odor is much reduced by spraying the cleansed nose with weak solution of permanganate of potassium. LEWIS A. COFFIN.

Rhinœstrus.—A genus of gad-flies. The larvæ of *R. nasalis*, attack horses in Russia. This species may lay its eggs in the eye of man where the larvæ cause serious trouble. A. S. P.

Rhinopharyngitis Mutilans.—*Definition.*—A peculiar destructive ulceration of the nasopharynx prevalent in certain areas in the tropics, without constitutional symptoms and usually running a self-limited course with a tendency to cicatrization. It is almost certainly infectious and quite probably contagious. Its specific cause has not been discovered.

HISTORY AND GEOGRAPHICAL DISTRIBUTION.—Lesions similar to those which characterize this disease, and not to be accounted for by any connection with syphilis, tuberculosis, or leprosy, were mentioned in 1839 by Maxwell[1] who encountered them in Jamaica and believed them to be sequelæ of frambœsia (yaws). Following Maxwell in this belief, Numa Rat[2] described sixty cases which he encountered in a limited district on the windward side of the Island of Dominica, West Indies, as probably representing some late stage or sequel of yaws. C. W. Daniels,[3, 4] who encountered cases in Fiji, was the first to throw doubt upon their connection with yaws. Many observers who have had no familiarity with the condition and

who have seen it only casually have confounded it with leprosy, tertiary syphilis, or localized tuberculosis. It was differentiated from these diseases and from yaws and described as a disease *sui generis* under the name *rhinopharyngitis mutilans* by the present writer, first in 1904,[5] and again more fully in 1906.[6] Since its specific cause is still undetermined, and since any of the gross lesions characteristic of rhinopharyngitis mutilans may be produced by some other disease, its differentiation may be said to rest at present almost entirely upon its peculiar and extensive prevalence in certain places, certain known endemic areas. Among these are Fiji, Guam, the Caroline Islands, and the Island of Dominica, West Indies. A study of the condition at first hand in any one of these endemic regions will soon convince the most skeptical observer that he is dealing with a peculiar pathological condition which, whatever it may be, is certainly *not* syphilis, nor tuberculosis, nor leprosy.

The patient's denial of any venereal history, a failure to demonstrate the *Treponema pallidum* in any isolated case of extensive nasopharyngeal ulceration, and failure of such a case to respond in a prompt and striking way to iodides afford no sufficient grounds for excluding tertiary syphilis. Nor is failure to demonstrate the bacilli of leprosy or of tuberculosis in any such single case sufficient to exclude those diseases. Articles dealing with rhinopharyngitis mutilans have been published by several writers of very limited acquaintance with it; by some who have never been in any of the places where it is known to exist and who confess to having had no experience of it at all. An isolated case of rhinopharyngeal ulceration in a negro from Panama,[7] treated in New York, has been tentatively accepted as a case of rhinopharyngitis mutilans. From an extensive experience on the Isthmus, the present writer can state that the disease is unknown in Panama. Another case has been reported, with photograph, in the person of a confirmed leper, an inmate of a leper asylum;[7] and a third case, occurring in a white American adult, in which there was an acceptable history of syphilis contracted five years previously, and the lesions described were characteristic of that disease.[8, 9, 10] The reporting of such dubious cases as these, while the etiology and differentiation of rhinopharyngitis mutilans are still a problem, tends only to obscure and confuse the subject. It is not likely, as has been pointed out before, that any progress will be made in solving this problem until it is undertaken by competent investigators working in one of the endemic areas.

Mink and McLean[11] have made a clinical study of eighty-one cases in Guam and tabulated them in a valuable report. It is to be regretted that, owing to lack of familiarity with the Spanish language, these writers should have mistaken a common Spanish adjective, *gangosa*, meaning "nasal-voiced," for a substantive, and employed it as a title for their article and a name for rhinopharyngitis mutilans. Others have followed them in this error which, beside its essential incorrectness, tends to introduce confusion into nomenclature.

Etiology.—The disease affects persons of all ages; and from the fact that several members of the same family are often seen to be affected with its peculiar lesions and to be otherwise in good health, the disease would appear to be contagious. It may not improbably be caused, like the blastomycetic dermatitis, or like mycetoma, by the local invasion of a parasitic organism. No cases that can be regarded as authentic have yet been reported in others than Malays and negroes.

Clinical Course.—The patient, if seen early, as few are, complains of sore throat. On examination, an ulcer is seen on the back of the pharynx, on a faucial pillar, or on the free edge of the soft palate. It is superficial, movable, covered with a thin, dirty, greenish-gray or brownish-gray pellicle of slough. This is apparently the initial lesion. The pellicle breaks down and leaves an ulcer which steadily increases, advancing up the throat into the posterior nares. The disease begins in the soft parts, but, after reaching the soft palate and eating its way through its entire thickness, attacks the bone of the palate and nasal septum, finally destroying them. The serpiginous ulceration, after being thus active and advancing for months or years, usually arrests itself at this stage, the ulcers healing, and leaves the victim with no septum, the nasal cartilage and skin fallen in, the nose and mouth one large cavity. The faucial opening is apt to be narrowed by cicatricial tissue, making deglutition difficult. The disease rarely advances downward from the pharynx, the larynx is only exceptionally affected and phonation remains normal; though, owing to palatal destruction, the quality of the voice is deranged and articulation is defective, the speech being affected precisely as in any case of cleft palate. There are no constitutional symptoms. The patients, if they were so in the first place, remain well-fleshed, strong, and able to follow their usual avocations. The disease process having ceased, the patient carries its marks, in palatal bone destruction and pharyngeal scar tissue, to old age. In a few of the cases, fewer than ten per cent. of them, the process is not arrested at this stage, and the ulceration destroys the cartilage and skin of the nose and advances upon the face. In about twenty-five per cent. of the cases (twenty-one out of the eighty-one cases in Mink and McLean's series) the process extends up through the nasal ducts into the conjunctivæ, where it produces in the eyelids granulation tissue at first, scar tissue afterward, with ultimate inability to close the eyes, keratitis and blindness frequently resulting. The tongue appears never to be involved. The upper lip usually remains as a bridge, in cases in which the nose has been destroyed, and through the anterior nares one looks into the mouth and throat. Even in these most extensive and aggravated cases, however, there is no evident impairment of the general health.

Diagnosis.—Rhinopharyngitis mutilans must be distinguished from *leprosy* by the tendency to a spontaneous cure, the absence of leprous lesions elsewhere, and the absence of the lepra bacillus; from *tuberculosis* by the non-existence of tuberculosis in other parts of organs, the infrequency of downward extension and laryngeal involvement, the peculiar tendency to extension through the nasal ducts and involvement of the eyelids, and the absence of the tubercle bacillus in the lesions; from *acquired syphilis* by the absence of any signs or history of primary or secondary syphilis, by the onset of the disease in infancy and childhood, by the absence of *Treponema pallidum* from the lesions; from *hereditary syphilis* by the absence of any of the signs of that disease and by its incidence in the healthy children of healthy parents. In its endemic areas where its prevalence is a familiar fact the diagnosis presents no difficulty.

Prognosis.—In natives who are well provided with the necessaries of life, who live in comparatively good hygienic surroundings, and who can be kept under observation and treatment, a favorable prognosis can be given for most cases. In children of five years or less the onset of the disease is apt to be sudden, and accompanied by moderate or high fever, and to result in death within a very few days. The term "fulminating" has been applied to these fatal cases in infancy and childhood.

Treatment.—Whether or not the process be due to some specific infection, it is at any rate difficult to arrest, especially in cases where the serpiginous ulceration has advanced into the nares and is difficult of access. In the few cases seen early, when the disease

is limited to the pharynx, and in the still rarer cases in which its beginning is visible in the anterior nares, cauterization with the silver nitrate stick may be practised. Swabbing or spraying with hydrogen peroxide is effective in removing the sloughing surface of the ulcer and developing a healthy granulating surface. Granulation may be stimulated by the application of tincture of iodine. The use of a detergent and stimulating gargle is beneficial. In some cases iron and tonics may be useful. Potassium iodide internally in full doses is usually well borne and seems to do good in some cases.

J. F. Leys.

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Rhinophyma.—See *Acne Rosacea.*

Rhinoscleroma.—Rhinoscleroma (from ῥίς, nose, and σκλήρωμα, a hard swelling) is a slowly progressing inflammatory condition which affects particularly the nasal tract, and which is characterized by the production of diffuse and nodular thickenings and indurations of the tissues. Although the disease usually begins in the nose and is most frequently seen in that location, it may begin in the pharynx, larynx, or palate and spread to any adjacent structure so that characteristic changes may be found in the trachea and bronchi, Eustachian tube, auditory canal and orbit. To the cases which are predominantly pharyngeal the term *pharyngoscleroma* is sometimes applied while the general term *scleroma respiratorium* emphasizes the widespread distribution of the lesions as seen in some instances.

Rhinoscleroma has been, and still is, a disease of eastern Austria and southwestern Russia, but attention has been recently called to its slow but steady advance toward the west, spreading from Russian Poland and Galicia into Bohemia. In addition, isolated cases have been reported from almost all parts of the world. The literature now includes about twenty-five cases from the United States, practically all of which have been among the foreign born. It is doubted by some whether any authentic case has been shown to have originated in this country.

Cases of rhinoscleroma are usually diagnosed in young and middle-aged adults. Because of the slow progress of the disease, usually the condition has been manifest for some time before the patients present themselves for examination. The sexes are about equally represented and the very poor and those from the lowest walks of life are especially prone to be attacked.

In 1882, Fritsch described a bacillus which he found present in all of the twelve cases of rhinoscleroma which he investigated. This non-motile organism, now known as the *Bacillus rhinoscleromatis*, resembles in many respects the Friedländer pneumobacillus. Morphologically, the resemblance is complete and the cultural characteristics are likewise almost identical. It differs culturally from *Bacillus mucosus capsulatus* only in that it forms no gas in dextrose bouillon, no acid in lactose bouillon, and never coagulates milk. Formerly described as Gram positive, it has since been shown to decolorize by this method. Because of this close resemblance to the other members of the *Bacillus mucosus capsulatus* group, doubt had been expressed as to whether the so-called *Bacillus rhinoscleromatis* should be considered the etiological factor in the production of the disease and not simply a secondary invader. Until recently the only evidence in favor of this organism as the causal agent has been its constant presence in the diseased tissue and the experimental production of nodular lesions of the conjunctiva of guinea-pigs. In 1910, however, Galli showed that in the blood serum of those suffering from rhinoscleroma there are antibodies which give a specific reaction toward the bacillus of rhinoscleroma and not toward the Friedländer bacillus. This observation is of great assistance in determining the position of the organism of Fritsch as the causal factor, but the question must still be considered an open one.

Rhinoscleroma begins as a localized hard papule, usually in some part of the nose, particularly the mucosa of the alæ and septum. In the course of a few years the process spreads to involve the cartilages and skin until finally the entire nose with the upper lip and palate may exhibit a diffuse induration which may be elevated and nodular. The structures involved become rigid and hard to the touch, resembling cartilage in consistency. In the increase in the size of the nose the organ becomes broader and flatter and the nasal passages are reduced in size but even in advanced cases, the various anatomical landmarks remain so that it is evident the disease involves the organ as a whole and is not a new growth destroying or replacing it, a point which has been emphasized by Richards in the differential diagnosis of rhinoscleroma and malignancy.

The cutaneous areas are often covered with a red or brownish-red skin, smooth or wrinkled and often shiny. Fissures frequently appear and both cutaneous and mucous areas may show secondary infection, ulceration and foul discharge. In the mucosa of nose, pharynx, and larynx the dense cartilage-like thickenings and indurations may become puckered and contracted through cicatrization. The olfactory mucosa usually escapes involvement so that the sense of smell is frequently preserved as long as nasal respiration is possible but deafness may result from occlusion of the Eustachian tubes. In the course of the disease the nasal passages become greatly narrowed or even occluded. The increasing respiratory difficulty and the facial disfigurement are the features of the disease of which the patients complain most bitterly.

In perhaps ten per cent. of the cases the disease begins elsewhere than in the nose. In these the lesions are of the same general character as described for the nasal tract while the symptoms depend upon the part involved.

Microscopically, rhinoscleroma presents the picture of a chronic infective granuloma. The epithelium may show little change unless secondarily infected or there may be a moderate epithelial proliferation with vacuolization of some of the cells. The underlying granulation tissue and fibrous connective tissue which together give the indurative character to the lesions are often densely infiltrated with round cells. In this tissue the bacilli can be demonstrated by certain staining methods. Usually there are to be found numerous connective-tissue cells containing one or more vacuoles or even showing a reticulated structure. These cells are the so-called *foam cells* or *Mikulicz' cells* and have been described as more or less characteristic of rhinoscleroma. They are not, however, greatly unlike similar vacuolated cells found in leprosy and, like the cells in leprous granulation tissue, may show large numbers of intracellular bacilli. Another degenerative change commonly met with is the formation of intracellular hyaline spherules which are strongly fuchsinophilic and which are

found between, as well as within, the cells. In general, it may be said that the histological picture is not sufficiently distinctive to afford sure ground for diagnosis in all cases and search should be made for the bacilli in properly stained sections as well as for the vacuolar and hyaline degenerations just described.

Malignancy, keloid, syphilis, tuberculosis, leprosy, rhinophyma, etc., must be considered in the differential diagnosis of rhinoscleroma. The practical limitation of the disease, in this country, to the foreign born of certain races, the age of the patient, the slow onset and progress of the disease, the characteristic hardness of the lesions and the usual absence of ulceration, unless due to secondary infection, will assist in the recognition of the condition. In doubtful cases a small portion should be removed for microscopical examination.

The course of the disease is a slowly but steadily progressive one. Aside from such conditions as are dependent upon the chronic inflammation of the upper air passages and the obstruction to respiration, the general health does not appear to suffer and the patients live for many years with increasing difficulty from the progressive stenosis of the upper respiratory tract, which may be indicated by dyspnea, hoarseness, dysphagia, mouth breathing, loss of sense of smell, tinnitus, or even deafness.

In general, rhinoscleroma has proven altogether resistant to treatment and the prognosis has been correspondingly unfavorable. It is possible that if the disease could be recognized in its early stage as a small localized papule, surgical removal might prove useful, but patients are rarely seen in that stage and diagnosis is difficult. In any later period, surgical intervention is but palliative and return of the growth is always experienced. Removal of the growth with knife, curette, or cautery may be required, however, to give relief from respiratory obstruction. Sodium salicylate and salicylic acid, by the mouth and injected in dilute solution into the tumor, have been recommended but are of doubtful value, and the administration of salvarsan has also proven unavailing. Of late much work has been done with autogenous vaccines of the rhinoscleroma bacillus, and with a preparation derived from stock cultures of *Bacillus rhinoscleromatis* termed sclerin or rhinosclerin. Some authors have reported that the progress of the disease has been checked, especially when injections of an autogenous vaccine have been made at intervals over a considerable period of time. No cures have been obtained, apparently, and Richards reports absolutely no reaction and no evidence of improvement even after the injection of very large doses. By far the best results have been obtained by the use of *x*-rays. Zwillinger, in particular, reports a high degree of success from this method of treatment and believes that healing of the process may be accomplished. These results, coupled with the possibility of earlier diagnosis than hitherto through application of serological methods, offer much hope.

CARL VERNON WELLER.

Rhinoscopy.—In order to obtain a successful inspection of the nasal cavities and neighboring parts, it is necessary to have the best illumination that it is possible to obtain, means for projecting this light, and aids through which this light can gain ingress into the remote parts to be examined.

Previous to the inspection of the interior of the nasal cavity, it is always well to make a thorough examination of the external nose. The external configuration of the nose, the aspect which it presents at the root, the evidences of deviation, the presence or absence of marked movement of the alæ nasi, the presence or absence of sound in nasal breathing, the relation of the alæ to the septum, and the outlines of the anterior nares should all be thoroughly considered before the interior of the nose is inspected. The appearance of the cutaneous covering of the external nose, the presence of excoriation on the upper lip, the odor of the breath, and the character of the voice should all be thought of in this preliminary examination.

In order that the examination may be successful, it is necessary to have, first, a good source of light; second, a concave reflecting mirror for projecting this light; third, variously devised instruments called speculums by which the vestibule of the nose is expanded and a greater volume of light admitted to the interior; and small plane mirrors for diverting the reflected light and receiving the image which is thus created.

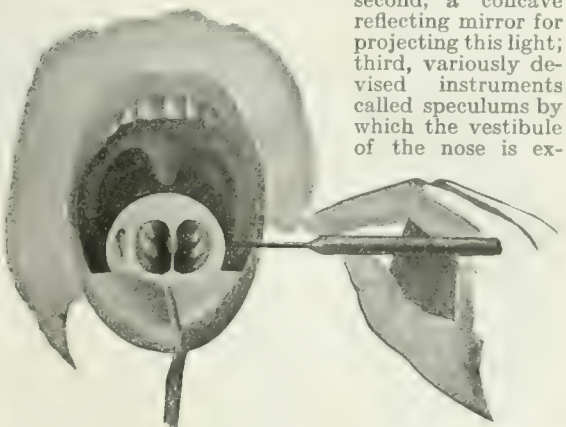

FIG. 4452.—Posterior Rhinoscopy Mirror in Position Showing Image Reflected Therein.

On account of the exigencies of circumstances, the use of the best light obtainable, sunlight, is not possible. The light which is sought is one as nearly white as possible. The three sources of light which are most frequently used are gaslight, electric light, and lamplight. Any source of light of sufficient intensity and penetrating power can be used when circumstances demand it, and one should adapt himself to these varying conditions. In office work the source of light can be controlled, and one should select that which gives the best illumination with the least inconvenience. For average general utility, gas fed through an Argand burner serves the best purpose. To increase its efficiency, use may be made of the Welsbach mantle, which gives a whiter light. With a moderate degree of care the mantles last for many months. The light thus obtained may be fixed or movable. It is better to have the burner attached to a movable bracket which can be placed at various angles and raised or lowered at pleasure. The apparatus is completed by surrounding the light with a cylindrical japanned tin or asbestos chimney which has a circular opening of two and a half inches in diameter through its lateral wall at the middle. This contrivance shuts off all the rays of the light excepting those coming through the lateral aperture. A further refinement of the equipment is the device known as the Mackenzie condenser. This latter device is not essential but renders the examination easier for the operator.

The electric light may be used in two methods, directly and indirectly. The direct method is the use of the electric headlight; the indirect method is the use of the electric light by reflection, as we use gaslight. The objection to the electric headlight is its weight and its want of penetration. Within recent years the various forms of instruments for the direct use of electric light have been so perfected that we have many excellent instruments that are now used for this purpose. They are principally used for operative work and house visitations, as they are not yet adaptable for the consultation room work. Among the most acceptable of these instruments are the Phillips

lamp and the Klaar headlight. With the use of the ground-glass globes we have a very good source of indirect illumination in electricity. The student's or Rochester lamp forms the best form of oil light. This light can be made whiter by the addition of a small piece of camphor to the oil, as suggested by Sajous.

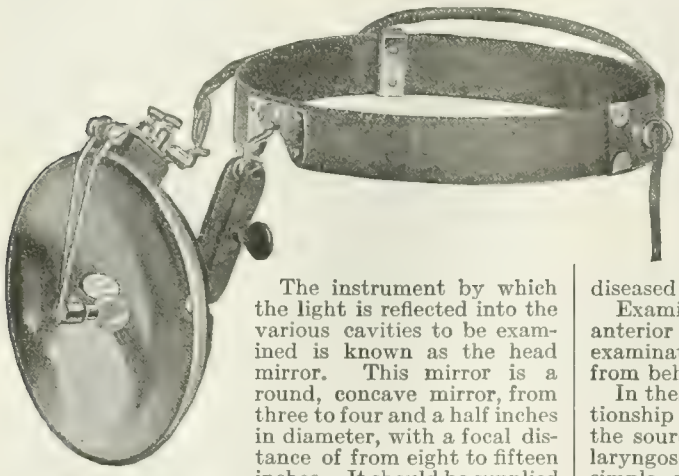

Fig. 4453. The Klaar Headlight.

The instrument by which the light is reflected into the various cavities to be examined is known as the head mirror. This mirror is a round, concave mirror, from three to four and a half inches in diameter, with a focal distance of from eight to fifteen inches. It should be supplied with a central orifice. The central orifice is for the purpose of more exact observation, as, through its use, the angles of incidence and reflection are made to coincide, and, therefore, the picture is rendered more perfect. This mirror is more serviceable if it is worn suspended through a ball-and-socket joint from a head-band which encircles the forehead. It may also be suspended from a rod which is attached to the lamp which furnishes the source of light. Steadiness and immobility, when it is fixed at the proper angle, are the most desirable features in the reflecting mirror. One having a diameter of three inches has, in my hands, proved the most serviceable. For the purpose of permitting as much light to enter the nasal cavity as possible, it is necessary gently to dilate the vestibule through the means of a speculum which is introduced into the anterior nares. Those speculums which are constructed on the bivalve system are the most serviceable. Their numbers are legion. I prefer the Schnitzler's. Hartmann's, Ingals', Roth's, and others are of this style. A number of fine, wire-like speculums, such as the Jarvis, the Bosworth, the Goodwillie, and the Ives, are made on the bivalve principle. Others are made to be self-retaining. The Schnitzler instrument, as offered for sale in the shops, is too cumbersome. I have it in a light frame, which not only makes a neater but a more useful instrument. The individual preference in speculums is also a question of adaptability and use. In making examination of the postnasal space and the nasal cavities from behind, which is designated as posterior rhinoscopy, it is necessary to have, in addition to a good light and the head reflector, small plane mirrors constructed like those used in examining the larynx, and a tongue depressor. These small plane mirrors are fixed at an angle of 105° to the shaft, and vary in size from three-eighths to three-quarters of an inch in diameter. The largest mirror which it is possible to use in the individual case should always be employed. This mirror is used to reflect the light behind the curtain of the palate.

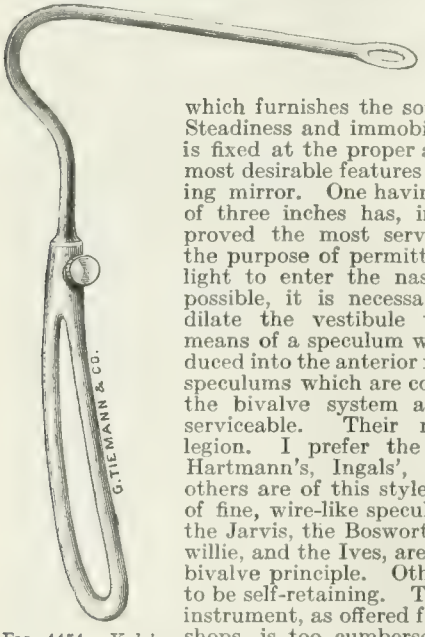

Fig. 4454.—Kyle's Tongue Depressor.

Usually it is necessary to control the tongue, as only a few patients are able to hold it relaxed in the floor of the mouth during an examination; therefore it becomes necessary to depress it through the aid of a tongue depressor. Numerous forms of depressors are on the market, but one that especially recommends itself, on account of its simplicity and of the ease with which it may be kept aseptic, is the one invented by Dr. D. Braden Kyle (Fig. 4454).

The nasal probe is indispensable to a thorough examination and understanding of diseased conditions in the nasal cavities.

Examination of the nasal chambers through the anterior nares is called anterior rhinoscopy, while examination of the upper pharynx and nasal chambers from behind is known as posterior rhinoscopy.

In these examinations of the nasal cavities the relationship of the patient and physician with regard to the source of light is absolutely the same as it is in laryngoscopic examinations. The patient sits in a simple straight-back chair, without head support. The physician sits directly in front of the patient, or what is preferable, directly beside and on the left-hand side of the patient. The source of light should be to the right of the patient, just to the side of and on a level with the upper border of the right ear. The patient should sit in an easy, erect, comfortable position, when the examiner reflects the light in a circle just upon the area to be examined. Either may then move, within a certain latitude, from this fixed position; nevertheless, it will be noted that when they return to the examining position the light will fall directly on the point upon which it originally fell. The method of examination, as well as the character of furniture used for patient and doctor, is a question of individual preference and perfected method on the part of the operator.

In anterior rhinoscopy the operator first makes a mental notation of the appearance and general configuration of the external nose. The light is then thrown upon the nose, the head of the patient is slightly tilted backward, and the general appearance, the patency, and the outline of the anterior nares are noted, after which the tip of the nose is slightly tilted upward and the vestibule is thoroughly inspected. Little children fear instruments, and, as their hairs are undeveloped, we may often make a thorough inspection without the use of speculums. Special care should be made to note fissures, abrasions, or pimples on the inner surface of the nares, which would make the introduction of the speculum painful.

We are now prepared to introduce the speculum. This instrument should be gently insinuated into the anterior nares in a closed state. After the speculum is placed slightly within the vestibule, it is moderately dilated until slight resistance is felt. No pain should ever be given. With the instrument in position, the two crura being controlled by the pressure of the thumb and index finger of the left hand and with the little finger of the same hand hooked under the lower jaw, the patient is practically under control of the examiner. Slight pressure is usually all that is sufficient to make the patient move in a required direction. With the patient's head slightly tilted forward, the first object that attracts attention is the prominent rounded red mass on the outer wall projecting nearly to the floor of the nose, and which we recognize as the anterior end of the inferior tur-

binate body. Opposite this we recognize the cartilaginous wall of the septum, and below, the floor of the nose and the inferior meatus. According to the amount of space between the inferior turbinate and the septum, we can see to a greater or less depth within the nasal cavity toward the pharynx. In many cases, with a fair amount of space between these parts, or when the turbinal tissue is contracted under the use of cocaine, we can well see the posterior pharyngeal wall. A tilting of the patient's head slightly backward brings into view the middle turbinate, which is paler and more translucent than the inferior, and just opposite its anterior extremity on the septal wall is seen often an aggregation of erectal tissues, which is designated the tuberculum septi. The whole extent of the visible upper surface of the inferior turbinate is seen in this position, as well as the middle meatus. It is only when the middle turbinate is removed or has undergone great atrophy that the interesting features contained within the middle meatus are brought under observation. Tilting of the patient's head still farther backward brings into view the upper portion of the middle turbinate and the roof of the nasal cavity. It is rather unusual to be able to demonstrate the superior turbinate body. Occasionally the orifice of the sphenoidal sinus can be made out. The use of the probe is indispensable in making this examination, and so also is the instillation, after the preliminary examination, of a very mild solution of cocaine —a procedure which should be followed by a re-examination of the parts after the effects of the drug have become manifest. Great care should be exercised in examining the septum; it should be viewed from both sides, and the head should be held carefully in the middle line.

Posterior rhinoscopy is the most difficult procedure in the examination of the upper air tract, and therefore requires more tact and skill in its prosecution. The position of the patient and of the source of light, and the methods of reflection are the same as in anterior rhinoscopy. The only instrumental addition is the rhinoscopic mirror and the tongue depressor. I have never found it necessary to make use of the so-called palate retractors, but see no objection to the use of such an instrument for holding forward the soft palate, if the examiner so desire. The most desirable instrument for retracting the palate is that invented by Dr. J. A. White. Occasionally the examination can be made without the use of a tongue depressor, but this is exceedingly rare. After depressing the tongue, and noting the space between the soft palate and the pharyngeal wall, as well as that between the pendent uvula and the base of the tongue, the largest size mirror which it is possible to use is gauged. The mirror is first heated to a proper temperature and the tongue carefully depressed. In introducing the tongue depressor care should be exercised in so introducing it that the tip of the tongue depressor first comes in contact with the tongue just posterior to its arch, which is somewhat anterior to the circumvallate papillæ. The tongue is then drawn downward and forward into the floor of the mouth. Backward pressure of the tongue is always to be avoided, as it is certain to give rise to retching and gagging.

If the depressor is so placed as to excite distress on the patient's part, it should be immediately removed and replaced. The depressor should be held between the thumb and index finger of the left hand, while the other fingers pass under the patient's chin. The mirror, which has been properly warmed, being lightly held between the thumb and index-finger of the right hand, is now quickly introduced into the widely open mouth along its left wall until we come to the dependent palatine arch. The important feature in the introduction of the mirror is so to insert it as not to come in contact with any of the tissues. As the palatine arch is reached, the mirror is gently insinuated by slight depression and rotation so as to glide through the space between the left pillar and the base of the tongue without coming in contact with either.

After the mirror has passed behind the palate and has reached the pharyngeal space, the operator, by slightly rotating the handle, may bring the reflecting surface around so as to face him, and then he should slightly depress the handle so as to carry the mirror upward until its upper border is slightly hidden behind the soft palate. The mirror now being in position, its handle is so held toward the left angle of the patient's mouth that there is no interference with the thorough illumination of the buccal cavity. Finally, the mirror is to be rotated from right to left, depressed and elevated, and given different degrees of angles while in position so as to bring into view in rapid succession the various surfaces and parts of the upper pharynx and back of the nose.

The success of the procedure depends upon the depression of the tongue, the careful introduction of the mirror, and the ability of the patient, not only thoroughly to relax the soft palate, but also to hold it immobile in this relaxed state long enough for the operator to make a thorough inspection of the parts. The patient is an uncertain quantity. Many can submit to a rhinoscopic examination without any difficulty; others require careful manipulation and several efforts have to be made before a successful view is obtained; and, finally, there are a few who are so constituted as to present almost insurmountable difficulties to the exploration. The greatest difficulty is the retraction of the soft palate, which in some individuals takes place immediately upon the introduction of the mirror into the mouth. Careful training in nasal breathing with the open mouth and with the sounding of the nasal consonants en and em, will often overcome this obstacle. Among the other methods which have been suggested for overcoming these obstacles may be mentioned the application of a five-per-cent. solution of cocaine to the palate and postpharyngeal wall, and the employment of the palate hook. The image reflected in the mirror at any given moment represents only a small section of the whole region. Consequently, in order to gain a fairly complete view, it is necessary to construct it in one's mind from the separate smaller pictures obtained by changing from time to time the angle at which the mirror is placed. Usually one observes first the upper surface of the soft palate and the lower portion of the posterior border of the septum which forms the inner boundary of the postnasal orifice, the choanæ. Then, by giving the mirror a slight upward inclination, it will bring into view the whole length of the septum, broad above and tapering to a narrow edge below, and the posterior view of the nasal cavities as displayed through the choanæ. On either outer wall, from above downward, will be noted the ridge of the superior turbinate body; immediately below it and separated from it by a dark line—the superior meatus—will be observed the middle turbinate body which stands out as a somewhat elongated fusiform body of a very faint pinkish-white appearance. Below the middle turbinal body will be seen the middle meatus, and immediately below this the upper half of the inferior turbinate body, which ofttimes seems to merge into the floor of the choanæ.

The color of the inferior turbinal body is of a pinkish white, resembling much the color that an ordinary mucous membrane assumes when edematous. By slightly inclining the mirror to right or left, the corresponding mouth of the Eustachian tube will be observed, as well as the depression which separates it from the postpharyngeal wall—the fossa of Rosenmüller. By changing the angle of the mirror to a more obtuse angle, the dome-like vault of the pharynx

will be brought into view, as well as the upper portion of the postpharyngeal wall. The vault of the pharynx is usually dome-like and smooth in its contour. In some individuals it may show elevations and depressions, or be so filled out as to appear flat, these alterations depending upon the amount and degree of enlargement of the pharyngeal tonsil.

Besides the method above described for the use of reflected light, we have as additional aids for diagnostic purposes in rhinology, the use of variously devised instruments for direct illumination of the nasal and pharyngeal cavities. The simplest form of direct illumination of the nasal and pharyngeal cavities is through a small incandescent electric bulb, well hooded, and provided with a long flexible stem which can be bent for appropriate introduction into the postnasal chamber.

The most appropriate instrument perfected for this purpose is the Hays pharyngoscope which is planned like an endoscope. It consists of a horizontal shaft eight inches in length, and three-eighths of an inch in width, which is nearly flat. It consists of three tubes. The two lateral tubes convey the wires for the two lamps at the distal terminations. The central tube conveys the telescope. The mirror at the end of the telescope can be rotated so as to give a view from above or below. The vertical portion is used as a handle and the conveyer of the electrical conductors to batteries or rheostat. The instrument is introduced flat upon the tongue as one would introduce a tongue depressor, approaching to within a fraction of an inch of the postpharyngeal wall. When the instrument is introduced into position, the patient is directed to close the mouth and breathe through the nose, which causes the soft palate to relax, and the mirror being rotated upward the postpharynx is brought into observation through the telescope. By rotations of the mirror downward, the view of the larynx may be obtained.

Dr. Edgar Holmes, of Boston, has invented a similar device which he designated as the nasopharyngoscope, and which consists of a single tube, with electric light and lens. The nasopharyngoscope is introduced into one or the other nasal cavities through the inferior meatus. It is especially designed to give a perfect view of the condition of and about the Eustachian tube orifices.

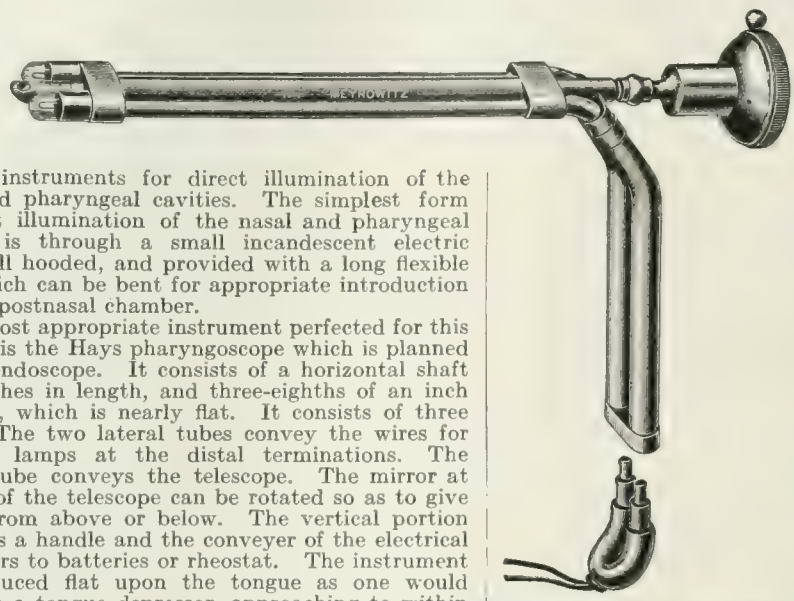

Fig. 4455.—The Hays Pharyngoscope.

The Röntgen ray is used for diagnosing the condition of the various sinuses communicating with the nasal cavities and for the discovery of foreign bodies which may be located within or thereabout. Full description of their use and value will be given under appropriate articles.

Besides the rhinoscopic methods of exploration of the nasal chambers and postnasal cavity we have, as additional aids to diagnosis, the digital exploration and the use of electric transillumination. Digital exploration is especially of value in exploration of the postnasal cavity in very youthful patients and in adults in whom it is impossible to make use of posterior rhinoscopy, or in whom, for various other reasons, it is desirable to make use of this method. This procedure can usually be made in little ones, without causing alarm, by the use of judicious tact. No instruments are necessary. The hands should be well washed and the index finger scrubbed with a nail brush before the examination is made. The child is seated in the examining chair while the parent sits in front of the child and holds the little one's hands. The operator stands to the left side of and facing the patient, with the right hand firmly grasping the vertex of the head. I usually find it wise to tell the patient what I propose doing and of its unpleasant nature, but at the same time I assure him that the procedure does not cause pain. The patient is then told to open widely the mouth, the hands and head are firmly grasped, and the index-finger of the right hand is quickly but dextrously introduced into the mouth and behind the soft palate into the postnasal place. In this manner the character and condition of this region may be quickly determined through the tactile sense.

Another method of making the examination is by placing the child in the position described by Dr. A. A. Bliss. By this method the child is placed in the lap of a nurse or parent, facing forward. The little one's legs are held firmly between the legs of the assistant, while the arms of the assistant are slipped under the armpit of the patient and the hands extended upward and held firmly on either side of the head. The child is thus held immobile.

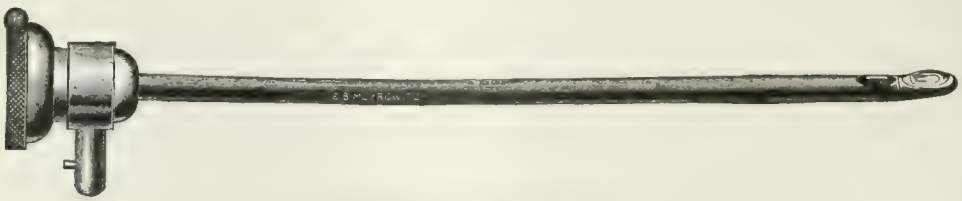

Fig. 4456.—The Holmes Nasopharyngoscope.

Transillumination of the accessory cavities is resorted to as an aid to the diagnosis of the condition of these pneumatic cavities. The value of this method of exploration lies in the fact that most of the pneumatic spaces in the normal state allow the transmission of rays of light through their thin walls. The light used for this purpose is electric, furnished through the medium of a small lamp of about six candle-power. See article on *Sinuses, Accessory Nasal.*

Charles W. Richardson.

Rhinosporidium.—A genus of Sporozoa, Family, *Sarcocystidæ*, with a well-defined sporoblast. *R.*

kinealyi has been recorded only once. It caused a polypus on the nasal septum of an Indian in Calcutta. See *Protozoa.* A. S. P.

Rhipicephalinæ.—A subfamily of ticks, in which the palpi are no longer than broad and the frontal margin of the body is emarginate. The genera included are *Euripicephalus, Margaropus, Rhipicentor, Dermacentor,* and *Hæmaphysalis.* Many species carry fevers caused by protozoans of the genus *Babesia;* some, like *Dermacentor andersoni,* transmit fevers of unknown cause, such as spotted fever. See *Arachnida.* A. S. P.

Rhizoglyphus.—A genus of small mites, Family, *Tyroglyphidæ. R. parasiticus* has very short legs which are armed with spines. It invades the skin on the soles of the feet of Indian coolies and causes sores. See *Arachnida.* A. S. P.

Rhizopoda.—A group of the Sarcodina which contains many parasites. Pseudopodia take the form of loose lobose or reticulate processes. The Amebæ and Foraminifera are the most important representatives. See *Protozoa.* A. S. P.

Rhizostoma.—A genus of large jelly-fishes. The great medusæ are very common in tropical shore waters. There is no mouth but food is taken in through many minute apertures by ciliary action. Several species may cause local redness or irritation when touched. This is due to the stings of nematocysts which are numerous on most parts of the body. A. S. P.

Rhodinus.—A genus of true bugs, Hemiptera. *R. prolixus* is found in Colombia and Venezuela where it bites man. A. S. P.

Rhubarb.—See *Rheum.*

Rhus Glabra (N.F.).—Sumac or Sumach. The dried ripe fruit of *Rhus glabra* L. (fam. *Anacardiaceæ*). This very handsome shrub or small tree grows abundantly in dry places throughout the greater part of North America. It is well distinguished by its smooth young branches from the stag-horn sumac (*R. typhina* L.) upon which they are velvety, and it bears little resemblance to other species. R. copallina has the leaf rachis winged between the leaflets. The poison sumac (*R. vernix* L.; see *Poisonous Plants*) has smooth green or yellowish-green fruits, in very loose open panicles, while that of *R. glabra* occurs in very large and very dense pyramidal crimson masses. The commercial fruits are about a sixth of an inch long and broad, and somewhat flattened, ovoid, obtuse, truncate at the base. The epicarp is of a deep crimson color and glandular-tomentose, and contains a single smooth yellowish stone. The hairy covering is strongly acid and astringent. The hairs are rather short and matted, those of the stag-horn sumac being shaggy. The drug contains two different classes of constituents, imparting distinct medicinal properties, besides the fatty oil of the seeds. About two per cent. or three per cent. of tannic acid and a very little gallic acid make it a mild and useful astringent, while its malic acid renders it distinctly refrigerant. For the latter purpose it is now scarcely employed, although it was largely so during earlier periods, when lemons and similar refrigerant fruits were less readily obtainable in country districts. As an astringent, sumac berries are usually employed for gargling, in various forms of sore throat, and are frequently combined with chlorate of potash. The acid taste renders this more grateful than other throat astringents. The drug is also often used as an intestinal astringent. The principal preparation, formerly official, is the fluid extract, which contains ten per cent. of glycerin, and the internal dose of which is fl. ʒss.–i. (2.0–4.0). This is commonly diluted with from one to three parts of water, to be used as a gargle, though the decoction and infusion are more commonly employed for that purpose.

Henry H. Rusby.

Rhus Toxicodendron.—Poison Ivy, Poison Oak. The fresh leaves of *Rhus radicans* L. (fam. *Anacardiaceæ*). The general account of this plant will be found under the title *Poisonous Plants.* It is introduced here merely to refer to its homeopathic use, chiefly in the form of the tincture, in doses under two minims and usually minute, in the treatment of "paralysis, skin diseases, and incontinence of urine." Most physicians have failed to find its use warranted.

Henry H. Rusby.

Rhynchobdellida.—An order of leeches. No jaws are present but there is an extensile proboscis. Most of these leeches are small and do not attack man. See *Hirudinea.* A. S. P.

Rice Bodies.—*Synonyms:* Corpuscula or Corpora oryzoideæ; melon-seed bodies. In chronic tuberculous affections of the tendon sheaths, bursæ, and synovial membranes, there are frequently formed small hyaline bodies resembling grains of rice or boiled sago. They are often oval, flattened, and yellow, resembling melon-seeds. On section they are homogeneous or granular, or concentrically laminated. In the central portion there is usually a small cleft. Many of these bodies possess a definite capsule, which is narrow, and is made up of concentric layers containing a varying number of nuclei. In the main mass nuclei are either not present at all or are found in very small numbers. Others consist of a hyaline fibrous tissue which in certain parts may show few nuclei. Some are made up wholly of fibrin, while in others the fibrin consists of bands scattered throughout the connective tissue. Giant cells are often present. As shown by the staining reactions these bodies for the greater part represent organized masses of fibrin which have undergone a hyaline change. All stages of the process may be seen. Some of the bodies stain throughout as fibrin with the Weigert fibrin stain; in other cases the hyaline substance stains red with Van Gieson's method. Double staining shows in others the presence of fibrin threads in the midst of the hyaline fibrous tissue. Van Gieson's method causes some of the bodies to take a yellow or brownish stain, the material of which these are composed not giving a fibrin reaction. A deep diffuse blue staining with hematoxylin shows the presence of lime salts in others. There has been much dispute over the origin of the fibrin in these bodies, some writers holding that it is the result of a "fibrinoid degeneration" of granulation tissue. The actual facts, however, tend to support the view that the majority of these bodies are formed from masses of exudative fibrin which, becoming organized, undergoes a hyaline change.

As shown by the staining the genesis and nature of these bodies must vary. They may consist of fibrinous masses loosened from a fibrinous exudate covering the inner surface of the tendon sheath or bursa; or of partly organized masses of fibrin which have become loosened. The most common mode of formation is from loosened masses of tuberculous or syphilitic granulation tissue. The inner surface of the tendon sheath or bursa in such cases presents a

polypoid or villous appearance due to organizing masses of fibrin. The connective tissue grows into the fibrin, organizing it, and after organization becomes changed into a hyaline substance possessing no nuclei. At the end of the villi there are thus formed more or less firmly attached hyaline bodies, which when loosened from their attachments become rice bodies. Around the detached body fresh deposits of fibrin take place, through the organization of which the body acquires a concentric laminated appearance. The hyaline change may begin at the periphery or center of the body, or in any portion of its substance. It is also probable that portions of necrotic tissue loosened from the inner surface of a tuberculous hygroma may give rise to rice bodies. Their form and size are the result of pressure due to movements of the affected joint.

By the majority of writers the presence of rice bodies in the joints, in the sheaths of tendons, or in the bursæ, is regarded as positive evidence of the tuberculous nature of the affection. In the great majority of cases the process is undoubtedly tuberculous; tubercle bacilli may be found in numbers upon the surface of the rice bodies, and occasionally within their substance. The formation of these bodies is, however, characteristic of a fibrinous exudate within the structures named, whether due to tuberculosis, syphilis, or other infection. The number of the bodies bears a certain relation to the chronicity of the process.

In many cases great numbers of the bodies may be present within the distended sheath or hygroma. In some cases they may be distinctly felt, and give a marked crepitation when moved upon each other. On cutting into the sac the little hyaline bodies may roll out in great numbers. ALDRED SCOTT WARTHIN.

Richardson, Maurice Howe.—Born at Athol, Mass., Dec. 31, 1851, he was graduated from the Harvard Medical School in 1877. During his last year in the medical college and for one year after he graduated he was Assistant in Anatomy under Dr. Oliver Wendell Holmes. In 1895 he was made Assistant Professor of Clinical Surgery, in 1902 Associate Professor, and from 1903 until his death he was Mosely Professor of Clinical Surgery in the Harvard Medical School. From 1881 to 1910, he was Attending Surgeon at the Massachusetts General Hospital, and in the latter year he was made Surgeon-in-Chief of that institution. He died July 31, 1912.

He was a frequent contributor to periodical medical literature and wrote entire sections for Park's "Surgery by American Authors" and for Dennis' "System of Surgery." A. H. B.

Richfield Springs.—Otsego County, New York.

POST-OFFICE.—Richfield Springs. Hotels and cottages.

ACCESS.—From New York via New York Central and Hudson River Railroad; also via Delaware, Lackawanna, and Western Railroad. From Philadelphia via Delaware, Lackawanna, and Western Railroad.

This charming summer resort is picturesquely located on Lake Canadarago, at an altitude of 1,400 feet above the tide-water. Richfield may be classed among the most attractive of our summer resorts. In writing of his visit here Charles Dudley Warner well and truly said, "The charm of Richfield is in the character of its landscapes." It is scenery "that one grows to love, and that responds to one's every mood in variety and beauty. In a whole summer the pedestrian will not exhaust the inspiring views, and the drives over the hills, round the lakes, by woods and farms, increase in interest as one knows them better. The artist is here year after year, one season being too short to satisfy the demands which the charms of the region make upon his love of the beautiful." The art of man has added much to the natural attractiveness of the location. The greatest attraction of Richfield, however, is found in the fine White Sulphur Springs. There are sixteen springs at this resort, and some of them have become widely celebrated. The bath-house in connection with the springs is one of the most complete in the world, and provides for the therapeutic use of water combined with massage and electricity in a thoroughly scientific manner. It contains sixty-seven rooms for sulphur baths, Turkish and Russian baths, a large swimming pool, a pulverization room, inhalation rooms for the treatment of bronchitis and catarrh, electrical rooms, douche rooms, and a sun bath. The bath-house is situated on the grounds directly in front of the Hotel Earlington. The following analysis of the principal spring, known as the White Sulphur Spring, was made by Professor Chandler, of New York:

ONE UNITED STATES GALLON CONTAINS.

Solids.	Grains.
Sodium hydrosulphate	1.72
Calcium hydrosulphate	0.09
Potassium sulphate	1.67
Calcium sulphate	112.34
Strontium sulphate	0.01
Magnesium sulphate	5.15
Sodium hyposulphite	0.38
Magnesium bicarbonate	31.74
Sodium chloride	0.52
Lithium chloride	0.02
Silica	0.64
Alumina, barium sulphate, iron bicarbonate, and calcium phosphate	Traces.
Total	154.28

Sulphureted hydrogen gas is present to the extent of 14.20 cubic inches in each gallon. This spring, it will be observed, is very heavily charged with sulphureted hydrogen gas. Other important springs at Richfield are the Iron and Magnesia Springs, besides additional sulphur springs. The drinking-waters are obtained from springs west of the village, and are pure and abundant. A course of baths at Richfield has been found of value in cases of insomnia from overwork, in nervousness, in stomach disorders resulting from abused digestion, in chronic malarial infections, in gout and rheumatic troubles, in some of the disorders of the liver and kidneys, in strumous affections, and in skin diseases. The visitor will find in the Hotels Earlington, Berkeley, and smaller places accommodations to please any taste or exchequer. EMMA E. WALKER.

Ricin.—The name ricin was given to the toxic substance which may be extracted from the seeds of *Ricinus communis*, the castor bean. Although non-toxic when given by mouth the active principle of castor bean is extremely poisonous administered in any other manner. The toxicity is even greater than that of the snake venoms as little as 0.001 milligram per kilo being sufficient to kill a rabbit. The nature of the poison has been subjected to much controversy but it is probable that ricin is a coagulable albumin. The appearance of noticeable signs of toxic symptoms is rather slow. For a few hours food is refused, but the onset of severe symptoms is always sudden. Convulsions and opisthotonus are followed by extreme relaxation and again by a return of the convulsive effects. There are no truly specific symptoms to be observed and the influence of variation in dosage is exhibited primarily in the shortening or prolongation of the latent period before the appearance of appreciable symptoms. Among the gross pathological changes to be noted are the punctiform hemorrhages in the

peritoneal cavity scattered over the omentum and along the serous covering of the intestine. Ricin also has a marked agglutinating action upon the red blood corpuscles and Ehrlich has shown that animals may be immunized against ricin.

For literature on Ricin, see Osborne, Mendel, and Harris: A study of the Proteins of the Castor Bean, with Special Reference to the Isolation of Ricin. *American Journal of Physiology*, 1905, xiv., p. 259.

F. P. Underhill.

Ricinidæ.—A family of lice. The head is larger than the thorax; there are dark horny bands on the body. Many species in different genera are parasitic on mammals. A. S. P.

Rickets.—(*Synonyms:* Rhachitis or Rachitis; Fr., *Nouure, Rachitisme;* Ger., *Rhachitis, Englische Krankheit.*)

Definition.—A general disease of infancy and early childhood, characterized chiefly by alterations in the bony skeleton and by impaired nutrition. In severe cases there may also be changes in the viscera.

History.—The disease was known to the writers of antiquity, but was often confused with other maladies causing deformities of the skeleton, especially with tuberculous spondylitis. We owe the first accurate description of the condition to the English physician Glisson, who published a work upon the subject in 1650. The disease seems to have been especially prevalent in England at that time and later, and has always been the subject of study by English physicians; hence its name of the Englische Krankheit.

During the eighteenth century the French physicians made many contributions to our knowledge of the rachitic process, while more recently the Germans have been most active. Among the names which will always be connected with the history of the study of this important disease of infancy may be mentioned Trousseau, Guérin, Elsasser, Virchow, Kölliker, Rokitansky, von Recklinghausen, and Kassowitz.

Etiology.—The nature of the agent which underlies the pathological change which we find in rachitic children is still unknown. It has been assumed to be caused by an insufficient amount of calcium salts in the blood, and color has been given to this theory by the oft-quoted experiments of Sutton and others, in which rachitic changes were thought to be produced in animals by nourishing them on food practically free from lime salts. It has been recently shown, however, that the changes which were produced in animals by this means are rather those of osteomalacia than a true form of rickets. The similar belief that an imperfect absorption of the lime salts from the intestine was responsible for the rachitic condition has been shown to be untenable, for the urine of rachitic children contains an amount of calcium quite sufficient to supply the needs of the skeleton; and if larger amounts of calcium salts are administered to either rachitic or healthy children the excess is rapidly excreted in the urine.

The chemical theory that the lime salts either could not be deposited because of the diminished alkalinity of the blood or that they were dissolved out by the action of an acid circulating in the fluids of the body, has been shown to be without foundation. The blood of rachitic children contains neither an excess of acid nor an excess of alkali. The present belief is that the lack of calcification of rachitic bone is due rather to an inability of the diseased osteogenous tissue to combine with the lime salts present in the blood in quite sufficient quantities.

The view brought forward by Kassowitz that the bone changes are purely inflammatory in nature is not in entire accord with the anatomical findings. The most recent suggestions are that the disease is an infection or that it is an autointoxication. Neither view has been supported by sufficient experimental evidence to warrant its acceptance, however attractive the assumption may be. Severe intoxication of intestinal origin may occur in the type of infantilism described by Herter and yet no rachitic changes appear in the bones, though calcification may be below the normal. Although, therefore, we do not know the actual cause of the disease, there are many predisposing conditions which are known. Among these are chiefly imperfect food and unsuitable hygienic surroundings.

The disease is most frequently seen among the children of the poor, especially those who have been reared upon an artificial diet containing large quantities of carbohydrate and small amounts of fat. It is rare in children who have been breast-fed, the exceptions being principally the children of the laboring classes, where the mother begins to work soon after the delivery of the child, or in children who have been nursed for a long period until the milk becomes insufficient for the needs of the infant.

Children fed upon sweetened condensed milk are frequently rachitic, while those obtaining the unsweetened form are not likely to suffer. Boiling the milk is also thought to set up obscure changes in the composition of that fluid which affect the nutrition and may cause rickets and especially scurvy. The exact form in which the hygienic factors exert their influence is not so clear as it is with food. Some observers, notably Mey, are inclined to consider lack of light and fresh air as very potent forces in the production of the rachitic process; others, for example Lange, regard the hygienic factor as comparatively unimportant and, though acknowledging that the disease is more prevalent in cities where the hygienic surroundings are bad, they lay the most stress upon the food factor. It is certain, however, that rickets is very infrequent in the country, in high altitudes, and in the tropics. It is also true that the children born in these conditions are much more likely to be breast-fed than those in the tenement districts of large cities. The influence of race in the susceptibility to rickets is seen in the negro and in the Italians. The children of both of these races, when confined to the tenement districts in cities, offer our most marked examples of advanced and severe rickets. Congenital influences play some part in the causation of rachitis, though at present the trend of opinion is against a true congenital form of the disease. Cases so described are regarded as distinct from rickets, though showing bone lesions closely resembling those seen in rachitic children. Parental syphilis is a strong predisposing factor in the production of rickets, though it does not seem to be the cause of the disease, as Parrot attempted to show. Tuberculosis and alcoholism in the parents also predispose to rickets, chiefly by reducing the child's power of resistance. Both sexes are equally subject to the disease, though in hospital statistics a larger number of males will be noted. This apparent anomaly is due to the fact that a larger number of male children are received for hospital treatment than female, and large statistics, including private cases, will show about equal numbers affected. The clinical development of the disease is most noticeable in the second year of life, though a large proportion of children show signs of the disease during the first year. After the third year the disease is infrequent. Late cases have been described in children even up to the twelfth year, but such observations are extremely rare. The disease is one which concerns the period of the most active growth and formation of the bones, progressively diminishing as the skeleton assumes its definitive condition.

Pathology.—The constant and characteristic lesions of rickets are to be found in the bones; the vis-

ceral changes are comparatively slight and secondary. A rachitic bone, when examined in a fresh condition, is softer than normal, and the actively growing portions—that is, those parts near the epiphyseal junction in the long bones and the ossification centers of the cranial bones—are larger and much more vascular than in normal bones from a child of the same age. The periosteum is thickened and strips with some difficulty from the surface, leaving irregular areas of soft, newly formed bony tissue adherent to the inner layers of the periosteum. The bone from which the periosteum has been removed is soft and very vascular, and has a spongy appearance. The same changes may be noted if one of the long bones is split open and the internal layer of the periosteum is examined. The calcification zone at the epiphyseal junction, which in normal bone is well defined and narrow, is broad and not sharply defined in rachitic bone, and may be quite unrecognizable. In the later stages of the disease, when the acute process has ceased, the rachitic bone is usually harder than normal bone, especially where an active production of new bony tissue has taken place. This new-formed bone may resemble ivory in its density and texture. Frequently, however, when the restoration of the bone has been incomplete, it is soft and porous, and contains a considerable quantity of fat scattered through the substance. Such bones are very light and fragile, and green-stick fractures are frequent. Callus formation about such fractures is often extensive and may completely close the marrow cavity. Islands of cartilage are more abundant than in the normal callus. The microscopical changes correspond to the gross lesions. The centers of the flat bones of the skull are vascular and the bony layers are replaced by osteoid tissue. This may be very abundant in amount, in which case the bone is so soft that it can be easily indented by the finger, and gives a soft crepitus when palpated, a condition known as craniotabes; or the osteoid tissue may be located in small areas, a few millimeters in diameter, and give the bone an appearance of a coarse sponge. The osteoid tissue may not ossify, and the aperture thus left in the bone may be closed simply by the pericranium. Such marked changes in the regular course of ossification of the cranial bones are as a rule rare, and confined chiefly to the posterior portion of the cranium.

The more frequent course is for the osteoid tissue to be gradually replaced by bone, either by direct ossification or by the replacement of the abnormal tissue by normal bone. When the osteoid tissue ossifies directly the structure produced is as a rule more dense than normal and resembles ivory. In the long bones the most marked lesions are at the epiphyseal junction. It should be remembered, in order to understand the pathology of the subject, that the bones grow in length at this point, while they increase in diameter by the production of new bone from the inner layers of the periosteum. At the same time the medullary cavity is enlarged by absorption of the inner layers of bone. In rickets the pathological changes consist in the distortion of these normal conditions. The inner layers of the periosteum produce an excessive amount of very vascular osteoid tissue, which undergoes either ossification or absorption. The ossification which takes place is of a very imperfect sort, so that the new bone is soft, spongy, and very much more vascular than normal. In the medullary cavity the process of absorption is very irregular and often excessive in amount. The cavity may extend into the epiphysis, or it may be filled with osteoid tissue, which replaces the normal bone marrow and thus may contribute to some extent to the anemia from which rachitic children suffer by directly diminishing the production of the blood cells. The course of the bone growth, which takes place at the epiphyseal junction, is also disturbed by a combination of the same processes which contribute to the irregular bone production by the periosteum. The cartilaginous area of the epiphyseal portion of the bone is broken up and penetrated by a vascular osteoid tissue, which may be prematurely ossified or may form marrow cavities. The cartilage cells also proliferate and become dislocated from their normal positions. Absorption of these masses may occur or they may become ossified. The normal calcification zone becomes irregular and is broken up by the advance of the osteoid tissue into the epiphysis. After a variable period of from three to eighteen months the active process ceases and the formation of bone begins in a normal manner. The swelling of the epiphyses diminishes, the extreme vascularity is reduced, and the areas of osteoid tissue become calcified. The structural reparation is never quite complete, though a large amount of the distortion of the bone may disappear.

The effect of these changes in the structure of the bones is first to delay their growth, and second to cause deformities. The results of the first condition may be seen in the small bodies and shortened limbs of children that have suffered from rachitis of a severe type. The softness of the bones permits their easy distortion under pressure, as is so well seen in the chest, while the deformity which results from growth alone is best noted in the square form of the cranium or in the curvatures of the upper extremities.

The bone marrow in rickets varies with the stage of the disease. Soon after the onset of the process the marrow is hyperplastic, much more abundant than in normal bone, richly cellular, and very vascular. That in the center of the medullary cavity and near the epiphyses is composed largely of myeloblasts or myelocytes with numerous foci of erythroblasts, a condition often mirrored in the blood of cases of severe rachitic anemia, which resembles that of a myelogenous leukemia in the active stage. At the borders of the bone trabeculæ the marrow is more fibrous and contains osteoblasts producing the picture called endosteitis rachitica. The French observers especially, therefore, attribute these marrow and other hematopoietic lesions to a defensive reaction against various toxic agents of bacterial or alimentary origin, and consider marrow lesions as primary and the bone changes as secondary to the enfeeblement of the organism as produced by the toxemia.

The lesions of the viscera are not an essential portion of the rachitic condition, but they are quite frequently met with in severe cases. The lungs frequently show acute or chronic bronchitis or a bronchopneumonia. When the deformity of the chest wall is considerable, the lungs may be the seat of a marked emphysema in the areas upon which there is no pressure, while those portions which are compressed by the incurving of the thorax may be in a condition of atelectasis. The spleen is frequently increased in size owing to an interstitial splenitis of a chronic form; the liver occasionally shows similar changes. The lymph nodes are often swollen and hyperplastic. Hydrocephalus is no more frequent in rachitic children than in others, the enlargement of the head being due to the increase in thickness of the cranial bones. The muscles of the body are flabby and atrophied.

Symptoms.—The symptoms of the disease vary with the stage of the malady. The earliest symptoms are restlessness during the night, sweating of the head, craniotabes, and the beading of the ribs. The beading of the ribs is an especially early and valuable symptom, and consists of a row of nodules formed at the costochondral junction. The beading is often more marked internally, especially in cases with extreme incurving of the chest wall. The craniotabes is often an early symptom, and may best be demonstrated by gently palpating the posterior surface of the head with the tips of the fingers. Small areas, softer than the remainder of the skull, will be felt, and the tissue may

crackle under the pressure. In rachitic children the skull appears relatively large and the frontal prominences are well marked; alterations which, when associated with the prominent posterior part of the head, give to the latter the characteristic square appearance, the *tête carrée* of the French. The anterior fontanel is larger than normal, and its closure may be delayed even to the third or fourth year. The two lateral openings are often late in closing, as are also the sutures. The superior and inferior maxillæ are slightly distorted in severe cases, chiefly by muscular action. The teeth are delayed, not appearing until the end of the first year, or even later, and there are often irregularities in the time and order of appearance and arrangement of the different groups of teeth. Some observers consider the teeth of rachitic children to be especially prone to decay. The thorax, as has been mentioned above, is frequently deformed. In mild cases the only change noted is the swelling of the costochondral junction, forming the so-called rachitic rosary. The flexibility of the bones of the chest permits the pressure of the atmosphere to exert a considerable influence in the production of deformities, so that a distinct depression frequently exists along the line of the ends of the ribs, or there may be a transverse groove parallel to the line of the insertion of the diaphragm. The deformities known as funnel breast and pigeon breast are largely dependent upon an antecedent rachitic process. Any obstruction to the free admission of air to the chest, such as is associated with chronic bronchitis, enlarged tonsils, or adenoid growths of the pharynx, is likely to exaggerate any chest deformity. The lessened capacity of the thorax causes the liver and spleen to be much more prominent than their increase in bulk from hyperplasia would warrant. The abdomen is usually distended, the enlargement being chiefly due to the distention of the intestines with gas, aided by the weak condition of the muscles of the gut wall and of the abdomen.

In rachitic children the spinal column is much more flexible than normal, owing to the imperfect ossification of the vertebræ and the relaxation of the spinal ligaments. When such children assume an erect position a marked kyphosis can usually be noted, which disappears when the child assumes a recumbent posture. The curve of the rachitic kyphosis is rounded in form, and involves the bodies of a number of vertebræ, in contrast with the sharp projection of the kyphotic curve in spinal tuberculosis. There is usually a compensatory lordosis in the lumbar region and rarely a left-sided scoliosis.

The clavicle and the scapula may be curved slightly. The pelvis is often the site of serious deformities. It is flattened laterally and the promontory approaches the arch of the pubis, which is also narrowed. The approximation of the promontory to the pubis is in part due to the rotation of the sacrum on a horizontal axis, in part to the inward displacement of the ischia. These pelvic deformities are often permanent, and render the bearing of children difficult or impossible. The extremities very early show the characteristic enlargement of the epiphyses, especially of the lower end of the radius, ulna, and tibia. Such epiphyseal swellings may also appear at the upper and lower ends of the humerus and femur, but are much less marked.

If the disease is of a severe type the diaphyses of the bones may become curved. The convexity of the femur is forward and outward; that of the tibia and fibula is often lateral, but may also be forward; that of the radius and ulna is toward the extensor surface, while the humerus is bent forward. The irregular growth of the epiphyseal ends of the bones, combined with the curvature, gives rise to deformities which are especially serious in the lower extremities. The axis of rotation of the knee-joint may remain horizontal, or, as is seen in advanced cases, the axis may be rotated either inward or outward, so that a simple osteotomy of one bone will not suffice to correct the deformity, but both the femur and the tibia will have to be severed and the axis of the joint restored to its normal rotation plane.

The cause of these deformities is not, as is usually assumed, the result of allowing the child to walk before the bones are sufficiently hard, but is due to the rachitic curvature of the shafts of the bones and to the uneven enlargement of the condyles of the femur. A moderate amount of deformity may be increased, however, by allowing the child to walk while the rachitic bone is still soft. The traction of the muscles during their contraction probably plays a part in the production of some of the deformity, though a minor one. The other symptoms of the disease not connected with the skeleton are chiefly those relating to the digestive, respiratory, and nervous systems. The frequency of respiration of rachitic children is increased in those cases in which there exists a considerable diminution of the respiratory capacity, owing to the deformity of the chest wall and the pressure of the gas-distended intestines against the diaphragm. Bronchitis and atelectasis very frequently complicate the respiratory and circulatory changes produced by the narrowing of the thorax.

Laryngismus stridulus is a not uncommon complication of rickets, and is responsible for a considerable proportion of the fatal terminations of the affection. General convulsions are a frequent complication of the disease, and tetany is also occasionally seen.

A chronic gastrointestinal catarrh is usually present in rachitic children, and is easily increased in severity by slight indiscretions in diet. The stools are either constipated or thin and fluid. They are as a rule paler than normal and may be very foul-smelling. They contain an excess of calcium salts derived in part from the food and partly from the softening bone. The blood shows an anemia of the chlorotic type with a moderate reduction of the red cells and a considerably lessened hemoglobin content. A moderate leucocytosis may also exist, which is in all probability not characteristic of the disease, but is dependent upon the respiratory and intestinal complications. The urine shows no striking alterations. Occasionally there may be a trace of albumin present and a diminution in the excretion of the phosphates and the chlorides. There is no alteration in the amount of lime salts excreted in the urine.

Fever is not a regular accompaniment of the disease. When present it is due to one of the complications. The skin of the rachitic child is pale. Eczema is not infrequent, and occasionally multiple skin abscesses are seen. Severe sweating is the rule in all cases of rickets. The subcutaneous fat is well preserved, though the patients are soft and flabby.

Course and Prognosis.—Cases considered to be congenital rickets have been described by competent observers, but as a rule the symptoms of the disease begin in the latter half of the first year of life; and in a majority of the cases the disease runs its course inside of eighteen months or two years. Very chronic cases, lasting for years, are exceedingly infrequent. The condition which has been classed by some clinicians as acute rickets is probably a form of scurvy. The prognosis of an uncomplicated case of rickets is good so far as life is concerned. The disease is self-limited and often disappears without treatment when the child is old enough to begin a mixed diet. The prognosis of the bone deformities is not so good, and many of the severe cases are permanently deformed, though surgical interference will often allow the complete correction of the deformities of the lower limbs. Death results in all cases from some intercurrent disease and not from the bone lesions alone. Marasmus and laryngismus stridulus are responsible for a considerable proportion of the fatal cases, while the others are carried off either by bronchopneumonia, or by tuberculosis, or by some intestinal condition. Whoop-

ing-cough is an especially dangerous complication in rachitic children with marked deformity of the chest.

Diagnosis.—A well-developed case of rickets is easy of recognition, especially at a time when the bone lesions are most prominent; but in children in the early stages of the disease the diagnosis is more difficult, and must be made from the general symptoms. The most important of these are the restlessness at night, the sweating of the head, the general tenderness of the body, and the malnutrition. The craniotabes and the persistent and wide-open fontanel are valuable symptoms, as is also the late eruption of the teeth. The bone lesions of syphilis are in the nature of thickenings under the periosteum rather than of an increase in the size of the bone, and the necroses seen in syphilis are not present in rickets. The other evidences of congenital lues and the Wassermann reaction will aid in the differential diagnosis. Confusion between the kyphosis due to tuberculous spondylitis and that due to rachitic softening of the vertebræ and intervertebral cartilages will be avoided if it be remembered that the curve in tuberculous disease is sharp and affects the bodies of only one or two bones, while that due to rachitic disease is more gradual and less limited. The rachitic bones are not very tender to pressure, and the kyphosis can be overcome by placing the patient on a flat mattress. Pott's disease is rarely seen in children under two years of age, a time when rickets is most likely to be well developed.

Rickets is differentiated from scurvy by the absence of the ecchymoses and the changes in the gums.

Prophylaxis.—The prevention of the disease depends naturally upon the avoidance of the conditions determined as the immediate factors in the causation of the malady. This is perfectly possible among people of good circumstances, but becomes a matter of great difficulty when we must cope with the conditions of tenement life among the very poor.

Every care must be taken with the children of parents who have previously borne rachitic children, as the predisposition increases with each child. The mother should be allowed to nurse the child if it is possible for her to avoid hard, manual labor during the course of lactation. But if she is not able to do this, the better plan will be to feed the child on pasteurized cow's milk. A convenient form of apparatus for pasteurizing milk and one requiring a minimum of intelligence on the part of the user, is that devised by Dr. R. G. Freeman. During the hot season of the year the child should be sent to one of the seaside hospitals or to the country for a time; or if this is impossible, it should be given every opportunity to obtain fresh air that is possible.

Treatment.—The care of rachitic children should be begun as early as the diagnosis can be made, in order to prevent severe bone lesions and also to obtain the maximum result from the treatment, as the best results are secured in cases in which the disease has been recognized in the first stages. The diet should be altered from that under which the child has developed the disease to one which is more nearly normal. If the child is breast-fed the quality of the mother's milk should be determined, and if necessary it may be supplemented by cow's milk in the proper modification. If the mother cannot nurse the child, it must be fed upon properly prepared cow's milk. The diet should be rich in fats and proteids, and contain but a small amount of carbohydrates. This will eliminate all of the proprietary infant foods. The use of orange juice or other fruit juices should be begun early; green vegetables should be added to the diet as soon as the child's digestion permits. Cod-liver oil should be administered in small doses as soon as the stomach will tolerate it. Arsenic and iron are useful to combat the anemia. The excessive sweating may be relieved by cool sponging, and by atropine in doses of about gr. $\frac{1}{200}$ per day. Opinions vary as to the value of the phosphorus treatment of rickets. Originally recommended by Trousseau, it was rendered popular through the efforts of Kassowitz, who regarded it as a specific. It may be administered in the form of a solution in oil, made by diluting the official oil of phosphorus with olive oil, in doses of gr. $\frac{1}{200}$ three times a day after meals. The use of extracts of the thyroid, thymus, and adrenal glands has not given satisfactory results.

The hygienic treatment of the child is nearly as important as the correction of the food. The child should spend a large portion of the day in the open air and in the sun if possible. Such open-air treatment is best carried out in the country; but if this is impossible, the child should be taken on excursions on the water or to the country, and during the rest of the time be kept in the parks and open squares of the city. The roof of one of the tenement houses is better than the street for such a child, and if the weather is not too hot such a place is often the best possible. The child will be strengthened, and is much less likely to catch cold, if it is sponged off with cold water every day. The addition of some sea salt to the bath is of use if the child is strong enough to stand the stimulus, while massage or even gentle rubbing of the body and limbs before or after the bath is of the greatest value in keeping up the general nutrition.

The correction of the deformities of the extremities is a matter of surgical interference; but much can be done to prevent the curvature from becoming severe by not allowing the child to assume a posture which will increase the deformity, and also by keeping up the muscular tone. The kyphosis may be relieved by allowing the child to sleep on a flat, hard mattress without a pillow. If the deformity of the occiput is marked, the pressure may be prevented by the use of a firm horse-hair pillow with a concavity to receive the flattened portion. If the kyphosis is extreme in a child which is old enough to be about, and in which the bones of the legs are firm enough to permit walking, it may be advisable to fit the thorax with a jacket or a steel brace, which should be worn only when the child is in an erect posture. The use of braces in order to prevent or to cure deformities of the lower extremities is of but very slight benefit. It is better to wait in these cases until firm ossification of the bones has taken place and then to correct the deformity by a proper osteotomy.

Francis Carter Wood.

Ricord, Philippe.—Born at Baltimore, Maryland, of French parents, Dec. 10, 1800. In 1820 he went to Paris, France, and began the study of medicine

Fig. 4457.—Philippe Ricord.

under Dupuytren, Lisfranc, and other eminent teachers. After receiving his doctor's degree in 1826, he made several attempts to establish himself in practice in the vicinity of the metropolis, but was

unable to gain a footing anywhere. At last, in 1828, he secured, through a competitive examination, the position of surgeon at the *Bureau Central*, in Paris. During the following two years, however, he was obliged, in order to make money enough for his living expenses, to give courses in operative surgery at the Pitié. In 1831 he was chosen Surgeon-in-Chief at the Hôpital du Midi, an institution largely devoted to the care of syphilitic patients. In addition to his regular service as chief physician of the hospital, Ricord delivered lectures in this place up to 1860, when he severed his connection with the institution. In 1869 he was made a Consulting Surgeon of the Emperor Napoleon III. He died Oct. 22, 1889.

Of Ricord's more important published writings the following deserve to receive special mention: "De l'emploi du spéculum," 1833; "De la blennorrhagie de la femme," 1834; "Monographie du chancre," 1837 (contains a very clear exposition of his doctrine); "Traité des maladies vénériennes," 1838 (new edition, with sixty-six plates, in 1863); "De la syphilisation et de la contagion des accidents secondaires," 1853; and "Leçons sur le chancre, etc.," publiées par Alfred Fournier, 1857 (second edition, 1860). A. H. B.

Rigor Mortis.—As a result of the removal of the influence of the circulation from the muscles as by death or ligature of arteries, such as the aorta or muscle arteries, the condition of rigor mortis may be induced. In this condition there is a shortening and thickening of the muscle which also becomes hard and opaque. Under the usual conditions the rigor appearing is termed spontaneous, or fermentative rigor, because of the fact that there seems to be some relation between its formation and enzyme activity. Other types of muscle stiffness are recognized. For example, muscles may go into a condition of rigor by application of a sufficient degree of heat, thus heating frog's muscle to 40° C., mammalian muscle to 48–50° C., or bird's muscle to 53° C. may cause the appearance of muscle stiffness. It is probable that heat rigor is caused by the coagulation of the muscle proteins, which view is in harmony with the observation that amphibian muscle proteins coagulate at a temperature lower than those of mammalian origin. The application of distilled water may also cause the appearance of rigor (water-rigor). Acids, even those as weak as carbonic acid, may induce or accelerate rigor. Many chemically different substances, such as ether, chloroform, alcohol, and ethereal oils, and many alkaloids, such as caffeine, quinine, and strychnine may also produce rigor.

According to some investigators spontaneous rigor commences first in the heart muscle, but is generally seen first in the muscles of the face from which it proceeds downward to the extremities. The appearance of rigor varies with the conditions previous to death. In general, it may be stated that "all conditions that lead to excessive muscular metabolism, with its resulting increase in the acidity of the muscle fluids, will hasten the onset of rigor mortis; thus, people killed suddenly during violent activity may remain almost in the position in which they met death. Acute fevers, strychnine poisoning, tetanus, etc., cause likewise a rapid onset of rigor, which may, indeed, appear almost simultaneously with death or even before the heart has stopped beating. When a healthy individual meets death without previous exertion, rigor does not usually appear for four or six hours, but will be hastened by heat and retarded by cold. Death from hemorrhage or asphyxia is followed by a slow development of rigor. Under ordinary conditions rigor usually begins between the first and second hours after death and is complete in one or two more hours. The duration of rigor mortis also is influenced by many factors. In general, it may be said that the duration is in inverse relation to the rapidity of onset, and directly to the musculature of the individual. Therefore, in an emaciated individual dying with fever, rigor may appear and disappear again within two or three hours, or indeed, escape observation altogether. The body of a muscular man dying from accident or hemorrhage may, on the other hand, show rigor for two or three weeks if kept in a cold place. Once the rigor has been broken by force, it does not return again." When a muscle passes into the state of rigor mortis the change is accompanied by a transformation of the amphoteric reaction to an acid condition. This is explained by most authorities as due to the development of lactic acid. There is much controversy over the question whether in rigor mortis there is present *free* lactic acid. There is no doubt that a part of the acid reaction developed during rigor may be explained by a transformation of a portion of the diphosphate into monophosphate by lactic acid produced. At present there are two views as to the nature of the process involved in the appearance of rigor mortis. One idea is that rigor differs from ordinary muscular contraction only in degree, and that the two processes are essentially alike. The greater degree of contraction in the case of rigor is explained as a loss of inhibition to contraction. According to the other theory, which is the one generally accepted, rigor mortis is regarded as a coagulation of the muscle proteins in a manner similar to blood coagulation. By coagulation of the plasma a clot is produced which is the cause of the hardening and of the diminished transparency of the muscle. From our knowledge of blood coagulation it might be assumed that rigor was induced through enzyme action, but no evidence of this type of activity has been shown. Like blood coagulation rigor is influenced greatly by the presence of calcium, but calcium is not absolutely essential for the production of rigor.

Probably the acid reaction of dead muscle is of the most importance. The acidity may increase in twenty hours after death by from 6.7 to 12.8 c.c. N/10 acid for each 100 grams of muscle. Although it is possible that the acidity might in time increase to a degree sufficient for the coagulation of the proteins by itself, yet before any such acidity appears rigor mortis appears. The hypothesis has been advanced by Meigs that rigor is induced by the swelling of the muscle colloids under the influence of acid. If enough acid is formed the muscle may swell to the extent that the structure of the muscle cell is entirely destroyed and then a condition of "waxy degeneration" obtains. This view affords an explanation for the modification of the time of onset of rigor by the amount of muscle metabolism before death.

It is probable that the disappearance of rigor mortis is accomplished by autolytic processes, such as the influence of proteoses, but it must be admitted that the products of such autolysis, as the proteoses and peptones, have not been found in such muscle. It has been suggested that the softening of the muscle after rigor is caused by coagulation of the proteins, in this way bringing about a diminished tendency for the swelling. Frank P. Underhill.

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Rilliet, Frédéric.—Born at Geneva, Switzerland, July 14, 1814. He received his doctor's degree from the University of Paris in 1840, the title of his graduating thesis being: "De la fièvre typhoïde chez les enfants." In 1843 he published, in association with Barthez, the famous treatise on children's diseases ("Traité clinique et pratique des maladies des enfants"). It was issued in three volumes, and a second edition was published in 1853. He died at Geneva June 2, 1861. A. H. B.

Rio de Janeiro.—Rio de Janeiro, the largest city in South America, with a population of 811,265, is situated upon the western side of one of the most magnificent harbors in the world. It is in no sense a health resort—indeed, quite the contrary—but it is mentioned as an illustration of a tropical or equatorial climate, and also to convey some knowledge of its climate to those who for any reason, either temporarily or permanently, are obliged to reside there.

The city itself occupies flat land with hills in the outskirts, and beyond rise precipitously mountains of from 1,500 to 3,000 feet high. Foreigners are advised to make some of the high-lying suburbs or towns in the vicinity their place of residence, at least during the warmer months, in order to escape the continuous heat and great atmospheric humidity which combine to make the climate of the city itself so debilitating.

The population of the city is a heterogeneous one, composed of Portuguese, Italians, Germans, French, English, and negroes. There are parks, a national library, museum, colleges, various schools, hospitals, and an observatory. An immense amount of coffee—said to be more than one-half of the world's product—is exported from here.

The water supply is good but somewhat inadequate, and the drainage is said to be satisfactory. Modern sanitary conditions exist. In the outskirts, among the hills and mountains, the scenery is most beautiful and the vegetation luxuriant.

The humidity is really greater than would appear from the average relative humidity as shown in the table, on account of the high temperature, for a humidity of over seventy per cent. at a temperature of over 70° F. is very moist. The excessive moisture is one of the striking characteristics of this climate, and renders the heat so unbearable. The daily occurrence of the sea breeze, however, mitigates this condition. There is a large amount of cloudiness and there are but few clear days. The average yearly rainfall is 42.5 inches, and there are 127 days of rain. March and December are the rainiest months and July is the driest month. The most prevalent wind is from the south and southeast—the sea breeze—and next in frequency is that from the northwest—the land breeze.

Yellow fever was formerly prevalent during the warm months, sometimes occuring in severe epidemics. In the lowlands intermittent fever prevails. The negro population suffers from smallpox. There is, at St. Sebastian, a large hospital which was founded in 1888, and which is devoted to the treatment of epidemic diseases. One would naturally infer that the mortality in such a climate and with so many epidemic diseases would be high, but from the official statistics the average mortality from 1897 to 1901 is found to be 19.4 per 1,000. Tuberculosis causes much the largest number of deaths of any one disease, and bronchitis and bronchopneumonia come next in frequency, while infantile diseases rank third. It would appear, then, that any one individual resident of Rio de Janeiro had many more chances of dying of tuberculosis than from yellow fever, and that this dread disease (tuberculosis) may be quite as prevalent in warm countries as in cold.

EDWARD O. OTIS.

CLIMATE OF RIO DE JANEIRO. LATITUDE, 22° 54′ 23″ S.; LONGITUDE, 43° 8′ 34″ W. FROM OBSERVATIONS MADE AT THE OBSERVATORY OF RIO DE JANEIRO, PERIOD OF OBSERVATION, NINE TO FORTY YEARS.*

	Jan.	Feb.	March.	May.	July.	August.	Sept.	Nov.	Year.
Temperature (degrees Fahrenheit)—									
Average or normal	79.45°	79.6°	78.6°	72.4°	69.1°	70.1°	70.8°	74.4°	74.2°
Mean maximum	94.4	94.7	91.6	84.6	78.2	83.9	86.1	93.3	88.7
Mean minimum	66.7	68	66.3	59.7	57.4	57.8	58.1	61.3	55.8
Highest or maximum, 102° Dec. 8, 1889.									
Lowest or minimum, 50.3° Sept. 1, 1882.									
Humidity—									
Average relative	78%	80%	79%	79%	78%	77%	80%	77%	78%
Precipitation—									
Average in inches	4.6	4.3	5.3	3.5	1.4	1.7	2.2	4.2	42.5
Wind—									
Prevailing direction	S. S. E.	S. S. E.	S. S. E.	N. W.	N. W.	N. W.	S. S. E.	S. S. E.	S. S. E.
Weather—									
Average number clear days	11.2	9	12.8	10.9	16.8	12.5	5.7	9.1	131
Cloudiness†	61	62	59	60	50	77	71	64	64
Average number days of rain	12.6	12	11.5	10.6	5.9	6.5	11.1	11.8	127
Average number days of storm	6.3	5.3	3.8	9.6	0.4	0.6	1.4	2.7	30

* "Le Climat de Rio de Janeiro," by L. Cruls, Director of the Observatory of Rio de Janeiro, from observations taken during the period of 1851 to 1890, Rio de Janeiro, 1892.

† 100 is taken to represent a completely covered sky, and 0 a completely clear sky.

The climate can be summarized as a moist, warm, tropical one; warmest in what is our winter and spring, and coldest in our summer and autumn, but at all times warm or hot. The rainfall is high, the largest amount occurring in our autumn and winter. The air is often sultry and very debilitating. There is generally a daily sea breeze from the south and southeast—part of the trade winds come from the southeast—it begins about 1 P.M. and lasts until about four or five o'clock. The nights are usually calm. The climatic chart has been arranged from the very elaborate series of observations published by L. Cruls, director of the Observatory at Rio de Janeiro, and the reader who desires to make a more exhaustive study of this climate is referred to this work.

The temperature arrives at its maximum at the beginning of February, and at its minimum the beginning of July. The mean annual variation does not exceed 10.8° F., and the mean diurnal variation does not reach 5.4° F.

Riviera, The.—As the various especial resorts upon this coast have been, and will be, quite thoroughly discussed, only a very brief and general reference will be made here to this region as a whole, and the reader is referred for more detail to the articles upon *Alassio*, *Bordighera*, *Cannes*, *Hyères*, *Nervi*, *Nice*, *Mentone*, *Monte Carlo*, and *San Remo*.

The Riviera is a strip of coast extending 323 miles along the shore of the Mediterranean at the foot of the maritime Alps and their offshoots. The portion from Hyères to Genoa, 203 miles, is called the Western Riviera; and that extending from Genoa to Leghorn, 112 miles, the Eastern Riviera. It is the former portion that is the more frequented, and is what is generally

meant when one speaks of the Riviera. The topography of this region is that of "a long shelf, or rather a series of shelves, on the south side of a very high mountain wall, which wall, up to the level of these shelves, is submerged in the waters of the sea" (Richards).

The general climatic features of all this region are the same, varying at one resort or another in certain minor aspects according to the local peculiarities of situation, principally with regard to shelter from the winds. These climatic features—and here the colder months of the year only are considered—are comparative warmth, moderate dryness, a large amount of sunshine, and great heat of the sun's rays; the small number of rainy days, and relative immunity from cold winds. No station is entirely exempt from these cold winds, but some are more exposed than others, as has been shown in treating of the various resorts. Moreover, the seasons differ from one year to another. The latitude of the Riviera has not so much to do in the production of its mild winter climate, but this is rather due to the protection afforded by the maritime Alps from the cold northerly winds, and also partly to the southern exposure and partly to the warm water of the Mediterranean Sea.

The mean temperature for the three cold months (December to February) according to Weber ("A System of Physiological Therapeutics," vol. iii., Book I., "Health Resorts," F. Parkes Weber, 1901), is from 47° F. to 49.8° F.; for the six cold months (November to April), about 51° F.

According to the same authority the mean relative humidity is from sixty-five to seventy per cent., and the annual rainfall from twenty-eight to thirty-one inches, the greater part falling during October and November.

The principal winds are the northwest—the "mistral," a cold dry wind prevailing in March; the northeast or "bise," a cold wind; and the southeast, or "sirocco" a "warm, wet, enervating wind."

Quoting Weber again, "during the six winter months 100 days or more may be expected to be fine enough for most invalids to be in the open air for several hours."

Besides the danger from the high winds, especially the dreaded "mistral," there is also to be mentioned the great difference between the sun and the shade temperatures, and the rapid fall of the temperature after sunset, with the increased humidity at that time. The dust is also an objectionable feature of this region. The Riviera season extends from about the end of October to the end of April. Abundant and good accommodations, all more or less expensive, are to be found in all the Riviera resorts.

As to the natural attractions of the Riviera, they are too well known to require any extended description. "Nothing," says Lindsay, "can exceed the loveliness of this strip of flowery coast land, with its jutting crags and circling bays, bounded on one side by spurs of the Alps, and on the other by the Mediterranean, now glittering in brilliant azure, again rippled into sapphire by the breeze." In comparing this region with the littoral of Southern California, the latter is undoubtedly superior in climate, but in beauty of scenery supplemented by art, the former is by far the more attractive.

The Riviera is visited in the winter by great numbers from northern Europe, who desire to escape the cold and more or less cheerless winters of their own region. This climate affords a blessed relief for those who desire to spend the winter in a warm, sunny climate amidst most attractive surroundings. The aged, the feeble, the convalescents; those with diminished powers of resistance, and those suffering from various chronic affections with deficient powers of reaction, all find more or less comfort, relief, and healing here. The diseased conditions for which this climate is recommended are chronic bronchitis and emphysema, bronchial asthma, certain varieties of pulmonary tuberculosis, scrofula, chronic pneumonia, and anemia.

The Riviera is now easily and comfortably reached by steamers sailing from New York or Boston direct to Genoa, and from Genoa the railroad runs along the shore of the Mediterranean parallel with the celebrated Corniche road for a good part of the way. Express trains also run from Paris direct to the Riviera.

EDWARD O. OTIS.

Roberts, Sir William.—Born at Bodedern, Anglesea, England, March 18, 1830. He was Professor of Medicine at Owens College, Manchester, and Surgeon of the Royal Infirmary, in the same city, from 1853 to 1883. In 1889 he removed to London, was made a Fellow of the London University in 1892, and died April 16, 1899; having a short time previously been made a Baronet.

Sir William Roberts wrote some very important treatises on Diseases of the Kidney and Urinary Apparatus. The following two deserve special mention: "A Practical Treatise on Ordinary and Renal Diseases," 1865; and "The Chemistry and Therapeutics of Uric Acid, Gravel, and Gout."

A. H. B.

Robin, Charles Philippe.—Born at Josseron, Department of Ain, France, June 4, 1821. He received the degree of Doctor of Medicine from the University of Paris in 1846. Robin was one of the first men in France to employ the microscope extensively in his studies of normal and pathological anatomy. In 1847 he was appointed an Agrégé of natural history in the Medical Faculty, and from that year to 1862 he gave, in his own private laboratory, courses of instruction in general anatomy which were attended by large and very appreciative audiences. In 1862 he was transferred to the newly established Chair of Histology. He died Oct. 6, 1885.

Of the published writings of this distinguished French biologist and histologist the following deserve to receive special mention: "Mémoire sur la rétraction, la cicatrisation et l'inflammation des vaisseaux ombilicaux, etc.," 1860; "Mémoire sur les modifications de la muqueuse utérine avant et après la grossesse," 1861; "Leçons sur les humeurs normales et morbides du corps de l'homme," 1867 (second edition in 1875); "Anatomie microscopique," 1868; and "Anatomie et physiologie cellulaire, animale et végétale," 1873.

A. H. B.

Rockbridge Alum Springs.—Rockbridge County, Virginia.

POST-OFFICE.—Rockbridge Alum Springs. Hotel and cottages.

ACCESS.—Via Chesapeake and Ohio Railroad to Goshen, thence by stage to springs.

These springs located in a glen-like nook formed by the spurs of the North and Mill Mountains, are seven miles beyond Cold Sulphur Spring. The Alum Springs break forth from a mass of slate rock at the base of the ridge. This slate contains large quantities of alumina and the salts of iron, and the springs are formed by the percolation of water through this mass. Four different reservoirs, numbered respectively No. 1, No. 2, No. 3, and No. 4, have been formed. The immediate surroundings of this resort are very attractive. The hotel and cottages afford comfortable accommodations. The entire property has been thoroughly overhauled and renovated. A commodious swimming pool of pure freestone water adds to the Alum's many attractions. The numerous springs here vary somewhat in their analyses.

Grains of Anhydrous Constituents in One Gallon of 231 Cubic Inches.

	No. 2.	No. 1.	No. 3.	No. 4.
Arsenic	Faint trace.	Trace.	Faint trace.	Trace.
Antimony	Faint trace.	Trace.	Trace.	Trace.
Lead sulphate	Trace.	Trace.	Trace.	Trace.
Copper	0.0424	0.04034	0.09287	0.10370
Iron persulphate	1.01850	1.94443	1.75922	2.90122
Manganese sulphate	0.85955	0.09177	0.52511	1.37352
Nickel sulphate	0.06298	0.14063	0.23969	0.33871
Cobalt sulphate	0.03547	0.01432	0.08082	0.08124
Zinc sulphate	0.11951	0.38906	0.20525	0.21748
Aluminum sulphate	31.24652	42.60887	43.95506	72.37335
Calcium sulphate	1.73110	3.22302	2.63598	2.31527
Magnesium sulphate	0.88761	5.60586	6.37371	7.36110
Potassium sulphate	0.17248	0.41290	0.38351	0.17586
Sodium sulphate	0.02134	0.02743	0.02130	0.93463
Lithium sulphate	0.01852	0.02006	0.02006	0.93241
Free sulphuric acid	3.23904	3.82512	2.04041	3.06633
Silicic acid	3.54627	3.69750	3.12807	4.38340
Sodium chloride	0.07547	0.19565	0.10565	0.14246
Calcium phosphate	0.01275	0.07251	0.20674	0.05174
Calcium fluoride	Trace.	Trace.	Trace.	Trace.
Ammonium nitrate	Trace.	Trace.	Trace.	Trace.
Organic matter	Trace.	Trace.	Trace.	Trace.
Total	43.08951	62.30647	61.77255	96.69242

Cubic Inches of the Gases in a Gallon of Water.

	No. 1	No. 2.	No. 3.	No. 4.
Carbon dioxide	12.27	10.89	11.95	12.72
Oxygen	1.53	1.49	1.65	1.64
Nitrogen	4.19	3.98	4.10	4.12
Total	17.99	16.36	17.70	18.48
Temperature	56° F.	54.5° F.	54.5° F.	54.5° F.
Specific gravity at 60° F.	1.0004	10.0118	1.00118	1.00174

These have long been regarded as among the best alum waters known. They are clear and odorless, but possess a strongly astringent and styptic taste. They are of undoubted efficacy in cases requiring an astringent chalybeate. They have proved valuable in atonic and catarrhal states of the different mucous membranes—for example, in chronic diarrhea, in leucorrhea, in pharyngitis, in rhinitis; also in various forms of dyspepsia, and in diabetes. They are very useful locally in scrofulous ulcers and in other slow-healing similar conditions. The waters sometimes prove purgative in large doses and are always diuretic in doses of one-quarter to one-half of a small tumblerful taken six, eight, ten, or twelve times a day. The effects of the waters often last far beyond the period during which they are taken.

Near the upper part of the grounds is the "Iron Spring," and a short distance from the hotel is the "Chalybeate Spring." This water, tonic and alterative, is valuable in anemia and in derangement of the uterine functions.

Analysis of Chalybeate Springs.

Calcium sulphate	4.462
Potassium sulphate	0.163
Sodium chloride	0.141
Calcium phosphate (tribasic)	0.016
Iron carbonate	0.853
Manganese carbonate	0.050
Magnesium carbonate	0.887
Lithium carbonate	Trace.
Alumina	0.066
Silica	0.865
Arsenic	Trace.
Copper	Trace.
Nitric acid	Slight trace.
Organic matter	0.107
Total	7.610

Connected with the hotel grounds are a large garden and dairy farm from which the table is bountifully supplied.

The elevation of the springs is 2,000 feet above the sea-level. The nights are always cool, even in summer, and fogs are seldom seen here. Various amusements are at the service of the guests.

Emma E. Walker.

Rocky Mountain Spotted (Tick) Fever.—*Synonyms:* "Black fever," "spotted fever of Montana," "blue disease," Rocky Mountain fever," "spotted fever of Idaho," "pyroplasmosis hominis," "tick fever of the Rocky Mountains," and "black measles."

Definition.—Rocky Mountain spotted (tick) fever is an acute febrile disease of unknown origin, occurring endemically during the warm months in the Bitter Root Valley of Montana, Snake River Valley of Idaho, and in other Rocky Mountain States. It is characterized clinically by a sudden onset with a chill and continuous fever, enlarged spleen, early albuminuria, slow pulse, pain in the head, neck, back, and joints, especially the wrists and ankles, and a characteristic eruption about the fourth day of the disease, first, on the wrists and ankles, later spreading over most of the body, including the palms and soles; it is characterized pathologically as a hemorrhagic septicemia, and is transmitted by the wood tick *Dermacentor venustus*.

History.—The first published account, contained in the Annual Report of the Surgeon General of the Army for 1896, Captain M. W. Wood[44] (now Lieutenant Colonel retired) gave a description of this disease as occurring near Boise Barracks, Idaho. From early settlers it seems that spotted fever was known in the Snake River Valley of Idaho as long ago as 1873, and in the Bitter Root Valley of Montana since 1890. This is by no means intended to represent its first appearance in these places. The Bitter Root Valley was settled by the Nez Percé and Flat Head tribes of Indians, who remained there until the above date. It is a well-known fact that history dates no farther back than the memory of man in an Indian settlement, and spotted fever as we know it now is denied among the Indians to-day; but they give a history of a "white spider" which was present in the valley before they evacuated it, and almost all persons who were bitten by this insect died. They also say that evil spirits visited certain places (Lo Lo Canyon) every spring and it was particularly hazardous to visit these places at that time. After the Indians were removed and the territory was taken up by the white man, we get a history of "black measles" visiting the valley every spring and summer, affecting but few persons, almost all of whom died. From the above statements it would seem most probable that spotted fever has existed at least seventy-five years in Montana, and existed previously among the Indians. However, there is no positive proof that the Indians ever suffered from this disease, and the same tribes now living on the Flat Head Indian Reservation, thirty miles distant, do not suffer from spotted fever.

The first detailed description of the disease was written by Dr. E. E. Maxey[30] in 1899 on "The So-called Spotted Fever of Idaho." Dr. R. Gwinn[17] of Missoula, Montana, published in 1902 an account of spotted fever as occurring in the Klondike, Alaska. McCullough,[25] also of Missoula, the same year read a paper on this disease before the Montana Medical Association. The following summer, Wilson and Chowning[40] of the University of Minnesota, visited the Bitter Root Valley and as a result of their studies, described a *Babesia*, which they believed was parasitic in the squirrel and accidentally transmitted to men

through the bite of the wood tick, but offered no experimental evidence to support their statement. For years there were persons living in the Bitter Root Valley who had associated the tick with spotted fever, and called this disease "tick fever." In 1903, Anderson[2] of the U. S. Public Health Service, investigated the disease and supported the tick transmission, described a piroplasma as the cause and named it *Piroplasma hominis*. Stiles[38] in 1905 discredited the tick transmission and the piroplasma etiology. Ashburn and Craig[6] of the U. S. Army published an excellent paper in 1908 on this disease and tsutsugamushi, pointing out their differences; in this paper, Ashburn[4] accepts the tick transmission. In 1906, King[21] found proof of the tick transmission, and from 1906 to 1910 the late H. T. Ricketts[34] of the University of Chicago, by his untiring efforts and most scientifically planned and completed investigations, laid the foundation for all subsequent campaigns against this disease. He demonstrated the immunity conferred by one attack, susceptibility of the monkey and guinea-pig, produced an immune serum, and demonstrated its limited value; he found ticks infected in nature and transmitted the disease from animal to animal by that means. He further demonstrated that an infected female tick transmitted the virus to her offspring and that the eggs, larvæ, nymphs, and adults resulting therefrom were capable of infecting non-immunes with spotted fever. McCalla[24] and Brereton of Boise, Idaho, transmitted the disease from man to man by the tick. McClintic,[26,27] U. S. Public Health Service, found infected ticks in nature and carried the disease along through several generations of guinea-pigs. His efforts were largely directed toward tick eradication and the search of a chronic source of the infection in nature. He trapped and killed large numbers of small animals in the Bitter Root Valley testing their susceptibility and immunity to spotted fever virus, and in tick eradication he dipped domestic animals in specially constructed vats containing an arsenic parasecticide. The valuable work of this able investigator was suddenly brought to an end by his tragic death from this disease after being bitten by an infected wood tick in his laboratory at Victor, Montana, during the summer of 1912. His death adds one more to the list of physicians who as martyrs to science have given up their lives for the good of mankind. Frick, [14,15,16] U. S. P. H. S., took up the work where his colleague, McClintic, left off and has been investigating the disease ever since. His efforts seem to be directed toward tick eradication and he has made the valuable discovery that approximately ninety per cent. of ticks that get on sheep perish, possibly due to the lanoline. He is interested now in grazing sheep over the infected districts in large numbers and on a scientifically planned campaign.

Distribution.—Spotted fever is remarkably endemic and its spread is very slow, in places where it has been reported the geographical lines can be very definitely drawn. So far as is known, this disease occurs only in the United States of America, and even here occurs only in certain States west of the Missouri River. After consulting all available literature and writing to the Secretary of the State Board of Health of every State west of the Missouri River, I have arrived at the following which seems to be a complete account of the distribution of spotted fever, arranged according to the largest number of cases reported. Idaho (generally over the State), Wyoming, (generally distributed over the State), Montana (Missoula, Ravalli, Granite, Powell, Park, and Carbon counties), Oregon (Crook, Grant, Malheur, and Harney counties), Washington (Grant and Lincoln counties), Utah (Box Elder county), Nevada (Humbolt and Washoe counties), Colorado (Garfield county), California (Lassen county). There was no report from Arizona. Several years ago the writer was informed that spotted fever occurred in British Columbia, but a recent letter from the health officer of that Province states that there is no case on record.

Idaho reports by far the largest number of cases. Dr. Ralph Falk of that State reports 386 for 1914 with fifteen deaths, and he has admirably tabulated these cases numerically and graphically.[31] The disease as it occurs in Idaho is of comparatively low virulence, two or three per cent. mortality, this is also true of Wyoming and all the other states except Montana. It is yet unexplained why, but the mortality in Montana is variously estimated from sixty to ninety per cent. The mortality is in direct proportion to the age, and nearly all cases that recover in Montana are in children or youths, the death rate being about ninety per cent. in persons over twenty-five years of age.

It is not known in which State spotted fever first occurred, neither is it known whether is occurred in Idaho or Montana first. The Bitter Root Range of mountains separates the spotted fever fields of the two States and Lo Lo Canyon is the connecting pass through which undoubtedly wild animals travel from one State to the other. In this canyon the largest number of cases that are found in Montana occur and the disease is of the most virulent type. Almost all the experimental work has been conducted with this virulent strain as found in the Bitter Root Valley. Both field laboratories and experimental laboratories have been located here, the workers thinking that this most virulent type offered a more fruitful field for experimentation. Ricketts demonstrated by cross-immunity tests that the Montana and Idaho strains were one and the same disease. Diagnoses in other States, so far as the writer knows, are based upon clinical findings, there being no experimental evidence on record to support any other conclusion.

Spotted fever has not been found to exist in nature in any lower animal, in either an acute or chronic form. All the late investigators have worked along this line, believing it to be the keynote to the situation. A few of the lower animals may be infected by inoculating them with virulent blood either subcutaneously or intraperitoneally. Among these the rhesus and guinea-pig reproduce the disease quite similar to that found in man with the exception of the eruption, and when they have white skins, an eruption may also be found. White mice, domestic cats, and dogs are reported immune.[27] White, black, and gray rabbits are partially immune. The gopher, a semi-cold-blooded animal that is found in the valley in great numbers, may be experimentally infected and the strain recovered by blood inoculation into a non-immune; but this animal is not a satisfactory one to work with as it does not run normally a constant temperature, this varying from 98° to 102°. There are many large and small wild animals in spotted fever districts, and it may be that a chronic source of the disease exists in one or more of them and is accidently transmitted to man by the wood tick, *Dermacentor venustus*. A chronic source is suggested because, if acute, the animals would either die or completely recover, and when once the temperature is normal, it has been found impossible to transfer the infection. This has been repeatedly proven with guinea-pigs and suggests that there is no such thing as a chronic human carrier of spotted fever, or any other animal that manifests the disease in an acute form.

Etiology.—The specific cause has not been determined. Since the mode of transmission is through an insect, a biological carrier, and on account of certain similarities to other protozoan diseases, it is very probable that the cause when isolated will be found to be an animal parasite. The only means of transmission now known is by the wood tick. A great deal can be said of the predisposing causes, but briefly, man does not possess natural immunity to spotted

fever, and any condition that makes one liable to be bitten by an infected wood tick, is a predisposing cause of this disease. These arachnids, both males and females, live entirely on blood, and although they are only occasional feeders, they must feed before each molt. During the act of feeding, the hypostellum is plunged into the skin and an irritating fluid ejected, this causes local hyperemia and retards blood coagulation; the animal now feeds. Since the infection is contained in the salivary gland as proven by Ricketts,[34] it is plain how man is infected. The tick *Dermacentor venustus* (or *andersoni* as it is sometimes called) is very generally distributed throughout the Rocky Mountain States; but the writer has been unable to find this tick around Galveston, Texas, or Vera Cruz, Mexico, although ticks are very numerous in both places. This is the species that Ricketts and McClintic found infected in nature, and the species with which the transmission has been proven. Although there are other species in the infected zones, and there is also some evidence to indicate that genera other than the dermacentor may transmit the infection, it has not been proven. With the advent of the first few warm days of spring, wood ticks appear by the billions, nymphs are probably more numerous and it is possible that this is the stage in which they hybernate over winter, certainly a large percentage of them. They can be found on all animals roaming the fields, large and small, wild and domestic; they can also be found on the vegetation, especially hay. The cycle is in four stages: egg, larval, nymphal, and adult. This may be completed in a few months under most favorable conditions of temperature and feeding, as in a laboratory, and in about two years under natural conditions such as are found in western Montana. Males and females while feeding on warm-blooded animals copulate, and fertilization takes place. After engorging with blood, usually requiring several days, the female drops from the host, remains quiescent for about two weeks, when ovipositing commences. A cream-colored mass of several thousand eggs is laid and the female dies. After about a month of summer temperature as in Montana, the eggs hatch; small "seed ticks" or larvæ appear. They are light yellow in color, have three pairs of legs, no sexual apparatus or spiracles. The larvæ are about the size of a pin's head, they become darker in color and attach themselves to some animal, usually a small animal. They feed for about a week and drop to molt, which takes about a month. Nymphs emerge from this molt with four pairs of legs, and also with spiracles, but no genital apparatus; they are about two by four millimeters in size, but the species cannot be determined at this stage. As with the seed ticks, nymphs seek a host, and after becoming attached they feed for about a week and drop. They remain active for several weeks when a white shell forms over the entire arachnid. It then enters into the second molt which is completed in about a month under most favorable conditions. When the tick emerges, it is a complete adult ready to recommence the cycle.

Although ticks of various genera are found the world over, it will be noticed that the spotted fever fields are from forty to forty-seven degrees North latitude, and from 2,500 to 4,000 feet above sea-level. Another characteristic is that spotted fever is confined to definite areas, for example, it appears every year on the west side of the Bitter Root River, but very rarely is there a case on the east side, and then the history of a visit to the west side can usually be obtained. There are fewer ticks on the east side and this is explained by Frick[16] as resulting from the greater number of sheep grazing on the valley and foothills. There is free communication across the river, persons, animals, and materials crossing freely. Rocky Mountain fever is purely a disease of the country, the wood ticks not being found in cities.

Immunity is established by one attack and the writer has been unable to obtain a history of a second attack. This corresponds to the laboratory findings; guinea-pigs cannot be reinoculated with spotted fever once they have recovered from this disease. Ricketts[34] has shown that the young of a pig rendered immune to spotted fever virus possess a certain amount of immunity. We too have found it unreliable to use offspring of immune mothers in experimental work (guinea-pigs). This would indicate that children of immune mothers possess at least a certain amount of immunity to spotted fever.

Pathology.—The following data are based on the observation of seven human cases with complete postmortem findings on three, and numerous complete postmortems on guinea-pigs. Rigor mortis comes on slowly, also the animal heat leaves slowly, and decomposition sets in quickly. The most noticeable features in viewing a body dead of spotted fever are intense and general jaundice, little emaciation, lividity around the mouth, small petechial and macular spots over the body more marked on the arms and legs, and marked bluish confluent blotches on the dependent portions of the body. The face remains free from eruption and only macules are seen on the palms and soles. On incising the skin, the dark color and fluidity of the blood are very noticeable. The writer has not noticed an enlargement of the superficial lymph glands in man, although it is quite common in guinea-pigs. The site marking a tick bite can usually be found as a red papule surrounded by a hyperemic zone. The cerebrospinal nervous system has shown nothing constant, and not enough to account for the marked brain symptoms. Organs of special sense have shown nothing, and this is also true of the lungs and pleura, except as complications, pneumonia being not uncommon.

The right heart and large veins are engorged, the left side being comparatively empty. The heart muscle is darker in color and softer in consistence than normal, occasionally showing hemorrhages under the visceral pericardium. Diaphragm negative; stomach, intestines, and omentum show nothing constant except jaundice; occasionally small hemorrhages are seen in the intestinal walls. Spleen, liver, and kidneys are the organs most affected. The spleen is always enlarged, often twice or more the normal size, is dark in color, firm, and friable; it bleeds freely on section and the tissue seems disorganized. The liver is also darker than normal, bleeds freely, is evenly enlarged, and bile-stained; the gall-bladder shows nothing abnormal. The kidneys too are acutely enlarged, and hemorrhagic throughout. All these organs show subcapsular hemorrhages. The adrenals are enlarged and hemorrhagic. Examination of the bladder and prostate gives negative results. Gangrene of the scrotum and prepuce was seen in three of the seven cases, the testicles being adherent and hyperemic, the tunica vaginalis showing acute inflammation, and the epididymis being soft and jelly-like. Gangrene of the pudenda and ears was often seen in guinea-pigs, but not after the first transfer of human blood. The testicles of guinea-pigs are not constantly seen in the scrotum, being at times in the abdominal cavity, but the above changes are more common when the organs are down. Both ovaries and testicles are hyperemic in guinea-pigs. The pancreas participates in the acute congestion; the bone marrow is darker in color and seems more fluid in consistency than normal.

Quoting Le Conte[23] of the University of Chicago for the microscopic pathology: "The changes are of two sorts, those connected with the occlusion of vessels and the more diffuse lesions affecting the entire group of organs. The diffuse changes are hyperplasia of lymphoid tissue and cloudy swelling and acute fatty changes in organs commonly the seat of such lesions in acute infectious diseases. The focal lesions are

more varied in their nature since they include not only the process leading up to the inclusion of vessels, but the results of such obstruction, necrosis in different degrees and the hemorrhages responsible for so many of the clinical and gross anatomic features of the disease as well as for the name 'spotted fever.' In sections of skin, liver, kidney, spleen, and adrenal both vascular occlusion and the necrosis resulting from obstruction are present."

In guinea-pigs the disease is quite similar to that in man. Skin manifestations are not the same but an eruption is sometimes seen on white pigs. Should spotted fever occur in the negro, it is very questionable whether or not it would be correctly diagnosed. This could be accomplished only by blood inoculation into some non-immune, as for example a guinea-pig.

Symptoms.—After an incubation period of from three to eight days the disease is ushered in suddenly with a chill or chilliness, pain in the head, neck, back, and joints especially the wrists and ankles, with malaise, anorexia, increased pulse and respiration, constipation, irritation, and inflammation at the site of the tick bite. Persons are frequently bitten in tick regions and it is impossible to differentiate the bite of an infected tick from one not infected by the appearance of the lesion. Pains continue and the large joints become quite painful, there is no redness or swelling but exquisite pain on the slightest movement. About the fourth day, calculating from the first day of fever, a deep-seated macular eruption appears on the wrists and ankles, spreading to the palms, soles, forearms, and calves of the legs. The eruption becomes darker in color and spreads more to the dependent portions of the body. Often it is petechial and confluent, forming spots an inch in diameter with a dusky hue; this latter feature is more commonly seen on the back and late in the disease. The eruption is not elevated, does not itch, and does not disappear on pressure. The pulse is slow as compared with the temperature; there is an initial rise, but a pulse of 100 or more in an adult is a bad sign late in the disease; it is full and of good tension, sometimes dicrotic toward a fatal termination. The temperature suddenly rises to about 102,° and continues a daily rise with but slight morning remissions until about the seventh or eighth day when it reaches about 105° or 106°. In favorable cases there is a fall about the ninth or tenth day, ending by lysis in a very slow convalescence. Patients show signs of toxemia very early, not only by headache, but by stupor and apathy. This usually gives way to muttering delirium, carphologia, and subsultus tendinum by the fifth or seventh day.

Slight catarrhal pharyngitis and conjunctivitis are common at the beginning, as well as nausea. Vomiting is usually a late sign and appears when the disease becomes hemorrhagic in nature. The writer has seen "black vomit" on the ninth day but it may appear sooner. The tongue is that of all febrile diseases. Constipation is the rule and continues well into convalescence. The circulation is sluggish with engorgement of the venous side; this produces a peculiar cyanotic appearance of the face, especially about the mouth, quite characteristic of the disease. Nephritis appears early, albuminuria and reduction in the amount of urine almost from the start; in severe cases, great numbers of granular and sometimes blood casts are seen. This continues through the severe febrile period; suppression is common, and retention or incontinence is a frequent sign. The spleen is palpable early, is greatly enlarged and hard, not the soft spleen of typhoid fever. In unfavorable cases, the skin becomes more hyperesthetic, there is incontinence of urine and feces, the temperature remains high, the brain symptoms increase, icterus appears (first seen in the conjunctiva and then becoming general), the eruption is more profuse and confluent with a purplish hue, pulse exceeding 110 (in an adult), and death occurs within twenty-four hours. In cases destined to recover, the temperature falls by lysis between the ninth and fourteenth days; morning remissions and evening rises are often seen as long as into the sixth week of convalescence. The urine increases in amount, the eruption fades with a fine desquamation, the mental condition improves, and the pains disappear. Convalescence is very slow and the mental condition of patients recovering from spotted fever remains sluggish for a long time. The macular eruption can be brought out by hot baths even months after the temperature is normal in some cases. Pregnant women usually abort. A late symptom is gangrene of the prepuce, scrotum, and testicles, sometimes of the faucial pillars. The testicle first becomes quite painful and then adherent to the scrotum. This is said to be more common in Idaho than Montana on account of the longer duration of the disease in Idaho. It is common in guinea-pigs, and, like the incubation period, varies with the virulence of the virus.

The blood is a valuable guide to the diagnosis; it becomes darker in color from the start, due to destructive processes and poor aeration; the coagulation time is also increased. There is an initial leucocytosis, then falling below 10,000 where it remains in favorable cases. A sudden increase in the number of leucocytes late in the disease is a very serious sign. The writer has seen a case in which the leucocytes numbered 1,000 per cubic millimeter the day prior to death, with a rise to 28,000 per cubic millimeter three hours before death. Large mononuclears and transitionals are increased; myelocytes are often present, and occasionally one will find a nucleated red cell. In severe cases of spotted fever, there are leucocytes that do not resemble any in the usual classification. In the seven cases of human blood examined in 1912, the "Arneth index" was a reliable guide to the patient's condition. Eosinophiles are reduced or absent; an increase is a favorable sign. The red count seems not to be affected, and the hemoglobin is 100 per cent. or more on the Talquist scale.[31]

The virus is contained in the blood from the appearance of fever until the temperature is normal, after that time the various investigators have not been able to transmit the disease by blood transfers. In perpetuating the strain in pigs we make the transfer at the height of the fever. The virus is contained in the serum and red and white blood corpuscles, and Ricketts also found it in the lymph. Animals cannot be infected by feeding and therefore the stools are not believed to contain the virus. Animals manifest the disease in from two to five days after intraperitoneal inoculation and five to ten days after being inoculated subcutaneously with virulent spotted fever blood. In this manner the same strain has been kept going through many pigs, and the University of Chicago has kept the same strain over two years. There is no difficulty in transferring the disease from man to guinea-pigs. The virus is not destroyed by storage in the ice-box for a week but is destroyed in twenty minutes at 55° C. (Ricketts[34]). It will not pass through a No. "N" Berkefeld filter in twelve hours.

During an investigation of this disease in 1912, as it occurs in the Bitter Root Valley of Montana, every culture medium of which there was an available description was tried with negative results. Many were tried aerobically and anaerobically, from temperatures of the ice-box to 45° C.; in absolute darkness and in variously colored lights. These cultures were checked by staining, microscopic and macroscopic examination, and by animal transfers when deemed advisable. In no case was there any evidence of a multiplication of the organism (?). These cultures included not only the common media, but also the spirochete medium of Noguchi and the plasmodia medium of Bass. In like manner every available stain and staining method was used. Many improvised stains were also tried with negative results. Specimens

were examined fresh and at various stages of the disease, by dark field and with variously colored diaphragms. Staining was done by high pressure, electrolysis, in variously colored lights, for various durations of time, and after using various fixing methods. All these were with negative results, but it is believed that with further concentration of the virus and transfers into species markedly different from the donor, interesting results may be obtained.[31]

Ricketts has demonstrated that the eggs, nymphs, larvæ, and adults of infected female ticks retain the virus and are capable of transmitting the disease. The disease as it occurs in other States than Montana is of much less virulence. The eruption and toxemia are less marked, the disease is less acute, more prolonged, of lower mortality, and gangrene is more common.

Complications.—Nephritis is present in all cases, myocardial degeneration and pneumonia occasionally occur. The brain symptoms indicate that at least meningeal irritation is present, although post-mortem examination fails to reveal any cerebral lesions. Gangrene of the scrotum, testicles, prepuce, or faucial pillars, sometimes occurs, more commonly in Idaho. Suppression of urine and uremia are late complications in the more serious cases. It is said that a large percentage of persons, who recover from spotted fever as it occurs in Montana, show marked mental impairment for a long period of time.

Prognosis.—The death rate in the Bitter Root Valley is about ninety per cent. in persons twenty-five years of age and over, is lower in younger people, thus varying directly with the age. It is said to be about three per cent. in Idaho, and it seems that the strains in States other than Montana are of about the same virulence as in Idaho. The vast majority of patients, as well as guinea-pigs in our experience, die on or before the ninth day. If life can be sustained until the fourteenth day with the Montana strain, recovery is quite certain. The danger signs are: jaundice, pulse over 100 (adults), leucocytosis over 10,000, absence of eosinophiles, Arneth index deviated to the left, marked diminution of urine, and profuse and confluent eruption. A short incubation period forecasts a bad prognosis. It is believed that patients showing the above syndrome never recover from the Bitter Root strain. After a case of spotted fever is diagnosed, each of the above signs is a fair index as to the patient's condition, and all of them taken collectively, furnish a most reliable basis for the prognosis from day to day.

Treatment.—There is no specific treatment for spotted fever, and immune serum is a failure in both prophylaxis and treatment. The patient should be put to bed and a brisk purge administered, a bowel movement daily being secured by purgatives or enemata. Sponge baths are advisable when the temperature is over 102.5° F.; although the temperature frequently does not respond satisfactorily to hydrotherapy, and the hypersensitiveness of the patients causes much discomfort during the bath, they feel better after the sponge. The diet should be exclusively liquid, and on account of the early, persisting, and serious nephritis and profound toxemia, as much water should be taken as possible; salines by the bowel (drip method) and a quart of lemonade drunk daily will greatly dilute and hasten the elimination of the toxins. Quinine, coal-tar products, arsenic, atoxyl, physiological salt infusions, continuous warm boric-acid baths, sodium cacodylate, salvarsan, and many other drugs have been tried and discarded as worthless.[31]

A quiet room with subdued light and an ice-cap to the head for brain symptoms are comforting to the patient, intermittent hot applications to the painful joints, with as little movement as possible, also give the patient some relief. One should guard against the patient getting out of bed on account of the extra strain on the heart. Cardiac stimulants must be begun when the pulse goes over 95 in an adult; digitalis is good but slow in action. If strychnine is used, it should be given at short enough intervals to maintain the stimulation, as for example one-thirtieth grain every five or six hours. The urine should be measured and the amount maintained to at least thirty ounces in twenty-four hours. The mouth should be cleansed frequently and the use of the bed-pan should be insisted upon. Of all drugs, sodium citrate gave the most encouraging results during the investigation in Montana in 1912. Unfortunately, it was not commenced until after the season was over, so was tried only on lower animals, and this too was interrupted by Army maneuvers. Several animals were so treated, guinea-pigs subcutaneously and rabbits subcutaneously and intravenously. The effect was very noticeable, the temperature dropped, the attack was shortened, and there was a marked general improvement in the animal.[31] In seven animals so treated, none died, although the mortality in untreated animals had been about eighty per cent., using the same strain. In another case, five per cent. sodium citrate was mixed with virulent blood and allowed to stand for twelve hours at room temperature then injected subcutaneously into a guinea-pig. This did not prevent the disease but it ran a mild course while in the control it ran a severe course and the animal died. In another instance, a non-immune guinea-pig was inoculated subcutaneously with 1 c.c. of virulent defibrinated spotted fever blood and immediately given 5 c.c. of two per cent. sodium citrate, repeated the following day. For five days subsequent to this the animal was given from 5 to 7 c.c. of three per cent. sodium citrate. The animal developed spotted fever but it ran a milder course than in the control, which died.

We can give no explanation for this at this time, and apologize for the small number of cases offered for consideration, but recommend the drug being pushed to tolerance in man from the start, preferably intravenously. This is recommended on the ground that it has given promising results in a limited number of cases of lower animals so treated, that it is harmless when properly used, and that there is no other drug now known that offers the slightest encouragement. It is safe to give 60 c.c. of a five per cent. solution intravenously when sterile and prepared with *freshly distilled* water. This dose can be given twice daily, and even larger doses may be used, depending on the patient. Intravenous medication is safe and simple, and the citrate can be given with either a syringe or any intravenous apparatus. The introduction of a small amount of air is of no concern.

Prophylaxis.—One will not naturally have spotted fever without being bitten by an infected wood tick. This insect is a slow feeder and Moore[32] says one and one-half to ten hours are required for the tick to attack; it crawls around a great deal before attaching itself, therefore if persons in tick-infested zones would carefully search for ticks on their person in the morning after rising, at lunch time, and before going to bed, the chances of contracting spotted fever would be very small. When a tick is found it should be removed at once, and if the head is embedded, a drop of carbolic acid should be placed on the head and traction made on the hypostellum. If this breaks off, the head should be extracted with a penknife, then a drop of one-half official strength tincture of iodine be injected into the wound. The great difficulty is that most of the cases of spotted fever occur in persons that sleep in their day clothing, and in that case the tick is not found possibly for days after attaching. An ointment composed of spirit of turpentine one dram, bichloride of mercury one grain, sulphur one dram, lano-

line one ounce, when rubbed on the skin of man or guinea-pig, will apparently prevent the tick from attaching. This could be used daily by persons going into tick-infested zones.

HENRY CLAY MICHIE.

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Rodent Ulcer.—See *Carcinoma of the Skin.*

Roentgen Diagnosis.—The announcement by Roentgen in 1895 of the discovery of a ray which he termed the "*x*-ray," but which now bears his name and is known officially in this country at least as the "Roentgen ray," marked the beginning of a new era in physics, chemistry, and medicine.

It is a remarkable fact that up to the present time the practical application of this ray has been largely confined to the field of medicine and surgery but it has been used to a limited degree in arts and sciences and even in commercial life. The destruction of the tobacco worm, the detection of flaws in steel and other metals, and the betrayal of contraband articles in bales of cotton are notable examples, and undoubtedly there are innumerable other applications which will be made of the ray.

In medicine and surgery where its uses have been developed to a larger degree it has proved to be the greatest single factor in the history of medicine. The discovery of ether as an anesthetic marked a new epoch in surgery and the discovery by Sir Joseph Lister marked another, but both of these are limited largely to surgery, while the Roentgen ray is of equal value in medicine and surgery.

Roentgen rays which affect the plate are derived from three sources: the direct ray from the focal point of the tube, the indirect ray which comes from the wall of the anterior hemisphere in the old type of tube, and from the posterior surface of the anode in the Coolidge tube, and the secondary or Sagnac rays which are generated in substances outside of the tube

by either direct or indirect rays. The sources of these rays are diagrammatically shown in Fig. 1458.

Direct rays come from a small source and cause crisp, clear-cut, well-defined shadows of the solid substance interposed between it and the plate. Indirect rays, because of the large area in which they are generated, cast indistinct shadows of interposed substances and the secondary or Sagnac rays generated largely in the body which is being exposed come from large areas close to the plate and therefore cause indistinct shadows of any substance interposed between this source of origin and the plate.

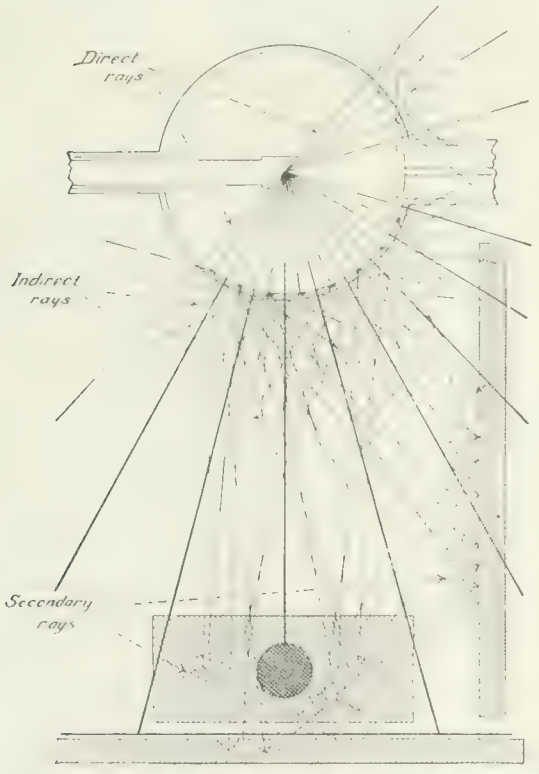

Fig. 1458.—Showing Sources of the Rays Affecting a Plate. The direct rays are generated at the focal point of the tube; the indirect rays at the surface of the glass; the secondary rays in substances outside of the tube.

Thus, from a Roentgen standpoint, we have the direct rays which give detail, and the indirect rays and the secondary rays which cause fogging of the plate. The ratio of the direct rays which reach the plate to the secondary rays which reach the plate varies in proportion to the size and area of the body, which is exposed to the direct rays.

In the examination of an abdomen which is more than seven inches thick on a single 14 × 17 plate there are more secondary rays which have been generated in the body that reach the plate than there are direct rays having sufficient penetration to pass through the body and register on the plate. Therefore, the importance of the fogging effect of the secondary rays can hardly be overestimated.

Technique.—There has been an exceedingly rapid development in the construction of apparatus. The newest types may be installed and within a year or two be so antiquated that they must be discarded. Therefore, no attempt will be made to describe the various machines that have been used. Three pieces of apparatus, however, are necessary for the practical application of the Roentgen ray in medicine and surgery: (1) A tube. (2) An apparatus for exciting the tube. (3) A table or tube stand for holding the tube and protecting the operator from the detrimental effect of constant exposure to the rays.

The original tube used by Roentgen was a vacuum tube first designed by Sir William Crookes, and excited by an induction coil. Rapid development in construction, especially the introduction of the solid target in the center of the tube and devices for regulating the vacuum brought us to a fairly standard tube which was used until the advent of the Coolidge tube, announced December 27, 1913.

The Coolidge tube differs from the ordinary tube in that its vacuum is approximately 1,000 times as high. Both the anode and the cathode are made of tungsten. A sleeve of molybdenum surrounds the spiral filament and aids in focusing the full cathode stream on the target. No discharge can be made to pass through the tube except when the cathode is heated to a sufficient degree to give off electrons and these when negatively charged by any ordinary apparatus are propelled against the anode causing generation of the *x*-ray. The penetration of the tube is regulated by the degree of incandescence to which the spiral tungsten filament is heated by a storage battery in circuit with the tube. The flexibility and stability of the tube are very remarkable and any desired degree of penetration may be obtained and held by regulating the supply of current from the storage battery. None but a Roentgenologist who has used the old type of tube can realize the practical advantages resulting from this mode of construction which allows accuracy of adjustment, stability of hardness, exact duplication of results, fixity of the focal point, long life of tube, flexibility, and tremendous output.

Apparatus for generating high potential current for exciting the tube is of three varieties: (1) The induction coil. (2) Static machine. (3) Transformer with rectifying switch.

The induction coil with some form of interrupter was generally used until the advent of the transformer with the rotary switch which is the machine now in general use. The transformers are of two types: closed and open circuit.

The tables and tube stands for holding the patient and tube are of many makes. Some have the tube above the table and the plate below—others have the tube below the table and the plate above the patient. All of them have the tube more or less surrounded with some substance opaque to the rays to protect the operator and that part of the patient not intended to be examined or treated.

Diaphragms to limit the area of the body that is exposed and compression blends or other methods of compressing the patient to reduce the thickness of the part under observation are fundamentals of every tube stand or *x*-ray table.

Various devices have been arranged in the form of screens, cross-bars, etc., to diminish the effect of the secondary rays. The author has recently designed an apparatus composed of three parallel moving slots which almost entirely eliminates the fogging effect of the indirect and secondary rays and gives a crispness to the plate, especially in Roentgenograms of large areas, that it has heretofore been impossible to obtain.

The application of the principles of stereoscopy to Roentgenography demands that the table be arranged for making two Roentgenograms within a relatively short time, the tube being moved about two and one-half inches between the time of making of the first and second Roentgenograms. These Roentgenograms are then viewed through a stereoscope, which may be one of two types—the prism or the Wheatstone. The study of properly made stereo-roentgenograms, as such are called, allows one to see the third dimension, that is, the depth of an object from the

EXPLANATION OF

PLATE LI.

EXPLANATION OF PLATE LI.

FIG. 1.—Fissure fracture in a long bone; clinical evidence doubtful.
FIG. 2.—Fracture of the head of the radius.
FIG. 3.—Supracondyloid fracture of the humerus.
FIG. 4.—Same as figure 3 after union.
FIG. 5.—Syphilis affecting the lower radius and lower ulna.
FIG. 6.—Tuberculosis of the hip.
FIG. 7.—Position of fragments after healing.
FIG. 8.—Definite involvement of the right frontal sinus; slight involvement of the left.
FIG. 9.—Renal calculus. This figure also illustrates the "spots and flaws" that must be differentiated from calculi.

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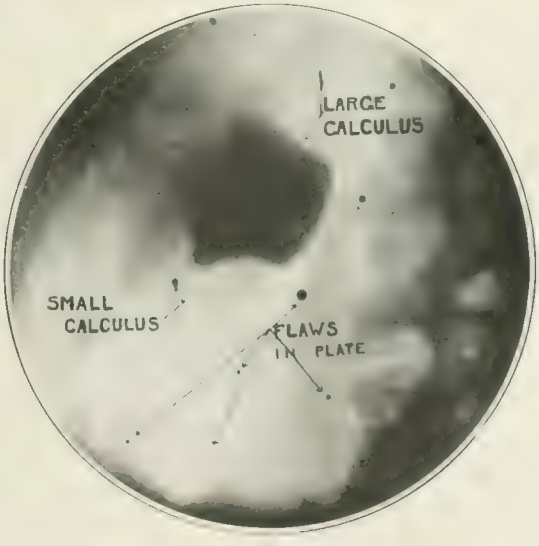

9

ROENTGEN DIAGNOSIS (*Cole*).

surface. This is of such great value in all classes of Roentgenography that it is rapidly becoming universally used.

Foreign Bodies.—The first practical application of the Roentgen ray in medicine or surgery was in the detection of foreign bodies. Metallic substances or any other matter of greater or decidedly lesser density than the tissue in which it is lodged may be detected by Roentgenograms or fluoroscopic examination (Fig. 4459).

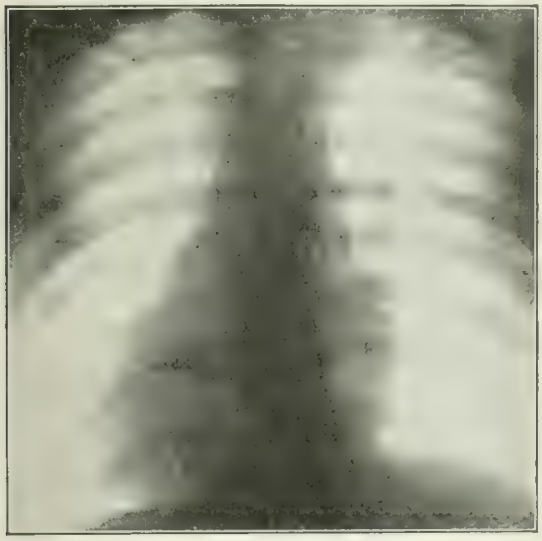

Fig. 4459.—Showing Foreign Bodies (Tacks) in the Bronchi.

Foreign bodies may be in the tissues or they may be in the alimentary, respiratory, or urinary tract. Metallic substances such as bullets, needles, pins, etc., are readily detected in practically any part of the body, but substances such as a splinter of wood, or a sliver of a certain kind of glass may be of about equal density to the tissue in which it is lodged, and then its detection, even if possible, is more difficult.

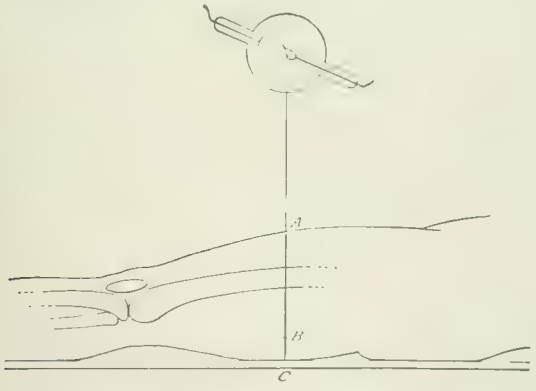

Fig. 4460.—A Simple Method of Locating a Foreign Body; first exposure giving the shadow C.

To determine whether any particular foreign body will show Roentgenographically one similar to it should be submerged in water and radiographed. If the one in the water shows, the similar one in the body should be discernible.

Localization of foreign bodies is more difficult. Numerous methods of localization have been described, some very complicated and proportionately accurate, others much less complicated but very practical. The very accurate but somewhat complicated method originally described by Sir Mackenzie Davidson[1] and the special method of localizing foreign

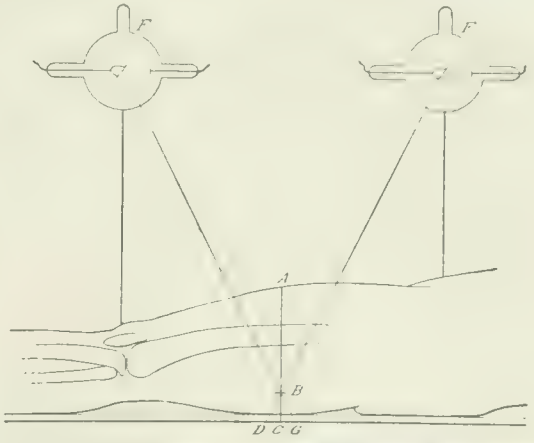

Fig. 4461.—A Simple Method of Locating a Foreign Body; second and third exposures giving the shadows *D* and *G*.

bodies in the eye described by Sweet[2] deserve special mention. A simple but sufficiently accurate method of locating foreign bodies under fluoroscopic or Roentgenographic examination is as follows (see Fig. 4460):

Fig. 4462.—Exact Location of a Foreign Body by Geometrical Calculation. Let *NO* = plane of the two positions of the tube. *E* and *F* = two positions of the tube. *EF* = 5″, distance between the positions of the tube. *LM* = plate, parallel to plane *NO*. *B* = foreign body. *A* and *C* = markers. *D* = shadow of foreign body when tube is at *F*. *G* = shadow of foreign body when tube is at *E*. *AC* = 20″. To find *CB*: By measurement *DG* is found to be 1″ $\angle CG = \frac{1}{2}''$ *EF* = 5″ $\angle EA = 2\frac{1}{2}''$ Lay off *FC* equal to *EA*. *GPE* and *GCB* are right-angled triangles having a common acute $< GEP$. The sides of right-angled triangles having a common angle have the same ratio. $PG : CG :: PL : CB$ or, $3'' : \frac{1}{2}'' :: 20'' : CB$ $\therefore CB = 3\frac{1}{3}''$

Note.—If the measurements of the lines for this procedure made exactly to correspond to the measurements they represent, the line *CB* will be obtained without the arithmetical calculation.

By manipulation under fluoroscopic observation, a piece of lead is placed on the point *A* on the anterior surface and another on the point *C* on the posterior surface. These are so located that the foreign body *B* is directly between them. Their position is then marked with indelible ink. A plate is placed in apposition to the body at the posterior mark, and the anode is placed directly above the anterior mark. On the plate make two exposures, moving the tube for the first exposure a short distance (two and a half inches) from its present position. For the second exposure move it exactly the same distance from its original position but in the opposite direction, a shift of five inches between the first and second exposures (Fig. 4461). The plate is then developed for the two shadows of the foreign body, and the exact location may be ascertained by geometrical calculation.

Geometrical Proof.—Measure the distance of the tube from the plate, and the distance the tube is shifted between the exposures (Fig. 4462).

Fractures.—The use of the Roentgenogram in the diagnosis and treatment of fracture has become almost universal. Fluoroscopy and Roentgenography may each be employed but one is not justified in making a negative diagnosis of fracture by fluoroscopic examination alone because many fissure fractures or even complete fractures with slight displacement cannot be detected fluoroscopically. Fluoroscopy is especially valuable during the reduction of the deformity of the fracture with marked displacement of the fragments. In a Roentgenogram having sufficient detail a fracture can be detected in any part of the body, and therefore, one is justified in making a negative or positive diagnosis of fracture on the Roentgen evidence.

Roentgen examination in cases of fracture is employed for two purposes: (1) For detection of fractures in doubtful cases (Plate LI, 1 and 2). (2) For ascertaining the position of the fragments in cases of fractures recognized by clinical methods (Plate LI, 3 and 4).

All cases of injury of doubtful fracture should be Roentgenographed for the good of the patient and the protection of the physician or surgeon. All cases of known fracture should be Roentgenographed after "setting" before union occurs, to determine the position of the fragments and prevent such deformities as shown in Plate LI, 7.

Bone Lesions.—Practically all kinds of bone lesions can be detected by this method of examination and the location and extent of the process accurately determined. Bone tuberculosis, syphilis, osteomyelitis, osteomalacia, rickets, scurvy, sarcoma of the various types, and cysts of the long bones can be detected and can usually be differentiated from each other solely on the Roentgen findings, and many of the more obscure or rarer lesions can not only be detected but the type of lesion diagnosed. In other cases, I, personally, have been compelled to content myself with determining the location and extent of the lesion and whether it was destructive or productive rather than putting it in any of the classes of lesions just mentioned.

They are so readily divided into definite groups with characteristic Roentgen findings that I believe the Roentgen method will eventually be used as a basis for a sound scientific classification of bone lesions (Plate LI, 5 and 6).

Head.—The head offers a fertile field for Roentgen study (Plate LI, 8). The size and shape of the frontal and maxillary sinuses may be determined, and infections, polypoid growths, or even marked congestion of the mucous membrane lining the sinuses may be detected by this method. These lesions by displacing the air that normally fills the sinus, cause increased density in the infected side, and when compared with the one on the opposite side this increased density is readily detected.

Infection of the ethmoid cells is detected by increased density of the infected side, and the bones do not have the clear-cut line of the normal ethmoid cells.

The length and height of the sphenoid sinus is readily detected in the lateral direction and its size is determined by this method and is a rather important factor in surgical procedure on tumors of the hypophysis when it is attacked up by the nasal cavity.

The infection of the sphenoid sinuses is difficult to detect in the lateral direction because one is not able to compare it with the opposite side. With extreme extension of the head, pushing back the top of the skull, and directing the rays in the anteroposterior direction underneath the jaw, the sphenoidal sinus may be shown much better than one would expect and in this direction the right and left sinuses may be compared with each other and infection of one be more readily determined. Tumors of the hypophysis are sometimes detected through their slightly increased density but usually by the manner in which they displace the anterior or posterior clinoid processes.

Aside from the tumors of the hypophysis one occasionally detects tumors of the brain especially if there are calcified capsules to the tumor or if it is near enough to the surface to involve the table of the skull. In the interpretation of the plates for brain tumors one must be extremely careful not to misinterpret the thin area of the squamous portion as a cyst, or the petrous portion of the temporal bone, or the pinna portion of the ear as tumors. Stereoscopic Roentgenography is especially essential in headwork.

Even slight fractures of the skull may be detected with remarkable accuracy particularly if the plates are made in various directions and studied stereoscopically.

In cases of hydrocephalus irregular markings of the inner table of the skull corresponding with the markings of the brain may be detected. Increase in the size and dilatation of the diploic sinuses are considered by some as indications of tumor or pressure from within.

Irregularities of the teeth and chronic abscesses (Plate LII, 3) of the alveolar processes have attracted such a great amount of attention recently that special consideration should be given to these subjects. Unerupted, misplaced teeth, and congenital lesions may be detected. The roots of devitalized teeth are incompletely filled in more than ninety per cent. of the cases examined. Around the apices of many of these teeth there is evidence of diseased bone, either localized abscesses or localized areas of osteoporosis. The presence of *Streptococcus viridans* or even a more virulent germ, and the relation of these organisms to constitutional symptoms, particularly joint lesions, are attracting much attention and is worthy of careful consideration. Sometimes these areas contain foreign bodies, especially broken dental instruments, fillings that have been thrust through the apex of the tooth.

Kidneys.—One of the early applications of the Roentgen rays was in the detection of renal, ureteral, and vesical calculi. Leonard's name will always be associated with the pioneer work in this line and although it is doubtful if he was the first one to detect a renal calculus by this method of examination, his thorough work did much to establish its accuracy. There has been much discussion as to whether all kinds of renal and ureteral calculi can be detected Roentgenographically, some contending that the pure uric acid calculus does not show, and others stating that a pure uric acid calculus of sufficient size to warrant operation never occurs in the kidney or ureter.

Certain types of sodium or ammonium urate calculi occur in the bladder and these cast much less dense shadows than the renal and ureteral calculi.

EXPLANATION OF

PLATE LII.

EXPLANATION OF PLATE LII.

FIG. 1.—Right lung normal; left lung showing infiltration, consolidation, and cavity.
FIG. 2.—Miliary tubercles involving both upper lobes
FIG. 3.—Abscess of a tooth.
FIG. 4.—Normal stomach.
FIG. 5.—Cinematograph pictures for the study of gastric motor phenomena.
FIG. 6.—Carcinoma.
FIG. 7.—Spasm in a normal stomach.

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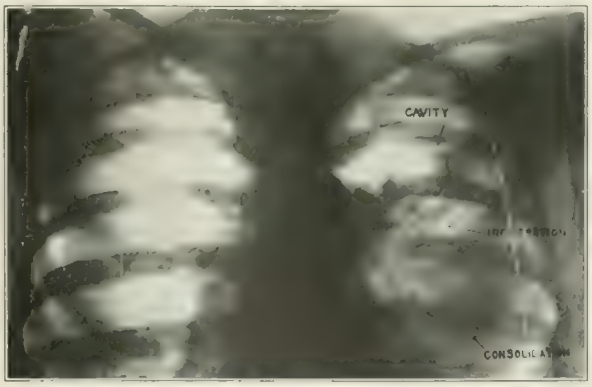

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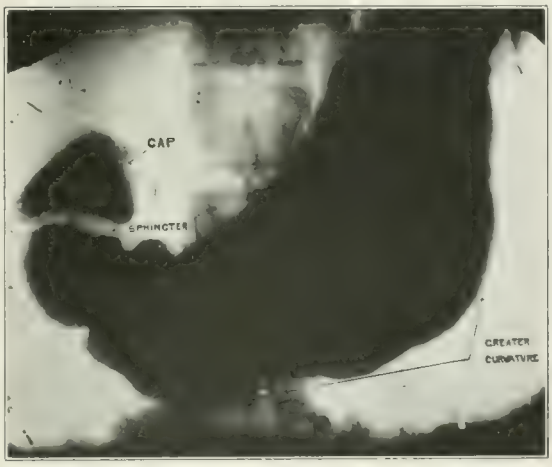

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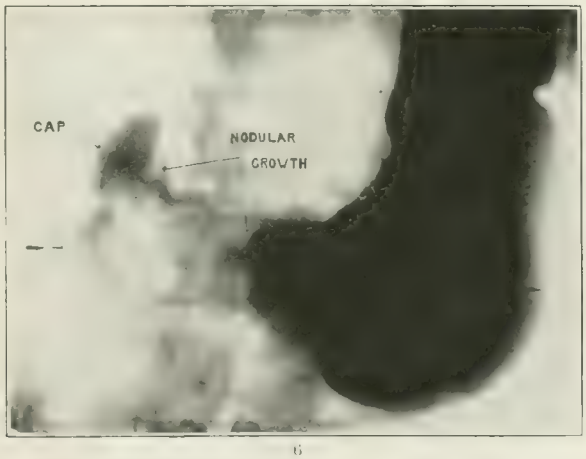

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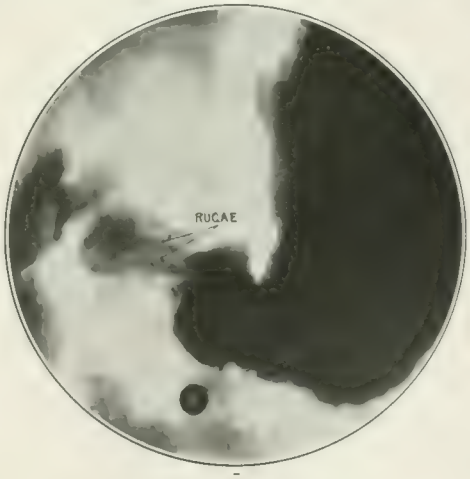

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ROENTGEN DIAGNOSIS (*Cole*).

More than a decade ago I stated that any renal or ureteral calculus of sufficient size to warrant surgical procedure for its removal could be detected by careful study of a Roentgenogram having sufficient detail (Plate LI, 9). At that time I defined the amount of detail necessary by stating that the eleventh and twelfth ribs, the tips of the transverse processes of the lumbar vertebra, the spine of the ischia, and the tip of the coccyx, and the border of the psoas muscle should be shown distinctly. Later I added that the kidney itself should be distinctly seen.

In 1913 at the International Congress of Medicine, in London, Thurston Holland reported Roentgen findings in about 1,800 cases of renal or ureteral calculus with an error of less than two per cent., and these included misinterpretation of extraureteral calcareous bodies. More recent articles report errors of from twenty to forty per cent. Undoubtedly these large percentages of errors are the result of examinations in clinics or dispensaries where the immense amount of work prevents the careful examination and interpretation of the plates. Aside from the detection of the calculi, their shape and location are important in determining whether surgical procedure is indicated and if so, what is necessary.

Without symptoms, simple detection of a renal calculus by the *x*-ray is not, in my opinion, sufficient evidence for surgical procedure, even where there is no doubt of its presence. Smaller calculi may pass from the pelvis into the ureter and it may be determined with a reasonable degree of certainty whether they will pass through the ureter into the bladder.

The tendency of these small calculi to lodge in the lower part of the ureter, and the difficulty of surgical removal at that point, brings up the question of whether they should be removed from the upper ureter when detected there.

Pyelography, or the Roentgenography of the pelvis and ureters injected with opaque substances such as one of the silver salts, has been extensively employed by some observers. It is a procedure requiring more skill on the part of the genito-urinary surgeon who catheterizes the ureters, and injects the solution, than on the part of the Roentgenologist who makes the examination. In the hands of the inexperienced the injection is not free from danger, and as far as my observation goes, has apparently been a painful procedure, although in the hands of such a practiced operator as Braasch I have seen it done with little or no pain to the patient.

In the region of the lower end of the ureter one frequently observes calcified bodies, and in some instances it is difficult to state whether these are ureteral calculi or so-called phleboliths, or calcified bodies external to the ureter. In such instances a ureteral catheterization with a stileted catheter or an injection of silver salts in the ureter combined with the Roentgen examination enables one to determine with certainty which of these it is.

Prostatic calculi are frequently detected. They appear as numerous shot-like bodies close up to the pubis. By inflation of the bladder with air, one may show Roentgenographically the softest possible type of vesical calculi, and even tumors and enlarged prostate. On a few occasions we have inflated the pelvis of the kidney with air to show the pelvis and calices.

While certain kinds of vesical calculi show as distinctly as renal or ureteral calculi, other kinds, particularly the sodium and ammonium urate calculi, are less dense to the *x*-rays than the renal and ureteral calculi, but I believe that even these can be detected in the great majority of cases if a satisfactory plate is carefully studied, and in all cases if the bladder is distended with air; however, as vesical calculi can usually be detected by cystoscopic examination the Roentgen examination with air in the bladder is not frequently made. Interpretation of the Roentgen findings offers a far greater opportunity for errors than the absence of the shadows themselves.

There are numerous things such as calcareous glands, gallstones, calcified deposits in the ligaments of the pelvis, so-called phleboliths, fecal concretions, pills and foreign bodies in the intestine, calcified arteries, calcified costal cartilages, prostatic calculi, flaws and finger-prints in the plate, and tuberculous calcareous deposits in the kidney which one must recognize provided he is to differentiate between the true renal calculi and all other conditions which resemble them. With experience in interpretation and with careful examination all these conditions can be distinguished from renal and ureteral calculi.

On account of the softness of the bladder stones it is wise to combine a cystoscopic examination in cases of doubtful Roentgen findings in the bladder.

Thorax.—The thorax, including the heart, aorta, and various lesions of the lungs, offers a fertile field for study. Roentgenograms of the normal thorax show the normal markings of the lung, blood-vessels, and bronchial septa, extending to within half an inch or less of the pleura. These appear like the branches of a tree.

The diaphragm is a trifle higher on the right than on the left side, and the heart shadow is shown distinctly. In the Roentgenograms with the plate on the anterior surface of the body the shadow of the heart is only slightly distorted, particularly if the tube is thirty inches or more from the plate. Around the roots of both lungs there is a moderate amount of density due to the thickening of the larger walls of, and the glands surrounding, the bronchi.

The greatest use of the rays in the thorax is in the detection of pulmonary tuberculosis (Plate LII, 1). I believe that its presence can be detected and the extent of the lesion be determined more accurately by stereoscopic Roentgenography than by any and all other methods combined. In cases where the process has not gone on to complete consolidation the individual miliary tubercles may be detected in small characteristic groupings (Plate LII, 2), and in studying the progress of tuberculous processes in a series of Roentgenograms even these individual tubercles may be counted and one may determine whether they have formed conglomerate tubercles or an area of consolidation.

With a reasonable degree of certainty one may determine whether the process is of the cellular (exudative) type or whether it is of the chronic fibroid type, and in cases of the exudative type the resolution which occurs after the process is checked may be determined by this method of examination. Pleurisy with effusive empyema may be readily detected and differentiated from tuberculosis by this method of examination.

Abscesses of the lungs, localized empyema, and metastatic tumors of the lung are discernible by careful Roentgen examination and while they can easily be differentiated from tuberculosis there is some difficulty in differentiating them from each other wholly on the Roentgen findings.

The Roentgen examination, particularly the fluoroscopic examination, plays a very important part in the collapse of the lung by artificial pneumothorax.

Pericarditis causes a characteristic finding. Dilatation, hypocardia, dislocation, and lesions of the great vessels, particularly of the aorta, are readily detected.

Aneurysm may be readily recognized and the size and width measured to within a fraction of an inch, also the lack of elasticity in cases of aortitis or calcification of the arch of the aorta in cases of atheroma.

There are certain types of foreign bodies which can be detected by Roentgenography and the location of which is important in cases of bronchoscopy for removal of foreign bodies.

Gastrointestinal Tract.—The Roentgen rays have been revolutionary in the diagnosis of gastrointestinal lesions. Two more or less distinctive methods have been employed: (1) The observation of *symptômes complices*, and (2) The direct detection of the pathological lesions.

1. *Symptômes complices*, as the name suggests, is a group of symptoms recognized in part by the use of the Roentgen ray, usually by fluoroscopic examination. This method has been developed by Roentgenologists in the large clinics of the Continent and is sometimes referred to as the "continental method." These symptômes complices are based on (1) The position of the stomach. (2) The time required for evacuation of a standard carbohydrate meal. (3) The mobility of the pylorus to palpation. (4) The detection of local points of tenderness. (5) Hyperperistalsis. (6) Gastric hypermotility. (7) Antiperistalsis.

Various combinations of these symptômes complices together with the gastric analysis and clinical history are supposed to indicate certain organic lesions of the stomach or duodenum. But they vary as greatly as the observers who compile them and one is at a loss to know which group of symptômes complices to follow. This method is of value in large clinics where a vast amount of material must be studied superficially at a minimum expense but its accuracy cannot be compared with the direct detection of the pathological lesion.

2. *The direct method* depends on the detection of morphological changes in the wall of the viscus, evidenced by alteration in either its contour or its pliability. In the grosser lesions this can be detected by fluoroscopic examination or single Roentgenograms, but in the small early lesions it can be detected only by a series of Roentgenograms which can be studied individually and collectively or matched over each other for confirmation. This implies a careful scrutiny of many plates—sometimes forty or even eighty being used for a complete examination. They may also be reduced to cinematograph size and projected upon the screen by a standard moving picture machine (Plate LII, 5); this enables one to study the gastric motor phenomena. These series of Roentgenograms are taken with the patient in various postures and at various intervals after the ingestion of the barium meal, as follows: Twelve prone, twelve erect, and six oblique, immediately after ingestion; six erect, or prone, and two oblique six hours after ingestion; and others at nine, twelve, twenty-four or thirty-six hours as the exigencies of the case may demand. By this method the exact appearance of the stomach under all conditions may be accurately noted and any variations from the normal will be evidenced by constant irregularities in the outline, by obstruction to the peristalsis, or by evidence of retention in the crater or niche of an ulcer. A complete examination of the gastrointestinal tract is necessary for full information in every case of gastric symptoms, and there is hardly a chronic lesion in which this method of examination is not valuable either in the detection of a lesion, in its differentiation from some other lesion, or in determining whether or not surgical procedure is indicated or possible. It not infrequently happens also that functional disturbance from a distant lesion may be detected without evidence of abnormality of the stomach itself, in which case the complete examination is needed to determine the cause of this disturbance.

Esophagus.—By administering a thick paste of barium or bismuth and water, the lumen of the entire esophagus may readily be determined, either Roentgenographically or fluoroscopically. By this technique even the lumen of the normal esophagus may be shown, and if there are any areas of diminished elasticity in the wall, they are apparent. Esophageal carcinoma must be differentiated from cardiospasm and esophageal diverticulum and, if possible, from benign cicatricial constrictions (Plate LIII, 1 and 2).

Stomach.—*Size, Shape, and Position.*—The stomach varies in size, shape and position in accordance with the build of the patient and it differs so far from the anatomical and surgical descriptions one can hardly realize that this variation may be normal. A stomach whose greater curvature drops to a point one or two inches below the umbilicus should not necessarily be considered prolapsed. The stomach will show a difference in distention and a variation in the position of the greater curvature according to the amount of food taken and the length of time after eating. The stomachs have been classified according to their form, and although this classification is of no significance from a pathological standpoint, it is an additional means of description. These classes are: *Normal:* Cow-horn, fish-hook, text-book, drain-trap; *abnormal:* prolapsed, hourglass, atonic, atrophic, prognathian, field-flask, saddle-bag (Plate LII, 4).

Appearance of Mucosa.—The Roentgenological appearance of the gastric mucosa is of great importance and figures largely in determining whether a lesion is malignant or non-malignant. When the stomach is empty or contains only a slight amount of food, the mucosa lies in folds and with the proper technique the bismuth may be made to fill these crevices. When the stomach is full the muscularis stretches and smooths out the mucosal coat so that the rugæ disappear. The rugæ run longitudinally following the long axis of the stomach but are sometimes seen running transversely or obliquely, and then they indicate pylorospasm or adhesions.

Dilatation of the stomach is of two types: one from atony, and the other from pyloric obstruction. In atony the entire stomach is dilated and there is no evidence of pyloric obstruction. Frequently the stomach fails to evacuate on account of lack of muscular tone. In cases of dilatation from pyloric obstruction the pyloric end of the stomach is dilated out of proportion to the pars media and pars cardiaca, and has the undershot appearance of a bull-dog's jaw, to which the term "prognathian dilatation" has been given. In these cases obstruction at the pylorus or in the cap can be detected and is due either to an annular growth of the pylorus or to a postpyloric (duodenal) ulcer.

Gastric Motor Phenomena.—Knowledge of the gastric motor phenomena was greatly advanced by Cannon's work on the peristalsis of the cat, so minutely observed and ably recorded in 1902. Fluoroscopic observation of human subjects by Holzknecht and Haudek have added much to the subject, and the investigations of Kaestle, Rieder, and Rosenthal confirmed the report made by Cannon.

The author's conception of the gastric motor phenomenon is that it is complex rather than simple, and that it is composed of a gastric cycle which is similar to a cardiac cycle, the stomach going through a series of shapes in a period of twenty seconds. The heart goes through a series of shapes known as a cardiac cycle in a little less than one second. The gastric cycle is composed of a progression of peristaltic waves from its origin to its termination, forming a systole and diastole which are similar to the systole and diastole of the cardiac cycle.

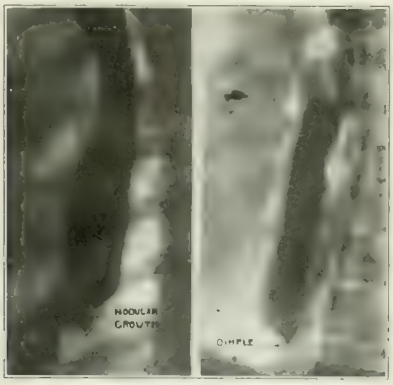
During the systole of each gastric cycle a small amount of chyme is forced through the pyloric sphincter into the cap, and there is no evidence of a periodical opening and closing of the pyloric sphincter independent of each gastric peristalsis.

Evacuation.—While the time of evacuation has been considered an important factor by various observers and particularly those who favor the symptoms complices method, too much importance has been placed upon it. Six hours is the time set by Hertz for normal gastric evacuation, but many conditions

EXPLANATION OF
PLATE LIII.

EXPLANATION OF PLATE LIII.

Fig. 1.—Carcinoma.
Fig. 2.—Spasm.
Fig. 3.—Inoperable carcinoma; growth too extensive for even an anterior gastroenterostomy.
Fig. 4.—Inoperable carcinoma; growth too extensive for removal, but one that never would cause obstruction.
Fig. 5.—Extensive carcinoma; operation for palliation of symptoms indicated.
Fig. 6.—Small annular carcinoma; operable for surgical cure.
Fig. 7.—Perforating gastric ulcer with sulcus and typical Haudek's niche.



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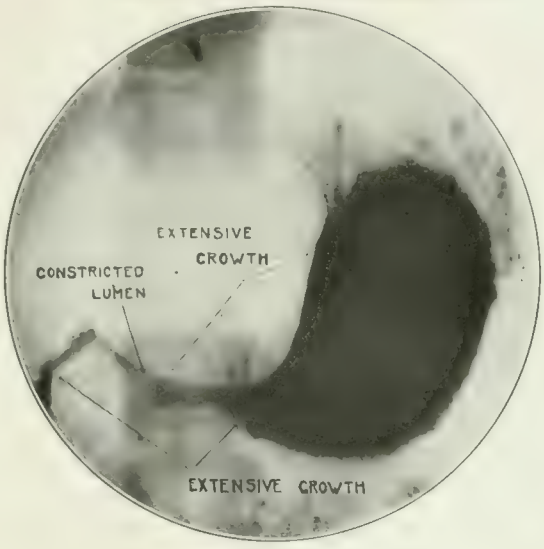

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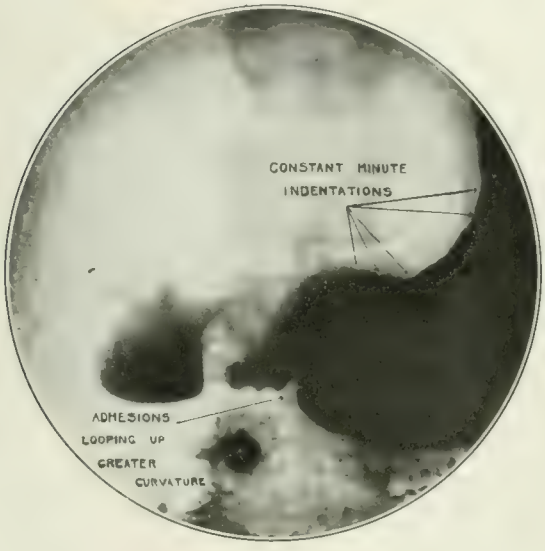

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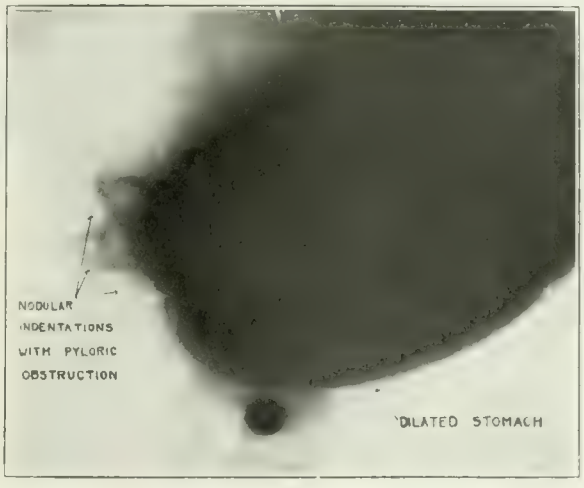

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7

ROENTGEN DIAGNOSIS (*Cole*).

other than pathological lesions may accelerate or retard its emptying. Some of them are: (1) Character of food in which the bismuth is swallowed—whether liquid, solid, or semi-solid. (2) The position of the patient during digestion, evacuation being more rapid with the patient on the right side than on the left. (3) Exercise. (4) Condition of small intestines—whether previously evacuated or still retaining food.

This being true it is readily seen that the exact emptying time is not of very considerable importance in the determining of the classification of the stomach as normal or abnormal.

Pathological Lesions.—The pathological lesions that may be detected with remarkable accuracy by serial Roentgenography of the stomach are gastric cancer, or gastric ulcer, gall-bladder infection, or functional disorders from distant organic lesions.

The detection of gastric cancer or precarcinomatous indurated areas depends upon morphological changes in the contour of the stomach, as shown by constant deformities observed in a large number of plates, and the malignancy or non-malignancy of these lesions may also be determined in a great number of cases (Plate LII, 6 and 7).

Filling defects of the stomach may be non-malignant —adhesions or pylorospasm—or they may be malignant or premalignant indurated ulcers. There are certain definite Roentgen findings of malignancy or of precarcinomatous indurated areas which are given below and compared in parallel columns with the non-malignant deformities caused by adhesions or pylorospasm. In addition to the definite diagnosis of cancer the Roentgen examination is of great value in determining whether or not surgical procedure is necessary.

Malignant and Premalignant	Non-Malignant
Rugæ are absent	Rugæ show with unusual distinctness and run obliquely or transversely.
Lumen of constricted area is constant in size, shape and position.	Lumen varies in size, but never completely relaxes or contracts.
Peristaltic contractions are absent in involved area.	Peristaltic contractions in involved area are abnormally wide and shallow.
Lumen is encroached upon by nodular growth projecting into the wall of the stomach.	Lumen is diminished by a contraction of the muscular coats of the stomach without the projection into the lumen of the localized area.
Line of invasion is characterized by nodular indentations similar to finger prints in a ball or putty.	Line of invasion may be sharp and clear cut or finely serrated by the rugæ coming to the surface but shows no nodular indentations.

In considering surgical procedure carcinomas are divided into four groups: (*A*) Inoperable, because the lesion is too extensive to allow even a gastroenterostomy (Plate LIII, 3). (*B*) Inoperable, because the patient will die of constitutional symptoms before the growth obstructs the pars pylorica (Plate LIII, 4). (*C*) Operable, for palliative relief (Plate LIII, 5). (*D*) Operable, for surgical cure (Plate LIII, 6).

Gastric Ulcer.—By a sufficiently careful examination all kinds of gastric ulcer may be detected. Gastric ulcers are of three kinds: (1) Perforated (Haudek's niche) (Plate LIII, 7). (2) Indurated with or without a small crater (Plate LIV, 1). (3) Mucosal erosions (Plate LIV, 3. The Haudek's niche ulcer is widely described and easily identified. In my experience it is almost invariably malignant. The mucosal erosions have such a slight amount of induration that the ulcer cannot be detected by direct palpation of the gastric wall and can be observed only by opening the stomach and examining the mucosal surface. This type may be detected by serial Roentgenography with remarkable readiness.

Indurated gastric ulcer with or without a crater involves only the mucosa, submucosa, and muscular coats, but does not form a pouch and is not surmounted by gas. It is surrounded by an amount of exudate sufficient to make its presence felt by careful palpation of the gastric wall during operation.

Postpyloric (duodenal) ulcer is a term applied to indurated ulcers involving the cap, and to cicatricial contractions resulting therefrom.

Pylorospasm.—Pylorospasm is a very important finding, and is often the clue to some lesion at a distant point. It may be of such a degree that it distorts the pars pylorica as much as an organic lesion would, but it must be recognized and differentiated from the constant deformity of the stomach wall caused by cancer or precancerous induration.

The Cap.—That portion of the tract just beyond the sphincter, previously known as the first portion of the duodenum is not duodenum in any sense and from its close embryological, histological, physiological, and surgical resemblance to the stomach it has been given the name of pileus ventriculi, or cap of the stomach. Its appearance is so similar to the antrum that the two have been confused, and in many early communications the cap was considered the pyloric antrum. If the pyloric ring be obscured by a pencil or some other object placed at right angles to the axis of the lumen, the contour of the cap seems to merge into that of the pars pylorica without any discernible line of division.

The appearance of the sphincter should be carefully noted and in normal cases its gastric and duodenal surfaces are clear-cut and well defined.

Changes in the contour of the cap are readily recognized but a large series of plates must be studied to differentiate between ulcer and spasm of the cap or to distinguish the ulcer from partial emptying of the cap by the normal duodenal peristalsis. Since the whole width of the cap is about one inch any area of deformity is very readily recognized and the detection of postpyloric ulcer is based on the constant evidence of such deformity in its outline. The induration surrounding the ulcer and the cicatricial contraction resulting therefrom cause a deformity in the cap as constant as one's fingerprints in a ball of putty. These ulcers are divided into two groups: (1) Cap deformity with obstruction (Plate LIV, 2). (2) Cap deformity without obstruction (Plate LIV, 4).

The first group comprises those readily recognized fluoroscopically or by making one or two Roentgenograms, but they comprise only about one-third of the cases of postpyloric ulcers. The second group can be accurately diagnosed only by serial Roentgenography.

In considering the necessity for surgical procedure it is absolutely essential that those having obliterated cap, pyloric stenosis, failing peristaltic compensation, or with bullet-hole craters or secondary gastric involvement be differentiated from simple deformity of the cap without obstruction or crater formation. The first demand surgery and are relieved by it. The second should be treated medically first and surgery resorted to only "for relief of symptoms" and then one is not sure of relief by surgical procedure in this type of ulcer.

Gall-bladder adhesions are so closely allied in their Roentgenological appearance to adhesions from postpyloric ulcer that it is not always possible to distinguish between them. However, as the indication for surgical procedure is the same in both, the essential thing is to determine whether surgical procedure is imperative and the differential diagnosis may be left to the surgeon.

Gall-bladder Infection.—Indirect evidence of gall-bladder infection with or without calculi is gall-bladder adhesions drawing the stomach or cap to the right. When this evidence is present especially if combined with characteristic clinical symptoms, it is of more importance from a surgical standpoint than the direct detection of the gallstones themselves (Plate LIV, 5 and 6).

A special gall-bladder examination with proper

technique for distinguishing stones of varying density should be made. Stones are usually of the same type in the same person, but they differ greatly in degree of density in different persons. Those with a large deposit of calcium give a distinct shadow and are readily detected. Those of pure cholesterine are more difficult to observe but since we established the fact that they are of lesser density than the bile and hence give a negative shadow it has been possible to detect them in a large percentage of cases. The medium stones with just enough calcium to make the density approximately the same as that of the surrounding bile are the most difficult to find, but by the ring-like shadows cast by the bile surrounding the calculus give a characteristic finding. If the indirect evidence of the gall-bladder adhesions is corroborated by direct evidence of the stones themselves, one is justified in making a positive diagnosis and advising for or against surgical procedure.

Small Intestine.—The duodenum, descending and horizontal, is characterized by ring-like folds, readily demonstrated (Plate LV, 1). It usually forms a C from the top of the cap, but the C varies so widely in shape and position that its form cannot be considered of pathological importance. Dilatation of these coils usually means some obstruction—most often at the duodenojejunal junction. Such obstruction is caused by adhesions, pressure from the mesentery artery, or by some growth interfering with the normal progress of the chyme. Dilatation of the duodenum may be artificially produced by means of the Einhorn dilator. Lesions of the duodenum are detected by failure to expand and contract in a normal manner, and absence of the ring-like shadow. This break in the peristalsis may be distinguished by its constancy, as contrasted with the peristaltic contraction which occurs in the same place at much longer intervals.

The jejunum (Plate LV, 1) is distinguished by the flocculent appearance of its contents. This part of the tract may be best seen in the early stages of digestion, as it is usually emptied of its contents later, owing to the drawing of food into the terminal ileum. The upper part of the ileum with its coagulated appearance is readily differentiated from the terminal portion in which continuous coils are observed broken only by an occasional peristaltic contraction.

Intestinal stasis before the advent of Roentgenology was usually termed chronic constipation and treated as such. Ileal stasis is due to one of the following causes, and Roentgen evidence is of the greatest value in determining which is the cause in any particular case: (1) Atony and incomplete evacuation of cecum and ascending colon. (2) Various types of membranes and veils involving the colon. (3) Kinks or adhesions involving the terminal portion of the ileum. (4) Insufficiency of the ileocecal valve. (5) Chronically diseased appendix or adhesions resulting from its removal.

In order to differentiate these causes it is advisable to study Roentgenograms made at intervals of nine, twelve, fifteen, and twenty-four hours after the ingestion of food, in conjunction with colon plates made after the injection of a barium clysma.

In resorting to surgical relief for this condition it is essential that the surgeon find the real cause of the stasis, as surgery for atony and incomplete evacuation will not give relief if the cause is insufficiency of the ileocecal valve, nor the loosening of adhesions in the terminal portion of the ileum bring relief from gall-bladder adhesions involving the colon. Sometimes the removal of a chronically diseased appendix will restore the efficiency of the ileocecal valve and so bring relief from ileal symptoms. Kinks in the terminal ileum are detectable but are not as frequent a cause of real ileal delay as some observers would have us think.

Colon.—The colon may be examined in two ways: by studying the progress of the bismuth impregnated meal, and by a barium clysma. The clysma examination shows the shape and position of the colon, with any abnormal kinks or loops, and the complete progress of the clysma from the rectum to the ileocecal valve. If the clysma fails to pass all the way to the cecum it is evident that there is obstruction in or of the colon, or pressure from without.

If it passes through the valve into the ileum, there is an incompetency of the valve, and its degree of insufficiency may be clearly shown by the extent of the regurgitation (Plate LV, 2). The pathological significance of incompetency of the valve is becoming more widely recognized and Kellogg's simple operation for the relief of this condition has been employed.

Stasis of the colon may be caused by carcinoma, pericolic membranes, gall-bladder adhesions involving the hepatic flexure, adhesions causing permanent acute angulation or diverticulus.

Carcinoma of the colon is readily detected and must be differentiated from spasm. It is amenable to surgical treatment, especially if detected before it has reached an advanced stage. In lesions of the lower end of the sigmoid and rectum the proctoscope and the Roentgen ray should be used to corroborate each other.

Membranes and veils involving the colon are readily distinguished by Roentgenography and the characteristic "double-barreled shot-gun" appearance recognized. In noting this appearance one must be sure the coils are adherent, as they may lie in this position and yet be perfectly normal.

Diverticula are sometimes seen best in Roentgenograms made after the ingestion of a barium impregnated meal, but it is doubtful if these pouches have much to do with stasis.

The degree of colonic stasis is influenced by character of the food, the amount and quality of food in preceding and succeeding meals, hour of eating, and exercise. This being the case, one must take all these things into consideration before deciding there is a prolonged colonic stasis.

The indication for surgical procedure is not absolutely determined. There are certain cases when this is imperative, but indiscriminate diagnosis of colonic stasis requiring surgical procedure cannot be too strongly condemned, and colectomy, short-circuiting, etc., must not be undertaken except upon certain evidence that such a course is the only method to bring *final* relief to the patient. The Roentgen ray has been and will be of invaluable aid in determining these cases.

Lewis Gregory Cole.

1. Davidson, Sir Mackenzie: Method of Localizing Foreign Bodies. *Brit. Med. Jour.*, Jan. 1, 1898.
2. Hansell and Sweet: Diseases of the Eye.

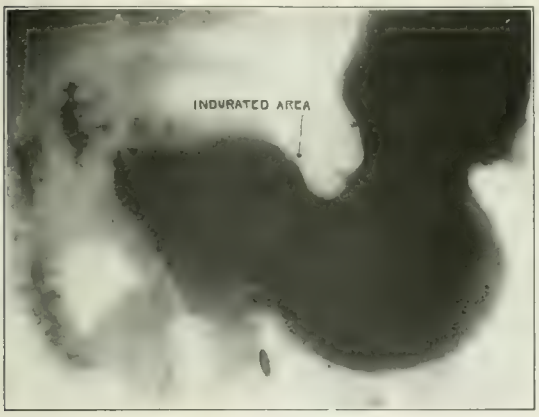
Rokitansky, Karl.—Born at Königgratz, Bohemia, Feb. 19, 1804. He studied medicine at the universities of Prague and Vienna, and received his doctor's degree from the latter institution in 1828. Six years later, upon the death of Johann Wagner, he was made Prosector of the Allgemeine Krankenhaus at Vienna, and Professor Extraordinary of Pathological Anatomy in the University. The regular professorship was not bestowed upon him until the year 1844. In 1863 he was made Hofrat, in 1869 President of the Vienna Academy of Sciences, and Baron (*Freiherr*) in 1874, on the occasion of his seventieth birthday. He died July 23, 1878.

For many years Rokitansky held in Vienna very much the same position that Virchow held somewhat later in Berlin. Both of these men, who had done so much to make pathological anatomy the favorite study in their respective medical schools, possessed in a rare degree the power to kindle in the minds of

EXPLANATION OF
PLATE LIV.

EXPLANATION OF PLATE LIV.

FIG. 1.—Indurated gastric ulcer with small crater.
FIG. 2.—Post-pyloric (duodenal) ulcer; typical clover-leaf deformity of cap, with obstruction.
FIG. 3.—Mucosal erosion (ulcer) without induration.
FIG. 4.—Post-pyloric (duodenal) ulcer; deformity of cap without obstruction.
FIG. 5.—Gall-bladder adhesions; indirect evidence.
FIG. 6.—Direct evidence of gallstones.



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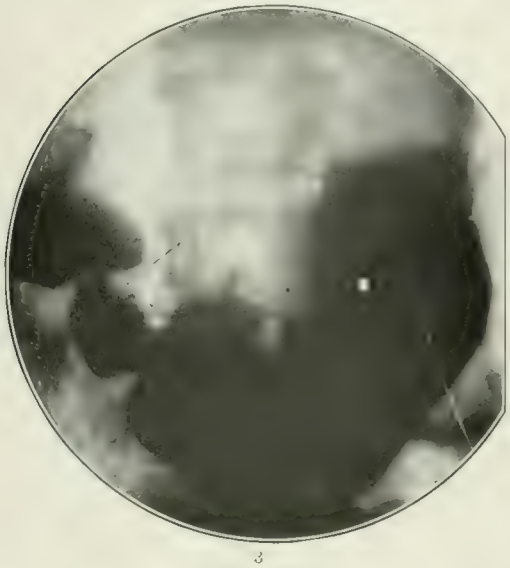

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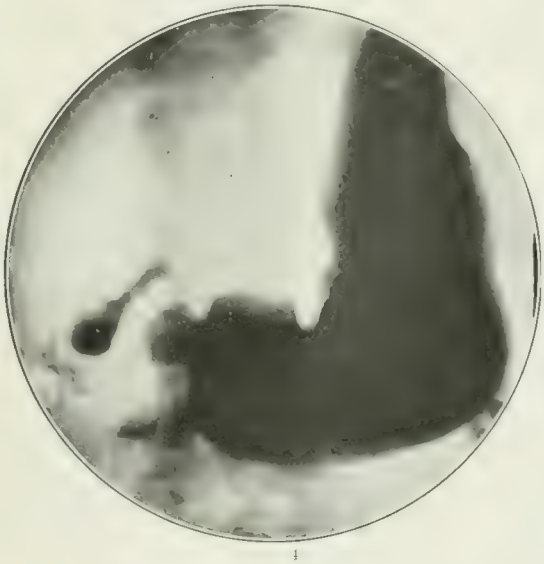

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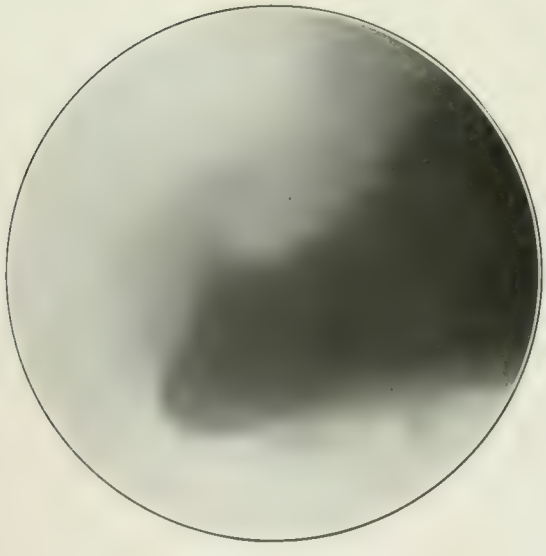

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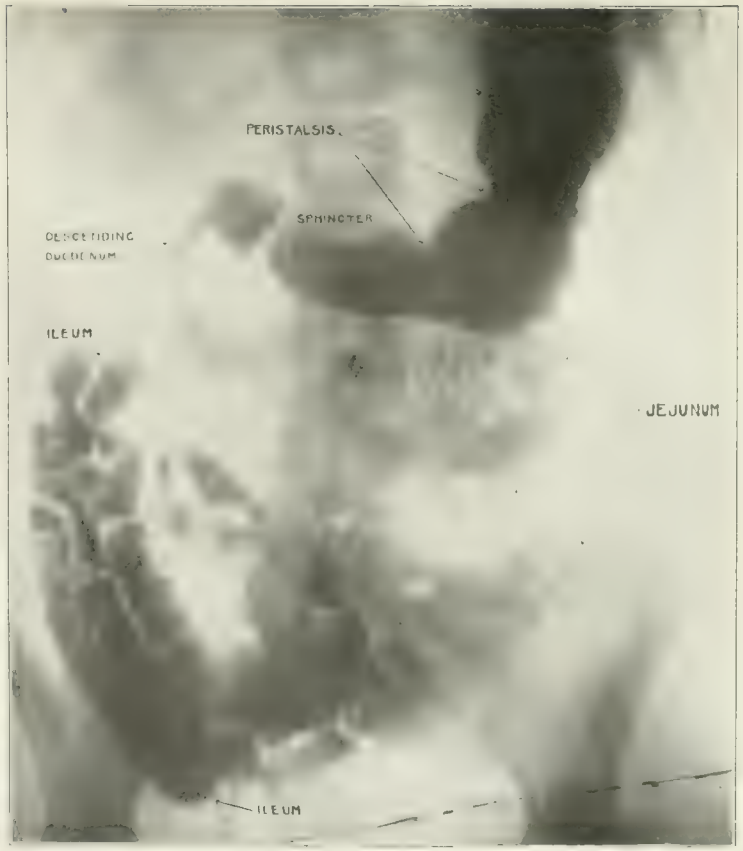
ROENTGEN DIAGNOSIS (*Cole*).



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2

ROENTGEN DIAGNOSIS (*Colon*).

1. Normal stomach and small intestines.

2. Colon after injection with bismuth clysma showing transverse and descending colon, and spasm of the ascending colon, and numerous coils of the small intestine filled with barium clysma.

the students a strong interest in the topics upon which they lectured; indeed, both were commanding figures in the university world, and, in addition, both took an active part, as members of the legislature, in moulding public opinion.

Fig. 4463.—Karl Freiherr von Rokitansky.

Of the published writings of Rokitansky the following deserve to receive special mention: "Handbuch der pathologischen Anatomie," the first volume appearing in 1841, the second in 1844, and the third in 1846 (an illustrated and thoroughly revised edition was issued in 1855); "Ueber das Auswachsen der Bindegewebssubstanzen," 1854; and "Ueber Bindegewebswucherung im Nervensysteme," 1857.

A. H. B.

Rolando, Luigi.—Born about 1770. He studied medicine at Turin, Piedmont, and was beginning to make some headway in the career of medicine when the French conquered the country, and he was thus forced to leave. He followed the King to the Island of Sardinia, and was made Professor of the Theory and Practice of Medicine at Sassari. Completely shut off from all communication with the continent, he devoted himself with great ardor to the study of natural history and also to that of anatomy. The treatises which he published in 1807 and 1809, on the structure and functions of the brain and nervous system, show beyond a doubt that, during this period of isolation from the world, and without aid from anybody, Rolando had succeeded in making most of those discoveries the credit for which is divided among a large number of anatomists of the same period. In 1814, upon his return from the Island of Sardinia, he was made Professor of Anatomy by the University of Turin. He died April 20, 1831. One year before his death he described the cerebral fissure to which his name is attached.

The following are the titles of a few of the treatises published by Rolando: "Sulle cause da cui dipende la vita negli esseri organizzati," 1807; "Saggio sulla vera struttura del cervello dell'uomo e degli animali, e sopra le funzioni del sistema nervoso, Sassari, 1809 (a second edition was published in Turin in 1828); "Ricerche anatomiche sulla struttura del midollo spinale," Turin, 1824; and "Della struttura degli emisferi cerebrali," Turin, 1830. A. H. B.

Rolph, John.—Born at Thornbury, Gloucestershire, England, March 4, 1793. He crossed the Atlantic in 1812, but, before he reached New York, war had broken out between Great Britain and the United States. It was not until after the battle of Queenstown, in the Niagara District, that he was permitted to cross over into Canada. Soon afterward he returned to England and engaged in the studies of both law and medicine. He was a student at Cambridge University, where he was recognized as a young man of more than ordinary ability. In medicine he was a pupil of Sir Astley Cooper. He became a member of the Royal College of Surgeons, England. In 1821 he returned to Canada and established his residence in Charlotteville County, Norfolk, and in the same year he was called to the Bar of Upper Canada. Dr. Rolph engaged in the practice of both law and medicine, and so it was not unusual to see him come into Court carrying a pair of saddlebags in his arms, one side being filled with surgical instruments and the other with briefs and legal documents and books. He would attend a case in Court, and, when through with the business in hand, he would catch up his saddlebags and ride off to visit some patient.

There was no regularly organized medical college in Upper Canada at that period, and the facilities for acquiring a competent medical training were few. In response to urgent requests from a number of influential persons in Toronto, Dr. Rolph established a private medical class in that city and gave instruction to a limited number of students. His teaching was eminently successful, and he made himself greatly beloved by his pupils. This school, which in due course of time became the Medical Department of Victoria University, enjoyed many years of prosperity. Dr. Rolph died at Mitchell Oct. 19, 1876, at the age of eighty-three. (From data kindly furnished by Dr. A. Primrose, of Toronto.)

A. H. B.

Romberg, Moritz Heinrich.—Born at Meiningen, Germany, Nov. 11, 1795. He studied medicine at Berlin, and received the doctor's degree from the University of that city in 1817; his graduating thesis bearing the title: "De rhachitide congenita." In 1830 he began, as a simple *Privatdozent*, to teach special pathology and therapeutics at the university; in 1831, and again in 1837, he took charge of a cholera lazaretto; in 1838 he was made Professor Extraordinary of Special Pathology and Therapeutics, and was given charge of the University Policlinic; in 1845 he was promoted to the regular professorship; and in 1851 he was given the title of Geheimer Medizinalrat. He died June 16, 1873.

Two of Romberg's published works are "Lehrbuch der Nervenkrankheiten," Berlin, 1840–46 (a third edition, in 2 vols., in 1853–55), and "Pathologie und Therapie der Sensibilitäts- und Motilitätsneurosen." The facts discovered in the domain of nerve physiology are there utilized for the first time in the construction of a systematic and logical exposé of nerve pathology and therapeutics. Of his other contributions to medical literature the following deserve to receive special mention: "Neuralgiæ nervi quinti specimen," Berlin, 1840; "Bell's physiologische und pathologische Untersuchungen des Nervensystems," Berlin, 1832, and again in 1836; "Commentationes quædam de cerebri hæmorrhagia," Berlin, 1830; and "Klinische Wahrnehmungen und Beobachtungen." A. H. B.

Roosa, Daniel Bennett St. John.—Born at Bethel, N. Y., April 4, 1838. He received the degree of Doctor of Medicine from the University of the City of New York in 1860. After studying ophthalmology and otology abroad for one year he established himself (1863) in New York City, first as a general practitioner, and then, in the course of a year or two, as a specialist in the treatment of diseases of the eye and ear. From 1866 to 1882 he was Professor of Ophthalmology and Otology in the University of the City

of New York, and from 1875 to 1880 he held the same chair in the University of Vermont. He was one of the founders of the Manhattan Eye and Ear Hospital and of the New York Post-Graduate School and Hospital and for a number of years he occupied the Chair of Diseases of the Eye and Ear in the latter institution. He died March 8, 1908.

Of Dr. Roosa's contributions to medical literature the following deserve to receive special mention: Translation of von Troeltsch's work on the Ear; Translation (with Dr. Charles E. Hackley and Dr. Charles S. Bull) of Stellwag's work on the Eye; and an original treatise on Diseases of the Ear, 1866 (also several later editions). A. H. B.

Rosemary.—*Roris marini folia.* (*Rosmarinus*, U. S. P. 1880.) The dried leaves of *Rosmarinus officinalis* L. Fam. *Labiatæ*.

These leaves are obtained from a small, slender, evergreen, blue-flowered shrub, native of the Mediterranean region, and somewhat cultivated for medicinal purposes and as a decorative shrub. The flowering twigs are also sometimes employed. The leaves are about 2.5 centimeters (one inch) long, oblong, but so strongly recurved at the edges as to appear linear in the dried condition, obtuse at both ends, destitute of a petiole, entire, coriaceous, dark green with a slight bluish cast above, and grayish green and densely woolly and glandular underneath. The odor is characteristic and somewhat camphoraceous, the taste aromatic, pungent, and somewhat terebinthinate. Although the use of the drug has now largely been superseded by that of its one or two per cent. of volatile oil, the action is not quite the same in both of them, since the drug itself also contains considerable tannin and resin and a little bitter substance. The latter, therefore, is a useful aromatic bitter and tonic. The fresh decoction, or the fluid extract, applied to unhealthy wounds, is a good vulnerary, though somewhat irritating unless carefully employed. The dose of rosemary is gr. vij.–xv. (0.5–1.0).

Oil of rosemary (*Oleum Rosmarini*, U. S. P.) presents the appearance of a colorless or at most a pale yellow fluid, has a specific gravity of from 0.895 to 0.915, is freely soluble in alcohol, and possesses the characteristic odor of the drug and a similar and somewhat camphoraceous taste. It contains cineol, borneol, and camphor, with other less important substances. It possesses the aromatic properties of the drug, but in an intensified degree. It is often given internally as a carminative and general intestinal stimulant, though its use has greatly declined. The dose is from one to five minims. It enters into the compound tincture of lavender. Owing to its actively local stimulant or irritant properties, it is considerably used as a local application for promoting the nutrition of the skin and also as a vulnerary.

Henry H. Rusby.

Rosenmueller, Johann Christian.—Celebrated German anatomist. Born at Hessberg, near Hildburghausen, in 1771. He studied medicine at Erlangen and at Leipzig. In 1794 he was appointed Anatomical Prosector at the university of the latter city, and in 1797 he received his doctor's degree. In 1802 he received the appointment of Professor Extraordinary of Anatomy and Surgery. Two years later he was made full professor. He died Feb. 29, 1820, before he had completed his forty-ninth year.

Rosenmueller's name is assured a permanent place in the history of medicine by his discovery and description of certain structures of the human body—for example, Rosenmueller's gland or node, Rosenmueller's organ, Rosenmueller's recess or fossa, etc. Of his numerous published writings the following is probably the most important: "Chirurgisch-anatomische Abbildungen für Aerzte und Wundaerzte, etc.," three parts, Weimar, 1805–12.

A. H. B.

Roseola Scarlatinosa.—*Synonyms:* Fourth disease. Dukes' disease.

It is to Clement Dukes that we owe this addition to the number of contagious exanthemata. Led by his experience extending over a number of years at Rugby School, Dukes published in *The Lancet* of July 14, 1900, his original paper on this subject with the title "The Fourth Disease; or, the Confusion of Two Diseases under the Name of 'Rubella.'" In this paper Dukes states that he had for several years suspected the existence of another contagious exanthem, but that he was not convinced of it until the advent of an epidemic in April, 1900. His reasoning is as follows:

German measles appears under two forms—one resembling measles, and the other resembling scarlet fever; an attack of one form of the disease does not protect the patient from an attack of the other form. He has never observed the slightest tendency of the fourth disease to develop into true scarlet fever, although this disease does closely resemble mild scarlatina. It is important to distinguish the fourth disease from scarlet fever chiefly because of the difference in the time of quarantine, especially in schools.

Epidemics of so-called German measles at one time resemble scarlet fever; at another time all of the cases resemble measles. The measles form usually affects large numbers of those exposed, while the fourth disease, like scarlet fever, affects a limited number, being apparently, like scarlet fever, least infectious at its onset. Moreover, cases of fourth disease occur in children who have previously suffered from scarlet fever.

Certain studies made by Dukes may be cited to bear out his contention of a fourth disease. In the year 1892 he was called to see sixteen cases of illness supposed to be scarlet fever, and he decided that it was the scarlet-fever variety of rubella, or what he later called Fourth Disease. The lads were in school and were sent to their homes. Subsequently, there was not a single instance of scarlet fever reported among the boys who went to their homes for the holidays; but one of the nurses after going home suffered from what was diagnosticated as a genuine case of rubella.

The second study was that of a concurrent epidemic of scarlet fever and fourth disease. In this instance the fourth disease preceded the onset of the scarlet fever by twenty days. Some of the boys had scarlet fever only, others had fourth disease only. One had scarlet fever first, and afterward fourth disease; and still others had fourth disease, followed by scarlet fever. Among those cases diagnosticated as scarlet fever two of the boys died.

Another study was made at Rugby in March and April, 1900—nineteen boys being affected by fourth disease, nearly one-half of whom previously suffered from rubella. Twenty days after the onset of the epidemic the school was dispersed. Of all these boys who went to their homes, there was only one who had a malady diagnosticated as scarlet fever.

The *symptoms* may be grouped as follows:

Incubation Period.—Varies from nine to twenty-one days, resembling rubella and differing markedly from scarlet fever.

Prodromal Symptoms.—Usually about, though occasionally chill, nausea, headache, backache, and loss of appetite are present.

Eruption.—The first symptom to attract attention is the rash, which in nearly every case is full and quite characteristic of scarlet fever, being small and thickly

set, pale red, and scarcely raised above the surface. It may cover half of the body in a few hours.

Throat.—The fauces are red and swollen, but there is little or no complaint. No matter how severe the eruption —and "in many cases it resembled the worst eruption in scarlet fever," says Dukes, the throat never looks like that seen in a well-marked case of scarlet fever. The lymph nodes of the neck are swollen, hard, and about the size of a pea. In some cases the axillary and inguinal nodes are enlarged.

Desquamation.—Usually there is free desquamation of small scales; but in a few the peeling was equal to that in scarlet fever. In this "fourth disease" the desquamation bears no relation to the intensity of the eruption. Nephritis is a rare sequel; but a trifling albuminuria may be present.

General Symptoms.—The pulse rate is unaffected; the temperature ranges from 98.4° to 104° F.

Infectiousness.—At the onset it is only slightly contagious, and the infectiousness disappears entirely in two or three weeks.

Since the publication of Duke's paper there has been world-wide discussion of the subject with a great deal of scepticism. It is to be said, however, that in 1885 Nil Filatow raised the same questions as Dukes, and that in 1896 he outlined a separate disease similar to the "Fourth disease." Moreover, J. J. Weaver furnishes support to Dukes' contention. Some months prior to Dukes' publication he noted in the Southport Infectious Disease Hospital, within three months after a number of scarlet-fever cases, recurrences with a new eruption and fever. He reported fourteen hospital cases with their temperature charts. These are of special interest because they are cases in which fourth disease either preceded or followed scarlet-fever. Many writers consider the cases as merely mild scarlet fever; others regard them as the scarlet-fever form of German measles. It is quite apparent from the literature that few observers have had experiences similar to Dukes; also that some of the best clinicians accept his conclusions. There are needed many confirmatory observations, especially of epidemics, before the disease can be regarded as definitely established. LINNÆUS E. LA FÉTRA.

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Roses.—The genus *Rosa* L. (fam. *Rosaceæ*) comprises upward of a hundred species of prickly shrubs. Although of little medicinal value, strictly speaking, these species contribute several articles possessing important uses in flavoring, perfuming, and coloring and exerting a mild stimulant, antispasmodic or tonic action. Two of these articles are official, as follows:

Rosa Gallica or *Red Rose*, "the petals of *Rosa gallica* L., collected before expanding."

Oleum Rosæ, *Oil of Rose*, *Otto* or *Attar of Rose*, "a volatile oil distilled from the fresh flowers of *Rosa damascena* Miller."

A third, formerly official, is *Rosa Centifolia*, *White Rose*, *Pale Rose*, or *Hundred-petalled Rose*, "the petals of *Rosa centifolia* L."

Although the red rose plant is native in Europe and adjacent Asia, the official product is obtained wholly from cultivated plants, chiefly in Southern and Central Europe, especially in France. The peculiar structure of the flower renders it quite an easy matter to collect the cones of unexpanded petals. The calyx lobes having spread backward before the opening of this cone, a sharp knife is drawn about the base of the latter, which is then lifted off, leaving the stamens still attached to the rim of the calyx tube. The cones are then very carefully dried in the shade, or they may be packed in salt. In the finest grades they mostly cohere in the cone, though loose petals may also be of fine quality. They should preserve a deep purple-red color and a fine velvety surface, as well as a strong and fine rose odor. The taste is bitterish, astringent, and very slightly acrid. The individual petals have a roundish outline, a notched summit, and a very short, broad, yellowish-white basal claw. Fragrant as they are, the amount of volatile oil in them is minute. The important constituent is a beautiful bright red, readily soluble coloring matter. Mildly astringent properties are imparted by a small amount of gallic acid. Small amounts of fat and quercitrin also exist. Red rose is practically inactive, though a sentimental effect is often gained by administering it in mild cases of hysteria. The Pharmacopœia provides a fluid extract, made with diluted alcohol and 10 per cent. of glycerin, and a confection consisting of 8 per cent. of the No. 60 powder, 64 per cent. of sugar, 12 per cent. of clarified honey, and 16 per cent. of stronger rose water. There is an official 12.5 per cent. syrup of the fluid extract. Red rose also enters into the pills of aloes and mastiche. There is, of course, no particular dose.

White rose is native of Western Asia, and is believed by some to be a mere variety of the red. Its constituents are identical with those of red rose except that the amount of coloring matter is extremely small. The use of this drug is therefore restricted almost wholly to flavoring.

Rosa damascena, the Damascus rose, is cultivated for the production of rose oil, chiefly in Bulgaria. This oil, commonly known as *otto* or *attar of rose*, being then exported and repacked in other countries, becomes the chief source of the various commercial brands bearing other geographical names, although a moderate amount of this product is actually distilled from roses grown in other countries. The oil is simply distilled with water. The following is the official definition and description:

"A pale yellowish, transparent liquid, having the strong, fragrant odor of rose, and a mild, slightly sweetish taste.

A volatile oil distilled from the fresh flowers of *Rosa damascena* Mueller (Fam. *Rosaceæ*), having, when assayed by the process given below, a saponification value of not less than 10 nor more than 17. It should be kept in well-stoppered, amber-colored vials, in a cool place, protected from light. When dispensed, it should be completely liquefied by warming, if necessary, and well mixed by agitation.

A pale yellowish, transparent liquid, having the strong, fragrant odor of rose, and a mild, slightly sweetish taste.

Specific gravity: 0.855 to 0.865 at 25° C. (77° F.).

The addition of seventy per cent. alcohol precipitates the paraffin hydrocarbons of the oil, but forms a clear solution with its other constituents, the solution being slightly acid to litmus T.S.

The congealing point, when determined according to the following method, should be between 18° and 22° C. (64.4° and 71.6° F.).

Introduce about 10 c.c. of oil into a test-tube of about fifteen millimeters diameter; insert a thermometer in such a manner that it touches neither the bottom nor the sides of the tube. Raise the temperature of the oil in the tube from 4° to 5° above the saturation point by grasping it in the hand, and shake the tube gently. Allow the oil to cool, and when the first crystals appear, note the temperature. This is regarded as the congealing point; a second test should be made for confirmation.

The important odorous constituent of rose oil is geraniol, long regarded as a distinct substance under

the name "rhodinol." There is also a small quantity of citronellol. Various derivatives of these also occur.

Although rose oil undoubtedly has antispasmodic and stimulant properties, practically its entire use is for perfuming and flavoring.

Official *rose water* may be regarded as indirectly a preparation of rose oil, although not prepared from that substance. It is recognized under two titles, namely, *Aqua Rosæ*, or *Rose Water*, and *Aqua Rosæ Fortior*, or *Stronger Rose Water*. The latter is the water, saturated with the oil, obtained as a by-product in the distillation of rose oil. The former is made by mixing, immediately when required for use, equal volumes of the stronger rose water and distilled water. From stronger rose water is prepared the *Ointment of Rose Water* or *Cold Cream* (*Unguentum Aquæ Rosæ*, U. S. P.), made with 12.5 per cent. of spermaceti, 12 per cent. of white wax, 60 per cent. of expressed oil of almond, 19 per cent. of stronger rose water, and 0.5 of 1 per cent. of sodium borate, these figures being approximate, since part of them respond to weights, part to measures.

In addition to the above official products, there is used in Europe, and there to only a very slight extent, a confection made from the fruits of *Rosa canina* L., the *dog rose*. This fruit contains only sugar, malic and tannic acids, and their compounds, and is a very inferior preparation.

Rosaceæ.—This great family includes several subfamilies regarded by many botanists as themselves entitled to family rank (*Pomaceæ*, the apple family; *Drupaceæ*, the prune family, etc.). Thus considered, it is doubtless the most important fruit-producing family, yielding raspberries, blackberries, strawberries, plums, peaches, cherries, and similar stone fruits, the apple, pear, quince, medlar, etc. From a medicinal point of view, the family is of considerable importance, yielding the almonds, wild cherry, North American ipecac, koosso, prune, quillaja, blackberry bark and the roses, all elsewhere considered, besides a number of minor drugs, several of which are considered below.

Astringent Drugs.—Probably the most common and important property of the drugs of the rose family is their astringency, due to the presence in them of considerable quantities of tannin. In such products as the leaves of the blackberry, raspberry, and strawberry, this tannin is accompanied by appreciable quantities of gum, thus favorably modifying the action, and these are very largely employed as domestic astringents. *Tormentilla*, the rhizome of *Potentilla tormentilla* L., as well as the rhizomes of other species of *Potentilla*, contains about the same amount of tannin as geranium, and is similarly employed. The same is true of *Sanguisorba* and of various species of *Acæna*, and of the root and bark of several species of *Spiræa*, *Hardhack*, or *Steeple Bush*, the leaves being also employed like those of the strawberry and raspberry. Under the names *Meadow Sweet*, *Queen of the Meadow*, and *Ulmaria*, the leaves of *Spiræa ulmaria* L. are also employed in the same way.

Henry H. Rusby.

Royat-les-Bains.—This well-known French spa is situated in the center of France, being one of a group of mineral-spring resorts in this region of the Auvergne Mountains. Not far distant are Mont Dore, La Bourboule, Chatel Guyon, Vichy, and others.

Royat, a small town of 1,528 inhabitants, is beautifully situated in a narrow valley watered by the Tiretaine, and surrounded by the lower Auvergne Mountains. All the surrounding country is charming, and there are many most attractive excursions, particularly to the Puy de Dôme, where an extensive and grand view is obtained. This resort has been called the "Ems" of France, but in climate, picturesqueness, and charm of situation it is far superior to the German spa.

The climate exhibits the characteristics of a mountain climate of moderate elevation, the altitude being 1,475 feet. There are sudden transitions of temperature; sudden storms of wind and rain with thunder; a dry atmosphere; and brilliant sunshine. The soil is volcanic, and the dust from such a soil is abundant and blown about in clouds by the wind. The peculiar situation of Royat itself, as Yeo says ("Health Resorts," J. Burney Yeo), also modifies the climate. "Lying as it does in the floor of a somewhat narrow valley, surrounded on all sides by mountains, and open only to the east, running, moreover, in a direction east and west, and facing the east, it is particularly exposed to the direct heat of the sun." "It is therefore," continues Yeo, "exceedingly difficult to find any kind of shady walks in the immediate vicinity of Royat when the sun is up and the sky is cloudless." Therapeutically the climate is invigorating and refreshing.

The waters are what are known as "warm muriated alkaline," containing bicarbonates of soda, potash, lime, and magnesia, together with chloride of sodium and a small amount of lithia. Arsenic in very minute quantity is also found in these waters, as are also the salts of iron and manganese. All the springs are rich in free carbonic acid gas. The natural temperature of the water is from 68° to 95° F. In this country the Healing Springs of Virginia and the Hot Springs of North Carolina are somewhat similar in their composition and uses. There are four principal sources: the Eugénie, St. Mart, Cæsar, and St. Victor. The Eugénie is the warmest (95.9° F.), and is the most highly mineralized. The St. Victor contains the most iron and arsenic. These springs together furnish 1,522,000 liters of water a day. The water is clear and transparent, and has no odor.

The waters of Royat are employed for drinking, bathing, gargling, and inhalation. The bathing establishment is complete, and said to be one of the finest in France. A specialty of this spa is the running water bath, where the water is led directly from its source and at its natural temperature into the bath-tub, and constantly flows in and out. There are arrangements for douches with massage attached to each bath, and also independent apparatus for douches of various forms. There are inhalation rooms; facilities for gargling, irrigation, and pulverization; baths and douches of water charged with carbonic acid gas; hydroelectric baths; a large public swimming bath; and a gymnasium.

The chief drinking fountain is from the Eugénie Spring, and is situated in a pleasant park. The water is very agreeable to drink. There are two casinos with music, concerts, balls, and theatrical performances. "The excursions," says Yeo (*loc. cit.*), "are numerous, varied, and interesting; for no more remarkable country to the geologist, the naturalist, and the archeologist can be found than this great mountainous district of extinct volcanoes, old medieval towns, historic churches, and Roman and even earlier remains."

The accommodations are abundant, good, and of reasonable price. Although open throughout the year, the season is from the 15th of May to the 15th of October.

Royat is about nine hours distant from Paris via Clermont-Ferrand, which is fifteen minutes distant from Royat.

The disorders for which these waters are of value are chiefly arthritic and anemic affections. Rheumatism; gout associated with anemia; skin diseases, such as eczema, acne, and pityriasis; chronic laryngitis and bronchitis; bronchial asthma; neuralgia; sciatica; atonic dyspepsia; various uterine affections; gouty glycosuria; biliary and renal lithiasis; neurasthenia; and various forms of anemia are all

treated here. The contraindications are organic cardiac affections, a tendency to hemorrhage, organic affections of the central nervous system, scrofula, and other tuberculous affections.

For the after-treatment the seaside for a short time is recommended, except in joint and bronchial affections, for which a winter in the south of France is preferred.

Not far from Royat is Durtol, 1,705 feet high, where is a sanatorium, opened in 1898.

For a further consideration of this resort, as well as others in France, the reader is referred to "Stations Hydro-Minérales, Climatériques, et Maritimes de la France," Paris, 1900. EDWARD O. OTIS.

Rubber.—See *Elastica*.

Rubella.—*Synonyms:* German measles, rötheln, rose rash, spring rash, epidemic roseola, hybrid or false measles, rubeola notha.

This disease was described by de Berger in Germany in 1752 and by Maton in England in 1815. It was first clearly differentiated from measles and scarlatina by Wagner in 1834. It is an acute highly contagious disease belonging to the group exanthemata, affecting all ages, chiefly the latter half of childhood, and occurring mostly in epidemics with the greatest incidence during the spring.

SYMPTOMS.—The incubation period varies from fifteen to twenty-one days, most of the cases having an incubation period of fourteen to eighteen days. The prodromal stage lasts about twenty-four hours and is characterized by the presence of slight fever, rarely more than 101° F., and of mild catarrhal symptoms of the upper and lower respiratory tracts. There is usually malaise and occasionally there is headache. Vomiting is extremely rare. Enlargement of the cervical and suboccipital glands occurs during this stage in at least one-quarter of all cases, and this glandular involvement may be so pronounced as to cause a stiffness of the neck. The enanthem described by Forchheimer (see below) may be present just before the appearance of the eruption.

The rash may be the first manifestation for which medical advice is sought. It appears first upon the face, the earliest spots being detected upon the brow and behind the ears. These spots are larger and much less closely set together than the punctate spots of scarlatina, and more definitely circular and much less raised than the papules of measles. The spots in rubella are generally smaller and less apt to coalesce than those in measles. The color of the rash is a pale pink or faded red. "It has neither the brilliance of the red of scarlatina nor the dusky or somewhat bluish-pink tint of measles" (Ker). The circumoral region is not free from the eruption. This spreads rapidly over the trunk and limbs, the dorsum of the foot being the last place reached. Within twenty-four hours the spots fade from the face without leaving the staining characteristic of measles and become more and more profuse upon the body. The individual spots being less defined present an appearance closely simulating that of the eruption in scarlet fever. One important feature of the rash in rubella is its multiform character; its intensity varies in different parts of the body. When nearly confluent upon the trunk it has already disappeared from the face and is present upon the dorsum of the foot as discrete papules. On the first day the rash more closely resembles that of measles; on the second day, that of scarlet fever. In some epidemics the rash is more distinctly morbilliform; in other epidemics it approaches the scarlatiniform type. The eruption lasts on an average from twenty-four to thirty-six hours; it may almost disappear and then come out again; it is brightest on parts of the body kept warm.

The enanthem in this disease is said to be constantly present and to be characteristic. It is described by Forchheimer as follows: "It consists of a macular, distinctly rose-red eruption upon the velum of the palate and uvula, extending to, but not on, the hard palate. The spots are arranged irregularly, not crescentically, of the size of large pin-heads, very little elevated above the mucous membrane, and do not seem to produce any reaction upon it." The enanthem appears just prior to or simultaneously with the eruption.

The extent and intensity of the rash are out of all proportion to the general symptoms. These may be insignificant. The eyes are often injected, giving a somewhat characteristic pink tinge to the conjunctiva, but there is neither lacrymation nor photophobia. The temperature is but slightly elevated. There may be little or no malaise. The glandular enlargement which begins during the prodromal stage is unmistakable during the eruptive period. According to Ker, "the glands most constantly affected are those lying along the posterior border of the sternomastoid muscle, where they may sometimes be seen and can always be palpated. They are felt as a chain of bullet-like masses, rolling easily under the finger, and not matted together or inflamed. They may be slightly tender, but tenderness is by no means an invariable symptom. The glands at the angle of the jaw are frequently enlarged, and still more characteristic is enlargement of the suboccipital glands which sometimes swell to an extraordinary extent. The mastoid glands are often, but not always affected. The axillary group usually suffers and often affords the most reliable evidence of glandular enlargement due to rubella. The inguinal glands are also frequently involved. Suppuration never occurs and the swelling subsides as rapidly as it has appeared, the glands often regaining the normal by the time the eruption has disappeared. In rare instances the enlargement of certain glands seems to be permanent."

The diazo reaction in the urine, so constantly present in measles, is absent in this disease. Albuminuria is extremely rare. The blood shows a polynuclear leucocytosis during the period of incubation and a leucopenia during the period of eruption.

There is usually a slight desquamation, best marked on the face and not affecting either the palms or soles. Complications are extremely rare. Relapses and second attacks may occur.

DIAGNOSIS.—The diagnosis of this disease, ordinarily simple, may be extremely difficult if measles or scarlatina is epidemic. (See article *Exanthemata*.) On the second day of the disease one may easily mistake it for scarlet fever. But it is to be distinguished from the latter by the fact that at this time there is "a definite discrete circular spotting, especially in the situations where it is freshest, for instance on the dorsum of the foot, which should always be examined." The absence of the true scarlet tint, the mildness of the general symptoms, and the absence of the strawberry tongue are important points in the differentiation. From measles rubella is to be distinguished by the following: In the former there is a more prolonged prodromal stage with pronounced coryza and conjunctivitis and with a troublesome cough. The constitutional symptoms are severe. "While the rash on the face and extremities in rubella is often blotchy enough to resemble that of measles, the trunk only seldom shows a measly appearance, the rash there being either generally diffuse or, if remaining discrete, preserving its isolated circular spots which show little tendency to coalesce into macules in this situation. When the rash of true measles runs together into a diffuse redness we may be fairly certain the other symptoms of the disease are extremely well marked, and unlikely to be mistaken for rubella. The complete absence of staining as the eruption fades from the face and its tendency to assume a

multiform character are strong arguments in favor of rubella" (Ker). In rubella there are no Koplik spots and there is no diazo reaction in the urine. A lymphocytosis, as against a high percentage of polymorphs, suggests rubella. The rash of this disease must also be differentiated from eruptions caused by drugs, articles of diet, enemata, and serum.

TREATMENT.—This is purely symptomatic. In most cases little or no treatment is required. The patient should be kept in bed while pyrexia lasts, say for about five days, and kept in isolation about five days more. Disinfection of the patient's room is amply secured by ordinary household cleaning.

ALEXANDER SPINGARN.

Rubinat Mineral Springs.—The waters of Rubinat, a village in the province of Lerida, Spain, belong to the strongly aperient class, owing their purgative properties chiefly to the large quantities of sulphate of sodium they contain, although they also contain considerable sulphate of magnesium. In a thousand parts there are 104 parts total solids; 3.2 parts sulphate of magnesium; 96.0 parts sulphate of sodium; 2.1 parts sulphate of lime and potash, and 2.0 parts chloride of sodium.

These waters are comparable in their action to those of Hunyadi Janos, Pullna, Friedrichshall, and Apenta, although the latter contain more sulphate of magnesium and less sulphate of sodium.

The Rubinat waters are exported largely especially to the American markets, and are not used as local drinking cures. When an occasional saline purge is required, the Rubinat waters or those of similar nature act efficiently. The dose varies from one to eight or nine ounces according to indications, and the water is best taken in the morning on arising. It is said that these waters are not so likely to cause griping as are some of the stronger bitter waters. There are several varieties in the Rubinat group of springs, all of similar composition. Among the best known are the Rubinat Condal, Rubinat Serre, and Rubinat Storach.

EDWARD O. OTIS.

Rubus.—*Blackberry.* The bark of the rhizome or root of various species of *Rubus* (Fam. *Rosaceæ*).

The commercial bark is of a rather dark gray brown color, and occurs in slender, rather tough, tightly curved quills, rarely so thick as a lead pencil, with more or less adhering rootlets. Occasionally the wood is contained in them, but they are commonly so tightly closed and cord-like that they appear solid, as though containing the wood, when in reality they do not. The bark is decidedly thick for so small a quill. The drug has little odor, and a very astringent, slightly bitter taste.

Rubus contains about twelve per cent. of tannin and nearly one per cent. of the bitter glucoside villosin, which is soluble in alcohol and slightly so in water. Its properties are merely astringent, due to its tannin. The dose is two to eight grams (ʒss. to ij.), and the fluid extract was formerly official. The leaves of blackberry, raspberry, and strawberry are similarly used. They combine considerable gum with their tannin.

H. H. RUSBY.

Rubus Idœus.—The *raspberry*, formerly official, is the fruit of *Rubus idæus* L., the cultivated red raspberry of European nativity. The Pharmacopœia provided that the American wild red raspberry (*R. strigosus* Mx.) or the black cap (*R. occidentalis* L.) might be employed in the absence of *R. idæus*. This fruit contains only sugar, fruit acids, and their salts, like others of its class, and its medicinal properties are merely those of a mild laxative, refrigerant, and antiscorbutic. Its fine flavor and beautiful red color make it a very useful adjuvant or vehicle, and an official syrup of the fresh fruit was provided for this purpose. A similar syrup made of strawberries is in common use.

H. H. RUSBY.

Rumex.—DOCK. The root of *Rumex crispus* L. and of some other species of *Rumex* (fam. *Polygonaceæ*). *R. crispus* is known as "Curly," *R. obtusifolius* as "Yellow" Dock. Both are pernicious perennial weeds from Europe, with long stout roots and tall wand-like stems, the greenish flowers and three-cornered, winged, reddish-brown fruits growing in dense, narrow, pyramidal panicles. Both have leaves a foot or two in length. Those of the yellow dock are broad, nearly plane and blunt. Those of curly dock are only two or three inches broad, tapering and acute, of a darker green and with the margin much crisped. The leaves, especially of the latter, are used as a well-known pot-herb, having laxative properties. Its root is also preferred to the other in domestic medicine and is narrowly fusiform, from six inches to nearly two feet in length and reaching something more than half an inch in thickness. It is little if at all branched, somewhat annulate above, deeply wrinkled below, deep reddish brown without, whitish (if fresh) within, and with reddish medullary rays, becoming brown throughout by long keeping. The fracture is short. It has a slight characteristic odor and a bitter, astringent, slightly mucilaginous taste. The root of the other is similar, but is not so long, and usually divides just below the surface of the ground into a number of more slender, parallel branches.

The important constituents are chrysophanic acid, tannin, and an amaroid, with starch and gum. The herbage especially contains much oxalic acid. The immediate effect of rumex may be either astringent or laxative, according to the conditions, usually the former. The fresher the root and the larger the dose, the more likely, usually, is the irritant chrysophanic acid to overcome the tannic acid and act as a laxative. It unquestionably exerts a beneficial tonic or alterative action, favoring the elimination of waste matter and stimulating both appetite and digestion. It produces, however, no striking effects and has fallen into contempt. The dose of the fluid extract is fl. ʒss.–ij. (2.0–8.0).

HENRY H. RUSBY.

Rupia.—See *Syphilis.*

Rush, Benjamin.—Born near Philadelphia, Pa., Dec. 24, 1745. He pursued his early medical studies in Philadelphia, under Dr. John Redman, one of the most eminent physicians of that period, and in 1766 he went to the great medical school of Edinburgh, then at the height of its glory under the attractive teaching of Cullen. In 1768 he received the degree of Doctor of Medicine, and during the following winter he attended the hospitals, lectures and other sources of instruction in London. Afterward he spent some months in the hospitals of Paris; and then, in August, 1769, he returned to Philadelphia and began the practice of his profession. Only a short time elapsed before he was elected Professor of Chemistry in the Medical College of Philadelphia, his associates in the Faculty being John Morgan, William Shippen, Adam Kuhn, and Thomas Bond. In 1789, in his forty-fourth year, Rush was elected to the Chair of Theory and Practice, left vacant by the death of Dr. John Morgan. During the intervening period of nearly twenty years he devoted a great deal of his time to matters of a public rather than a professional character. These we must pass over, simply remarking that Rush was one of the signers of the Declaration of Independence. In 1791 the Medical College of Philadelphia was merged in the University of Pennsylvania, and Rush then became Professor of the Institutes and Clinical Medicine, the Chair of

Practice being confided to Dr. Kuhn. In the year 1793 a severe epidemic of yellow fever visited Philadelphia, and Dr. Rush then showed how admirably qualified he was to cope with a disease which at first appeared to be absolutely irresistible under all methods of treatment then known. Rush himself was attacked, after he had fearlessly devoted his best energies to the care of scores of victims of the disease. His life was apparently saved by a method of treatment which he had himself adopted a short time previous and with notable success. The following year he published a full history of this epidemic—a history of which Dr. Trotter, a man long versed in fevers, pronounced "the best history that was ever written of any epidemic." He died April 19, 1813.

Stone, in speaking of the death of Rush, quotes Dr. Charles Caldwell as saying: "From one end of the United States to the other the event was productive of emotions of sorrow; for, since the death of Washington, no man, perhaps, in America, was better known, more sincerely beloved, or held in higher admiration and esteem. For nearly 3,000 years past, but few physicians equal in greatness have appeared in the world, nor is it probable that the number will be materially increased for ages to come." Stone also quotes Jefferson as having made, in a letter to John Adams, the following comments on the death of Rush: "Another of our friends of '76 is gone, another of the co-signers of our country's Independence; and a better man than Rush could not have left us, more benevolent, more learned, of finer genius, or more honest." These brief quotations suffice to show that Rush had succeeded in winning for himself the respect and esteem of his fellow citizens in every part of the country.

Of Dr. Rush's numerous published writings only a few of the more important ones may here receive mention: "Observations on the Duties of a Physician and the Methods of Improving Medicine," Philadelphia, 1789; "Inquiry into the Origin of the Epidemic Fever in Philadelphia," 1793; "An Account of the Bilious Remittent Yellow Fever, as it appeared in the City of Philadelphia in the year 1793," Phila., 1794; "Observations upon the Origin of the Malignant Bilious or Yellow Fever in Philadelphia, and upon the Means of Preventing it," Phila., 1799; "A Treatise upon the Diseases of the Mind," Phila., 1812; "An Account of the Influenza, as it appeared in Philadelphia in 1789, 1790, and 1791;" "A Defence of Bloodletting as a Remedy for Certain Diseases;" "Observations on the Nature and Cure of Gout and Hydrophobia," 1797; "Observations upon the Cause and the Cure of the Tetanus," 1782; and "Case of Tetanus successfully treated by the Use of calomel, bark, wine, and the cold bath," 1789.

A. H. B.

Ruta.—Rue. The leaves of *Ruta graveolens* L. (fam. *Rutaceæ*).

This is a perennial herbaceous or partly woody plant two or three feet in height. It has pale green, cylindrical, branching stems, alternate, smooth, light green glandular dotted leaves, which usually dry yellowish; the lower twice or three times pinnate and long petioled, the intermediate once or twice pinnate, the uppermost simple and sessile; divisions wedge shaped, rounded, or blunt at the extremity. Flowers yellowish, in a terminal corymb, with the parts in fours or fives; stamens twice as many; sepals small, pointed; petals large (one-half inch long), rounded and hooded at the ends, narrow below. Fruit a dry, dehiscent capsule, containing numerous angular, blackish seeds. Rue is a native of southern Europe, the Levant, etc., and is also cultivated. It has a strong disagreeable odor, and a bitter, sharp taste.

The aromatic properties of rue are due to about one-fourth of one per cent. or less of a peculiar, very light volatile oil, usually more or less yellowish in color, and of an extremely powerful and disagreeable odor. Its bitterness is due to the crystalline yellow glucoside *rutin* ($C_{27}H_{30}O_{16}$), also known as *rutinic acid*, and said to be contained also in buchu, capers, and some other drugs. Considerable quercitin and sugar also occur.

Action and Uses.—Rue is one of the most ancient o. drugs. Its action appears to be that of the volatile oil, differing chiefly in its lesser intensity. Taken internally, in small doses, it is stomachic, laxative, and stimulant to the secretions, especially to those of the intestine and kidneys. In somewhat larger doses it is a powerful antispasmodic. It also acts as an emmenagogue, and is in overdoses an irritant intestinal and renal poison and an abortifacient. Among the ancients it was used for its aphrodisiac properties. The dose of the drug ranges from ten to twenty grains, and it is best given in the form of a twenty-per-cent. tincture, made with diluted alcohol, dose fifteen to sixty minims.

Oil of rue was official in the United States Pharmacopœia of 1870 and 1880. It possesses all the above-named properties of rue in a greatly intensified degree. It is a powerful counterirritant, capable of producing vesication similar to that from croton oil. It is a well-known and dangerous abortifacient, and is capable of acting as a fatal irritant-narcotic intestinal poison. It is not often given internally at the present time. The dose is from two to five minims.

Henry H. Rusby.

Rutland, Mass.—Rutland, situated in almost the geographical center of Massachusetts, fifty-four miles from Boston, is the seat of one of the four state sanatoria for pulmonary tuberculosis; the others, subsequently erected, are situated respectively at North Reading, Lakeville, and Westfield. The institution at Rutland was opened for patients in the incipient and curable stage of the disease, October 1, 1908, and was the first of its kind established in the United States. It accommodates 350 patients. The construction is of the older type of closed partitions, while the newer sanatoria are of the "lean-to" type.

In spite of the fact that the sanatorium is for incipient cases, the report for the year ending November 30, 1912, shows that only 30.5 per cent. of this class were admitted during the year, while 52.93 per cent. were moderately advanced cases. The report of 1912 gives 38 per cent. arrested and 32 per cent. improved. The results compare favorably with those of other state sanatoria.

Besides the pavilions there are numerous sleeping porches, and about twenty camps in the woods on the sanatorium grounds, which have been constructed by patients, and where many of them spend much of their time.

The medical staff consists of five medical officers, including the superintendent and bacteriologist. The average stay of considered discharged cases is about seven months, and the average age on admission about twenty-eight years. The per capita cost for 1912 was $10.15, of which amount the patient or the town or city whence he comes pays $4.00. A large proportion of the employees are "graduates" of the sanatorium.

The site occupied by the sanatorium and its grounds is at an elevation of 1,160 feet, protected on the northwest by a wooded hill rising 1,000 feet higher. There is a fine view of the surrounding country and there are no thickly settled portions near by. The climate is that of inland New England modified by the elevation. The air is unusually clear and bracing and there is a large number of clear days. The following weather report gives the various climatological data:

CLIMATOLOGICAL DATA, RUTLAND STATE SANATORIUM, RUTLAND. ALTITUDE 1,160 FEET, FOR THE OFFICIAL YEAR BEGINNING DECEMBER 1, 1911, AND ENDING NOVEMBER 30, 1912.

Date.	Mean temperature (degrees)	Clear days.	Partly cloudy days.	Cloudy days.	Days with rain or snow.	Precipitation (rain).	Precipitation (snow).	Total wind (miles).	Wind av. per hour (miles).	Mean relative humidity (per cent.).
December..... 1911	32.6	12	12	7	9	3.14	5.50	7,079.8	9.6	68.3
January..... 1912	14.1	17	8	6	10	2.51	22.00	7,816.7	10.5	67.1
February..... 1912	20.6	18	7	4	3	2.37	1.00	8,191.7	11.8	60.6*
March..... 1912	28.6	19	4	8	11	4.85	10.25	6,190.6	9.9	68.3
April..... 1912	43.1	18	6	6	14	4.44	1.25	8,118.2	11.3	71.7
May..... 1912	56.0	19	3	9	15	5.86	.....	7,957.9	10.7	76.0
June..... 1912	62.6	25	3	2	6	0.36	.....	6,651.2	9.2	66.6
July..... 1912	69.8	22	7	2	7	2.74	.....	6,321.0	8.5	73.6
August..... 1912	64.2	16	11	4	8	3.33	.....	6,356.8	8.5	78.2
September..... 1912	59.3	13	9	8	12	2.76	.....	5,333.6	7.4	85.3
October..... 1912	51.6	18	7	6	11	2.23	.....	6,687.7	8.9	76.9
November..... 1912	37.5	18	4	8	6	4.32	0.60	8,375.0	11.6	77.4
Totals.....	540.0	215	81	70	112	38.91	40.60	85,080.2	117.9	870.0
Averages.....	45.0	17+	6+	5+	9+	3.24	3.30	7,090.0	9.8	72.5

* Twelve days missing.

In comparing the weather of Rutland and Boston for the year, February, 1, 1913, to February, 1, 1914, we find that there were in Boston 134 clear days, 97 partly cloudy, and 134 cloudy; while in Rutland there were 178 clear days, 88 partly cloudy and 100 cloudy.

There has grown up in Rutland about the sanatorium various private sanatoria and private boarding-houses of moderate cost, which are under medical supervision, and where essentially the same treatment is obtained as in the large institution. To these come some who are waiting admission to the State institution, and others who prefer the privacy and care of a smaller institution or home. In order to increase the efficiency of these private sanatoria and create a standard of excellence, the Rutland Private Sanatoria Association has been founded; its membership including the managers of each of the accredited sanatoria and private houses. For the use of the patients in these private sanatoria an amusement pavilion is proposed. The management of all the State sanatoria is under a board of trustees appointed by the Governor.

EDWARD O. OTIS.

Ruysch, Friedrich.—Born at the Hague, Holland, on March 23, 1638. He began the study of medicine at the University of Leyden, and soon displayed unusual skill in his anatomical dissections. From Leyden he went to the University of Franeker, in Friesland (in the north of Holland), and there completed his medical studies. After receiving the degree of Doctor of Medicine from that institution he settled in Leyden and began the practice of his profession, devoting himself chiefly to surgery and midwifery. Whenever he could spare some time from the duties of his private practice he devoted it to anatomical work. The first fruit of these labors was the treatise on the valves of the lymphatics and lacteal vessels which he published in 1665. In the following year he was called to Amsterdam to fill the Chair of Anatomy, and he continued to perform the duties of this position during a period of over sixty years. He discovered a method of keeping dead bodies in such a perfect state of preservation that they would remain unchanged for a period of several years, and he brought the injection of blood-vessels—an art which at that time was in its infancy—to a high degree of development. The cabinet of anatomical specimens which he formed during this period, so excited the admiration of the Czar of Russia, on the occasion of his visit to Amsterdam in 1717, that he purchased it for the sum of 30,000 florins and sent it to St. Petersburg. Although, at the time of the sale, Ruysch was seventy-nine years old, he at once set to work to form a new collection, and was able to complete the work in a relatively short period of time.

From 1685 to 1728 Ruysch delivered lectures on medicine with great regularity; but, in the year last mentioned he was so unfortunate as to break his thigh. Recognizing the fact that he would now be obliged to give up further lecturing, he had himself transported to the amphitheater and there, at the age of ninety, he bade adieu to the class. He died nearly three years later, on Feb. 22, 1731.

Of his published writings the following deserve to receive special mention: "Dilucidatio valvularum in vasis lymphaticis et lacteis. Accesserunt quaedam observationes anatomicæ rariores," The Hague, 1665; "Observationum anatomico-chirurgicarum centuria. Accedit catalogus rariorum in musæo Ruyschiano," Amsterdam, 1691 (French translation, Paris, 1734); and a collection of his works entitled—"Opera omnia anatomico-medico-chirurgica," Amsterdam, 1721. His name is associated with a number of anatomical structures, such as Ruysch's membrane, R.'s muscle, R.'s tube, etc.

A. H. B.

Sabal, U. S. P.—*Saw Palmetto.* "The partially dried ripe fruit of *Serenoa serrulato* (R. and S.) Hook." The fruit is less than one inch in length, ovoid, of a dark brown color and disagreeable acrid taste. Its medicinal properties depend upon the volatile and fixed oils and resins present. This palm is the common evergreen of the southern coast states, and locally is used as a remedial agent in all bronchial and bladder affections, the leaves and bark as well as the fruit being employed.

Fluid extract of the fruit is the most convenient form for administering in doses of one-half to one dram. More agreeable aromatic elixirs are also prepared. It is given in chronic catarrh of the respiratory tract, asthma, bronchitis, and in all affections of the mucous membrane of the bladder. It is also thought to have a beneficial affect on the prostatic gland and reproductive organs.

BEAUMONT SMALL.

Sabina.—SAVIN. The leaves and young twigs of *Juniperus sabina* L. (fam. *Pinaceæ* or *Coniferæ*). This is a compact, horizontally spreading, evergreen shrub or small tree, resembling our common red cedar on a small scale, and bearing similar berries. It is widely distributed through the north temperate zone of the Old World, and is also met with in the northern United States (in the Great Lake region) and in Canada. The medical supply comes from Europe,

chiefly from Switzerland, in "short, thin, subquadrangular branchlets, the leaves in four rows, opposite, scale-like, ovate, lanceolate, sessile, more or less acute, appressed, imbricated, bearing on the back a shallow groove containing an oblong or roundish gland; odor peculiar, terebinthinate; taste nauseous and bitter."

The odor and taste of savin are mostly due to from two to four per cent. of essential oil (*Oleum Sabinæ*, U. S. P.), a pale yellow, terebinthinous liquid, becoming thicker and darker by age, colorless if redistilled, of a specific gravity of about 0.903 to 0.923, at 25° C. (77° F.). It has the odor of savin, a sharp, bitter, camphoraceous taste, and is more rubefacient and irritating to the skin than others of its class. Tannin and resin are less important constituents of savine.

Action and Use.—Savin and its oil are essentially like, but more intense than, oil of turpentine in physiological and therapeutical properties; irritating to the skin and mucous membranes, to the urinary apparatus by which they are eliminated, and to the uterus, which they may cause to abort. Besides these effects, convulsions and coma may follow. Vomiting, diarrhea, gastrointestinal inflammation, strangury, with or without convulsions or unconsciousness, these are the usual symptoms of savin poisoning; abortion may or may not take place. This potent drug is not much employed. It has been given as an emmenagogue, also as a hemostatic, for leucorrhea and other purposes mostly connected with the uterus. It is not infrequently used with criminal intent to produce abortion, usually without success, unless it nearly or quite kills the mother also; externally it is the basis of some moderately useful stimulating ointments, liniments, and "hair-restorers."

In this country, the oil of juniper, which is milder, is perhaps generally substituted for oil of savin. Oil of turpentine is also often substituted for or mixed with it. Oil of savin can be distinguished by the fact that it does not form a solid mass with hydrochloric acid; also by the fact that very little of it distils under 200° C.

The dose of savin (leaves) is about gr. viij. (0.5); of the oil, from one to four or five drops. A fluid extract of the former is an eligible preparation and the basis of the cerate, strength about twenty-five to 100 savin.

Henry H. Rusby.

Saccharin.—See *Benzosulphinidum.*

Saccharomycosis.—Our knowledge of pathogenic yeasts and of the pathological conditions produced by them is at present but slight; and the unsatisfactory state of the classification and terminology of the blastomycetes has led to much confusion. Inasmuch as the blastomycetes are usually divided into various genera, *Saccharomyces*, *Oïdium*, *Monilla*, etc., the term *saccharomycosis* should be limited to the pathological conditions produced by the yeasts which are included under the *Saccharomycetes*, viz., those characterized by their power to ferment sugar and form alcohol, of which *Saccharomyces cerevisiæ* may be taken as the type. Foreign writers, however, apply the term to the conditions caused by pathogenic blastomycetes that in America are classed as *blastomycosis, blastomycetic dermatitis, oidiomycosis, coccidioidal granuloma*, etc. The nature of the organisms producing these granulomatous affections is still unsettled, and a precise terminology cannot at the present time be decided. (See *Blastomycosis.*)

In 1895 Busse obtained pathogenic yeasts (*S. busse*) from a woman suffering with a cystic tumor of the tibia, which on microscopical examination presented the appearance of a sarcomatous-like granulation tissue containing giant cells. Pure cultures of the yeast were pathogenic for mice and rabbits, giving rise, when injected into the animal, to nodules of chronic granulation tissue, and leading to the formation of metastatic miliary nodules in the brain, kidneys, and lungs. The patient died thirteen months after the appearance of the tibial tumor, and at autopsy numerous foci of disease, containing the yeast in great abundance, were found in the lungs, kidney, and spleen, some reaching the size of an apple.

In the next year a similar case was reported by Curtis, who obtained a yeast, *Saccharomyces subcutaneus tumefaciens*, from myxomatous tumors appearing in a young man, beneath the skin of the neck and thigh, and also from a large ulcer of the loin. Microscopically these tumors resembled myxosarcoma. Both in and between the tumor cells yeasts were found in large numbers. These were easily cultivated, and caused sugar to ferment with the production of alcohol. Dogs, rabbits, rats, and mice were susceptible to inoculation, a chronic inflammation and proliferation being produced at the site of injection.

Corselli and Frisco report a case of saccharomycosis in which "sarcomatous" nodules were found in the omentum and mesentery. The chylous ascitic fluid contained the yeast fungi, which were cultivated and found to be pathogenic for dogs, rabbits, and guinea-pigs.

Pathogenic yeast fungi have also been found in cases of chronic catarrh of the uterine cervix (Colfe and Buschke), and in proliferative catarrh of the nasal mucosa (Busse). Saccharomycetes have also been reported as occurring in the secretion from a case of peculiar inflammation of the conjunctiva and cornea; in the scalp in certain forms of alopecia (*S. capillitii*); in pharyngitis (*S. tumefaciens albus*); in the purulent discharge of otitis media; in the blood, sputum, and urine of a case of typhus (Calmette); in a pseudomembranous angina in a patient suffering from typhoid fever (Froisier and Achalme) and in pyemia (*S. hominis*). *Saccharomyces ruber* has been regarded as the cause of a house epidemic of intestinal catarrh, the infection occurring through the contamination of milk. This same yeast was isolated by Casagrandi from diabetic urine. A variety closely related to, if not identical with *Saccharomyces cerevisiæ*, has been found in the coating of the tongue, in diarrheal stools, in vomited material, and in diabetic urine. Sanfelice regarded (*S. neoformans*) as a probable etiological agent in cancer; it is now generally believed that the yeasts frequently formed in ulcerating cancers are only accidental or secondary invaders.

Pathogenic saccharomycetes have also been found in a number of diseased conditions of the lower animals.

The pathological conditions produced by the various forms of pathogenic yeasts so far observed have all been of the nature of "tumor" or "sarcoma-like" granulomatous inflammatory growths rich in giant cells, and showing a tendency to suppurate. In these nodules the yeast cells are found encapsulated. In sections stained with hematein and carbol-fuchsin they take a bright red. They may be cultivated on malt or glucose-agar.

Aldred Scott Warthin.

Saccharose, or cane sugar, is the ordinary table sugar. Chemically it belongs to the group of disaccharides and upon inversion yields a molecule of dextrose and one of levulose. The mixture is known as invert sugar. Saccharose occurs to the greatest extent in the stalk of the sugar-millet and sugar-cane, the roots of the sugar beet, the trunks of certain palms, maples, in carrots, etc. It dissolves very readily in water, is strongly dextrorotatory, specific rotation = α_D = + 66.5°, is not directly fermentable with yeast and does not reduce metallic oxides.

F. P. U.

Saccharum. —Cane Sugar, $C_{12}H_{22}O_{11}$; *Sucrose* (B. P.).

The refined sugar obtained from *Saccharum officinarum* L. and from various species or varieties of *Sorghum* (fam. *Gramineæ*); also from one or more varieties of *Beta vulgaris* L. (fam. *Chenopodiaceæ*).

Common sugar is one of a group of similar substances formed in plants and animals, distinguished by their sweetness, solubility in water and diluted alcohol, and insolubility in ether. Like starch, their function in the plant is nutritive. They represent carbohydrate nutriment, in a condition ready for use, as starch represents it in a condition for permanent storage, and they represent the latter substance in a transformed condition. Cane sugar is very widely distributed in the vegetable kingdom, being the variety generally characteristic of stems and roots. In a few plants the percentage is so large as to render the process of extraction and refining commercially profitable. The more important sources are as follows:

Saccharum officinarum L., the *sugar cane*, native of southern Asia and cultivated in all tropical countries, is the most important. The yield of sugar from a good article is from fifteen to eighteen per cent. Modern operations in the development of new varieties from seed have resulted in the production of a much greater yield (up to nearly twenty-five per cent.), and the seedlings are in many cases far more vigorous and better capable of resisting disease than the old varieties, which were wholly the product of stem propagation.

Beta vulgaris L. (fam. *Chenopodiaceæ*) yields a number of varieties collectively known as *sugar beet*, which are especially rich in sugar, yielding upward of twelve per cent. For a long time the production of beet sugar was little more than an experiment, but recently the industry has made great strides and beet sugar has come to be a very formidable rival of that from the sugar cane.

Acer saccharum Marsh. (*A. saccharinum* Wang—non L.; *A. barbatum* Mich.), the *sugar* or *rock maple* of eastern and central North America, is next in importance to the above as a sugar producer in the United States. Maple sugar, as it is called, especially when somewhat imperfectly refined, possesses a peculiar flavor, aside from its sweetness, in which it differs from the other varieties of sugar here considered. This flavor, while not affecting its medicinal or pharmaceutical properties, renders it a great favorite with many persons for table use.

Sorghum sugar, formerly a very important article of domestic manufacture in the central United States, has declined greatly in production, owing to the increasing cheapness of sugar cane and beet sugars. It is the product of *S. vulgare* Pers. (*Andropogon sorghum* Brop.; *A. sativus* Hack.), of which there are many varieties. It is believed that broom-corn is merely a variety of the same plant. That which yields sugar is distinguished as *var. saccharatum* (L.) Gray. (*Holcus s.*—L.; *Andropogon s.*—Roxb.). This plant is often known as *Chinese sugar cane*. In tropical Asia and in other tropical countries considerable quantities of sugar are manufactured from *Saguerus rumphii* Roxb. (*S. saccharifer* Bl.), often known as the *sugar palm*, from other species of palms and various other plants; but these products are rarely if ever articles of commerce in this country.

The official sugar is thus described:

White, dry, hard, distinctly crystalline granules, odorless, and having a purely sweet taste. Permanent in the air.

Soluble, at 15° C. (59° F.), in 0.5 part of water and in 175 parts of alcohol; in 0.2 part of boiling water and in 28 parts of boiling alcohol; also soluble in 80 parts of boiling, absolute alcohol, but insoluble in ether, chloroform, or carbon disulphide.

The aqueous solution, saturated at 15° C. (59° F.), has the specific gravity, 1.345, and is miscible with water in all proportions.

The aqueous or alcoholic solution of sugar is neutral to litmus paper.

Both the aqueous and the alcoholic solution of sugar should be clear and transparent. When kept in large, well-closed, and completely filled bottles, the solutions should not deposit a sediment on prolonged standing (absence of *insoluble salts, ultramarine; Prussian blue*, etc.).

If one gram. of sugar be dissolved in 10 c.c. of boiling water, the solution mixed with four or five drops of silver nitrate T. S., then about 2 c.c. of ammonia water added, and the liquid quickly brought to the boiling-point, not more than a slight coloration, but no black precipitate, should appear in the liquid after standing at rest for five minutes (absence of *grape-sugar*, or of more than a slight amount of *inverted sugar*).

Preparation.—The essential features of the manufacture of sugar are the rapid expression of the juice, the separation of impurities by various methods, partly mechanical and partly by precipitation, the evaporation of the water by boiling, the separation of the mother liquor or molasses (described below) and the crude sugar, and the refining and crystallization of the latter. These several processes may be performed by various methods. Although such modifications are frequently very slight, from a theoretical standpoint some of those of modern introduction are of so great an economic importance that they have completely revolutionized the industry, and their introduction into certain countries and not into others has even resulted in the complete ruin of the industry in the latter places. One of the most important of these series of modifications consists in the better use of lime or other alkalies for the purpose of neutralizing the acids present, which, under the influence of the heat in boiling, were formerly responsible for heavy losses in the yield of sugar through its conversion into invert sugar.

The large number of commercial varieties of refined sugar, depending as they do chiefly upon the degree of purification, the form and size of the crystals and of the fragments, the processes of powdering, coloring, and so on, are merely incidental and without pharmaceutical or medicinal interest. There are, however, certain of the sugar products which differ enough from ordinary crystallized sugar to be worthy of mention.

Barley sugar (*Saccharum hordeatum*) is sugar brought into the condition of a transparent, non-crystalline, yellowish body, as a result of melting and cooling. In this condition its taste is markedly different from that of the crystalline substance.

Caramel is an empyreumatic product made by keeping sugar at a temperature of 180° to 200° C. (356° to 392° F.) until it turns brown and loses two molecules of water. Caramel possesses a peculiar odor and taste, as well as a brown color, and is chiefly used for coloring purposes. It can, however, be decolorized, this product having been named *caramelan*.

Invert sugar is produced from ordinary sugar by various methods, most readily through the action of dilute acids under the influence of heat. It can also take place as a result of the prolonged action of heat alone upon a mixture of sugar and water. Invert sugar is a mixture of the two products dextrose and levulose, the latter not being capable of crystallization.

Rock candy is a very pure form of sugar, made to form very large crystals.

The behavior of sugar under the action of certain ferments will be found considered under alcohol. Other changes produced in it are considered under the subject of digestion.

Action and Use.—Sugar has been known from a very remote period in India, where the cane has been

used as food from prehistoric times. It found its way into Europe about the beginning of the Christian era, probably as a natural exudation, like manna, from the wounded canes. It was originally an expensive rarity in Europe and used only as a medicine or luxury. Its general use there as a food dates back only two or three hundred years. Even at the present time, its consumption as a food is continually increasing upon a vast scale, partly because of the extension of its uses for preserving purposes, but chiefly on account of the continued cheapening of its price. It has no medicinal importance except for its slight expectorant properties (see below, under *Molasses*). Certain morbid conditions induced by its excessive or improper use are very general. Undoubtedly the human race would be far better off, so far as health is concerned, if the use of pure glucose could be generally substituted for that of cane sugar.

In pharmacy, the uses of sugar are varied, extensive, and highly important. As a preserver of some unstable chemicals, like iodide and suboxide of iron, fruit juices, and other perishable vegetable and animal products, it is invaluable. Mixed with water, it becomes a preservative solvent for many drugs, though if its strength be too greatly reduced it becomes readily fermentable. Its consistence frequently gives required body to preparations, and its taste is of the greatest value in many of its uses as an adjuvant. Finally, it is of great use as a coating for pills.

The only official preparation of sugar itself is *Simple Syrup* (*Syrupus*, U. S. P.), made by dissolving 850 grams of coarsely powdered sugar in enough distilled water to make 1,000 c.c. It may also be made by the percolation of distilled water through sugar. Other official and unofficial syrups are to be regarded rather as syrupy preparations of the drugs themselves than as preparations of sugar.

Other Sugars.—Other kinds of sugar, animal and vegetable, will be found described in this work under the titles *Dextrose, Manna, Mel, Saccharum lactis*, as well as in connection with the liver, diabetes, etc.

Molasses or *treacle* is the mother liquor remaining after the separation of all the sugar which can be caused to crystallize after the boiling down of the prepared juice of the plant. The varying color, odor, flavor, and consistence of different varieties and grades left in it, the degree of refinement and cleanliness observed in its preparation, and more or less purification to which it may be subjected. The practice prevails very largely at the present time of making molasses out of glucose, the latter chiefly manufactured from Indian corn, or of adding such glucose to natural molasses. Syrup, sugar-house syrup, or crystal drips, is a product of the final draining to which refined sugar is subjected.

In the household, the different varieties of molasses are credited with important and varied medicinal properties. Doubtless molasses or syrup has quite an important action in relieving an irritable cough, and many of the popular proprietary cough syrups probably owe the most of whatever value they possess to the influence of the syrup which they contain.

HENRY H. RUSBY.

Saccharum Lactis.—SUGAR OF MILK. "($C_{12}H_{22}O_{11} + H_2O$). A peculiar, crystalline sugar, obtained from the whey of cow's milk by evaporation, and purified by recrystallization" (U. S. P.). Sugar of milk crystallizes in four-sided rhombic prisms. These are usually collected upon sticks or strings hung in the concentrated solution; thus are formed long rolls, three or four inches in diameter, the crystals densely massed and tapering to a point at the axis of the roll. Much of the sugar, however, is crystallized in pans and comes in fragments of large cakes, two or three inches in thickness. The following is the official description:

"White, hard, crystalline masses, yielding a white powder feeling gritty on the tongue, odorless, and having a faintly sweet taste. Permanent in the air.

"Soluble in about six parts of water at 15° C. (59° F.), and in one part of boiling water; insoluble in alcohol, ether, or chloroform.

"The aqueous solution of sugar of milk is neutral to litmus paper.

"On adding to a few cubic centimeters of a hot, saturated aqueous solution of sugar of milk an equal volume of sodium hydrate T. S., and gently warming, the liquid will turn yellow and brownish red. On the further addition of a few drops of copper sulphate T. S., a brick-red precipitate will appear.

"If about one gram of powdered sugar of milk be sprinkled upon about 5 c.c. of cold sulphuric acid contained in a flat-bottomed capsule, the acid may acquire a greenish or reddish but no brown or brownish-black color within half an hour (absence of *cane sugar*)."

The aqueous solution differs from that of ordinary sugar in being thin and not in the form of a syrup.

The very numerous uses of milk sugar in the pharmacy, in connection with other substances, as an excipient, makes it unusually important that it be kept fresh and pure. Its delicate and extensive use in the preparation of artificial milk for infants renders this caution still more important. The substance has no special physiological action, and its use in milk preparations will be found described under *Milk*.

HENRY H. RUSBY.

Sacroiliac Joint, Diseases of the.—WEAKNESS OR INJURY.—Relaxation of the pelvic articulations incidental to pregnancy has long been recognized as a cause of disability, but it is only within recent years that attention has been called to the importance of local weakness or injury of the sacroiliac joint.

Benjamin Lee (*Trans. of the Am. Orth. Assn.*, vol. iii., 1891) was the first to identify injury as the cause of symptoms, simulating sacroiliac disease, particularly in the lateral deviation of the trunk and sciatic pain.

Since this time the investigations of Goldthwait and others have shown that weakness and strain of the articulation are the most important of the exciting causes of sciatica. Goldthwait has called attention to the effect of attitude, particularly the loss of normal lumbar lordosis, as predisposing to laxity of the articulation, and to the importance of preservation or restoration of the normal contour in prevention, and in the cure of the disability.

The *symptoms* of sacroiliac injury resemble those of lumbago or sciatica. The onset is usually sudden, often following strain or unguarded movement. There is usually local sensitiveness about the articulation, pain radiating about the pelvis and along the sciatic nerve, increased by bending the body forward, or flexing the extending limb on the trunk.

The symptoms may be transitory. They may recur from time to time, preceded in some instances by a sensation of something slipping at the articulation, or they may persist and eventually induce the attitude of sciatic scoliosis.

The *treatment* is based on that followed by Lee. In mild cases the discomfort may be relieved by binding the pelvic firmly with broad bands of adhesive plaster, or this may be replaced by a wide firm canvas belt strapped about the pelvis just above the level of the trochanters. In cases of more severe type a back brace will be required to support the spine in normal lordosis, and to prevent movements that cause pain. The pelvic band must be arranged to fit the pelvis and to exert the required pressure. For women a

long corset, provided with steel supports in the back, and a canvas belt below is equally efficient.

In chronic cases accompanied by deformity, and in those in which it may appear that there has been an actual displacement at the joint, the deformity may be reduced under anesthesia and supported for a time by a long plaster spica.

Tuberculosis.—Tuberculous disease of the sacroiliac articulation is uncommon—particularly in childhood. The *symptoms* are pain, limp, weakness, and change in attitude. The pain is referred to the side of the pelvis or radiates over the buttock or thigh. It is increased by jars, by turning the body suddenly, sometimes by coughing or laughing. A peculiar feeling of insecurity and weakness about the pelvis and hip-joint is a common symptom. The trunk is inclined toward the sound limb, as a result of which the pelvis is lowered on the affected side. The leg seems longer than its fellow, and the patient walks with a peculiar awkward limp. In the early stage of the disease there is no deformity of the limb, but if a pelvic abscess forms the thigh may become flexed. Locally there may be sensitiveness to direct pressure on the articulation and swelling in the neighborhood of the disease, although this is usually a late symptom. Pain is induced by lateral pressure on the pelvis or by any manipulation that disturbs the articulation.

Abscess finally appears in the majority of cases. It may be extra- or intrapelvic. In the latter case it may present itself above the crest of the ilium. It may pass through the sciatic notch or appear in the ischiorectal fossa, or it may break into the rectum.

Diagnosis.—Sacroiliac disease may be mistaken for sciatica or for disease of the hip or spine. The freedom of motion and the absence of muscular spasm when the pelvis is fixed, if examination is carefully conducted, should exclude both the one and the other, although the pain on lateral pressure, which is described as the most characteristic symptom, may be simulated closely by primary acetabular disease. The attitude is similar to that of sciatica, but the symptoms of local sensitiveness to jars and to manipulation are much more marked.

The *prognosis* is unfavorable, probably because the majority of the cases are in adults, a class in which the prognosis of any tuberculous disease is more serious than in childhood. In addition there is usually the complication of an infected and burrowing abscess.

Treatment.—The local treatment consists in protecting the sensitive parts from injury, by rest and splinting, and the operative removal of the disease if *x*-ray examination shows it to be practicable. In the ambulatory treatment a plaster spica bandage or Thomas hip brace combined with the use of crutches may be indicated, but in most instances a broad, strong pelvic girdle, which may be drawn tightly about the pelvis, will be most efficient. If motion of the spine causes discomfort, this girdle may be reinforced by some form of spinal brace. Constitutional treatment is of course indicated as in other forms of tuberculous disease.

Non-tuberculous Arthritis.—All the symptoms described as characteristic of the tuberculous disease of the sacroiliac articulation may be induced by other affections than tuberculosis, such, for example, as rheumatism or other forms of infectious arthritis.

Such causes are more common in early life than is tuberculous disease. The principles of treatment (that is, rest and protection of the sensitive part by the pelvic girdle or other support) are indicated. If this treatment is efficient the cure is usually rapid and complete.

Royal Whitman.

Safflower.—See *Carthamus.*

Saffron.—See *Crocus.*

Sage.—See *Salvia.*

Saint Augustine.—This picturesque and well-known winter resort is situated on the Atlantic coast of Florida, thirty-eight miles southeast from Jacksonville, and about 250 miles north of Palm Beach. The city occupies a narrow peninsula opposite Anastasia Island, which forms a breakwater against the open ocean. The surrounding country is flat and sandy and covered with the scrub palmetto.

The town is the oldest in the United States, and has a permanent population of 5,794 inhabitants, which number is doubled or more at the height of the season. The city retains many of its antiquities, and is exceedingly quaint and attractive. The narrow streets; the ancient Spanish "coquina," or shell-limestone residences, with their overhanging balconies; the old "City Hall," and Fort Marion, are all exceedingly interesting relics of the Spanish occupancy.

Many new and attractive buildings have of late years sprung up—several extensive hotels of the Spanish style of architecture, with beautiful grounds and courtyards; villas, with grounds ornamented with orange, lemon, and fig trees, palms, and a variety of tropical flowers and shrubs; churches, convents, and the restored Cathedral and Old Market.

The attractions at this resort are many and varied, as can easily be imagined. Besides those already mentioned, there are a United States military post, with daily guard mount, the sea wall affording a delightful promenade along the water front; many excursions by water; visits to the orange groves; drives, hunting, fishing, sailing, golf, and the never-ending delight of wandering through the old town. Connected with one of the hotels is a casino, where are Turkish baths, a swimming pool, various entertainment halls, lawn-tennis courts, etc.

The winter climate is a mild, equable, moist one; and in summer the heat is tempered by the sea breezes. Frosts are rare. Although the climate is of a somewhat less tropical nature than that of the resorts on the lower half of the peninsula, such as Palm Beach, Tampa, and Miami, still a very comfortable, mild atmosphere is found here in the winter, and there is a good proportion of sunny days.

The average mean temperature of twenty years for the four seasons, as given by Dr. Wall (*The Climatologist*, October 15, 1891), is as follows (degrees Fahr.): Spring, 68.5°; summer, 80.3°; autumn, 71.5°; winter, 58.1°; and for the whole year, 69.6°. For the four winter months, according to the same authority, it is, for December, 57.2°; January, 57°; February, 59.9°; March, 63.3°. The average yearly rainfall is about 49 inches, varying quite considerably in different years; for example, it was 67.4 inches in 1880 and 33.9 inches in 1851. The least rainfall appears to be in January. The prevailing winds are from the northeast. The climatic data of Jacksonville, which is only thirty miles to the north of St. Augustine, can be taken as fairly accurately representing those of the latter resort, and the reader is referred to the article upon *Jacksonville* in vol. v. of the Handbook for more extended meteorological facts.

The water supply is abundant and obtained from artesian wells; and the streets are clean and well lighted. The sanitary conditions of the hotels are carefully looked after.

There is a well-appointed, indeed a luxurious, hydrotherapeutic establishment where hot and cold saline and hydroelectric baths are given by skilled attendants; and cases of rheumatism, gout, and nervous disorders are treated in this way. The Nauheim baths and the Schott system of treatment for heart disease; various methods of electrical applications, gymnastics, douches, and massage are also included in this establishment.

January, February, and March are the months in which St. Augustine is the most frequented. On account of its easy accessibility, mild climate, excel-

lent accommodations and many attractions, this has become a popular and fashionable winter resort, and has been compared to Newport and Saratoga. Excursions to other portions of Florida can easily be made from this point. EDWARD O. OTIS.

Saint Catharine's Well.—POST-OFFICE.—St. Catherine's, Ontario. Hotel, The Welland House.

ACCESS.—Via Grand Trunk Railway from Toronto, or Buffalo.

Analysis (Professor Croft).—Ten thousand grains of water contain: Carbonate of iron, gr. 0.5210; carbonate of lime, gr. 0.0820; sulphate of lime, gr. 19.7934; chloride of calcium, gr. 174.4876; chloride of magnesium, gr. 40.6644; chloride of sodium, gr. 378.4196; chloride of potassium, gr. 2.8119; bromide of sodium, a trace; iodide of sodium, gr. 0.0140. Total, 616.7938 grains.

St. Catharine's is situated twelve miles from Niagara Falls in what is termed "the Garden of Canada." There are a number of springs which have long been famous, and at different times sanatoria have been opened. The Welland is under excellent management and has during the past year been enlarged and furnished with all the appliances of a modern sanatorium. A resident physician is in charge with a staff of skilled nurses. Every provision is made to utilize the water after the most approved methods of hydrotherapeutics. The hotel is open throughout the year.

BEAUMONT SMALL.

St. Leonard's.—See *Hastings*.

Saint Louis.—This great city of nearly 700,000 inhabitants is situated in the northeastern corner of Missouri upon the Mississippi River, not far from its junction with the Missouri.

A description of the city is hardly necessary or pertinent in this connection, as the climate is the chief consideration, of which certain marked peculiarities deserve mention.

In the first place, as will be observed from the table, the excessive extremes of temperature are striking, the annual range being 123.4° F. Although the winter mean temperature is only a few degrees higher than that of New York, for example, the mean summer temperature is five and one-third degrees higher. In July a maximum temperature of 104° F. is noted, while in January a minimum temperature of −16° F. occurred in the cold wave of 1889. St. Louis is called a "Southern city," and yet it is seen that the winters are severe and quite like those of a Northern city. The summers are usually very hot, the nights as well as the days, and a continuous high temperature may exist for many days in succession; moreover, this heat may continue through the month of September. In July, 1901, there was hardly a day for three weeks in which the temperature was not 100° F. or over. The daily range of temperature is also seen to be considerable, and, consequently, one might hastily conclude that the summer nights would be comparatively cool; but if the day temperature is very high, a diminution of fifteen or eighteen degrees would still give a high night temperature.

Another striking feature of this climate is the prevalence of south winds throughout the year except in March, when the blizzards change the direction from south to northwest.

The mean relative humidity indicates a moderate amount of moisture, a little less than that of New York City. The rainfall is not excessive and is pretty evenly distributed throughout the year, rather more falling in the spring and summer. There are a few more clear and fair days in St. Louis than in New York, especially in the summer and autumn. The flatness of the surrounding country and the atmospheric conditions favor the formation of tornadoes; and on May 27, 1896, there occurred in St. Louis one of the most terrific ones ever known in the United States, ploughing in a moment a huge furrow through the city and destroying a large number of lives and an immense amount of property. Such calamities, however, are rare, but, nevertheless, the latent conditions are always existent, and what has happened may happen again.

During the summer months all who are able seek a cooler climate at the seashore or in the mountains; but during the rest of the year St. Louis is a comfortable and wholesome place of residence. It has been feared that the Chicago drainage canal, which empties into the Illinois River—which latter in turn flows into the Mississippi above St. Louis—might pollute the waters of this river as it flows past St. Louis. No sure evidence, however, to the writer's knowledge, has been adduced to show that this is the fact, or that the drinking-water, which is derived from the river, is injuriously affected.

For a description of the manifold attractions in and about the city, the guide books must be consulted; and for the history of the founding of the city, the reader is referred to Parkman's fascinating works.

From St. Louis interesting excursions can be made either up the river to St. Paul, or in the other direction to New Orleans. From St. Louis to New Orleans is a distance of 1,250 miles, and the steamer occupies about a week in traversing it. For one who desires

CLIMATE OF ST. LOUIS. LATITUDE, 38° 38′; LONGITUDE, 90° 12′. PERIOD OF OBSERVATION, THIRTEEN YEARS.

	January	March	May.	July.	September.	November.	Spring	Summer	Autumn	Winter	Year
Temperature, degrees Fahr.—											
Average or normal	31.7°	43.1°	66.1°	78.8°	68.0°	42.4°	54.7°	76.8°	55.9°	34.0°	55.3°
Average daily range	15.8	16.8	18.7	18.2	19.2	15.5					
Mean of warmest	38.7	53.5	75.4	88.2	79.2	52.1					
Mean of coldest	22.9	36.7	56.7	70.0	60.0	36.6					
Highest or maximum	72.0	82.0	93.0	104.0	101.5	82.0					
Lowest or minimum	−16.0	8.0	32.0	57.0	40.0	5.0					
Humidity—											
Average mean relative	71.2%	66%	64.2%	67.9%	64.7%	67.9%	63.3%	67.1%	65.8%	70.9%	60.8%
Precipitation											
Average in inches	2.19	3.04	3.86	4.36	2.55	2.79	10.25	11.74	8.12	7.48	37.59
Wind—											
Prevailing direction	S.	N. W.	S.	S.	S.	S.	S.	S.	S.	S.	S.
Average hourly velocity in miles	10.2	11.6	9.7	7.7	8.5	10.6	10.7	8.0	9.5	10.2	9.6
Weather—											
Average number of clear days	8.8	7.7	9.8	11.4	13.9	7.7	26.9	33.5	34.4	24.5	119.3
Average number of fair days	11.3	11.9	11.5	12.9	10.9	12.2	35.2	40.5	34.9	33.0	143.6
Average number of clear and fair days	20.1	19.6	21.3	24.3	24.8	19.9	62.1	74.0	69.3	57.5	262.9

a slow, restful journey amidst oddly picturesque scenery, a journey soothing to tired nerves and yet of strange interest, this voyage down the Mississippi can be unqualifiedly recommended from personal experience. EDWARD O. OTIS.

Saint Louis Spring (Andrews Magnetic Mineral Springs).—Gratiot County, Michigan.

ACCESS.—Via Pere Marquette Railroad.

POST-OFFICE.—St. Louis. Hotels and sanatoriums. Analysis by S. P. Duffield:

Calcium sulphate	66.50
Calcium silicate	6 72
Calcium chloride	Trace.
Sodium bicarbonate	106.40
Calcium bicarbonate	69.40
Magnesium bicarbonate	17.50
Iron bicarbonate	1 20
Silica-free	2.88
Organic matter and loss	2 00
Total constituents	272.60
Bicarbonates	191.62
Free carbonic acid in gallon	6.21
Sulphureted hydrogen	Trace.

The water comes from the spring at a temperature of 50° F. and is pleasant for drinking. It flows from a depth of 200 feet with a volume of 280 gallons per minute. It is clear, sparkling, tasteless, and pure.

The results of treatment with these waters have shown them to be especially beneficial in dyspepsia, neuralgia, chronic rheumatic affections, and other troubles. The water, as shown by the analysis, is strongly alkaline, and also contains sufficient iron to impart to it the properties of the chalybeate class. The waters were once supposed to be strongly magnetic, but it has been proved by the experiments of Walton, and corroborated by a committee of the Michigan State Medical Society, that the so-called magnetic properties were derived from the metallic tubing which encased the well. The resort is still kept up well and is very popular. The climate is agreeable and the scenery is picturesque.

EMMA E. WALKER.

Saint Moritz.—See *Engadine*.

Saint Paul.—This city, and several other points in Minnesota, were formerly popular as winter health resorts for consumptives, on the theory that steady cold weather was peculiarly bracing to the constitution, and thus hardened the patient was put in a more favorable condition to overcome his disease. There is undoubted truth in this, provided the air is pure as well as cold, and provided other favorable climatic factors exist, such as sunshine, absence of high winds, and dryness. There have been developed, however, other and better climates of the bracing winter type, such as the various well-known resorts in the Alps and in Colorado; and, in consequence, the former reputation of Minnesota has declined. Further, large cities are obviously never so favorable as health resorts for pulmonary tuberculosis, and hence St. Paul and its sister city, Minneapolis, now grown so large, could not be recommended for a residence to those suffering from this disease, even if the climate were better than it actually is.

The characteristics of this climate are, first of all, the steady cold winter weather, the mean temperature of the four months, December, January, February, and March, being 19.6° F., while the minimum temperature has been as low as −39° F. in December and −31° in January. Secondly, may be mentioned the freedom from the sudden and constant great variations in temperature so common along the Atlantic coast; it is very cold in winter, but it is a steady cold, and there are no thaws. Again, when we consider the low winter temperature, a relative humidity of 72.4 per cent. indicates a dry atmosphere, quite different from that of New York City, for instance, with about the same relative humidity in winter, but with an average mean winter temperature 14.8° F. higher, the absolute humidity at St. Paul being only half as great in the winter as at New York City, so that we have a dry as well as a cold atmosphere. The average precipitation is seen to be small, about two-thirds of that of New York City.

There is no great amount of wind at St. Paul, particularly in the winter; and a very considerable amount of sunshine. In both of these respects St. Paul shows a marked superiority over New York City.

From its inland location, St. Paul is free from all those perturbations of temperature caused by the influence of the sea, which prevail in the large seabound cities of the United States, or in the cities lying upon the great lakes.

St. Paul is a beautiful city, of 214,777 inhabitants, and affords many attractive excursions in the vicinity—one is to Lake Minnetonka, forty miles distant, a popular summer resort with hotels and cottages, where the air is pure and invigorating, and where many opportunities are afforded for out-of-door life. Convalescents and those suffering from nervous affections are said to do well in this climate. From St. Paul the journey down the Mississippi River begins, and the portion between this city and

CLIMATE OF ST. PAUL, MINN. LATITUDE, 44° 58′; LONGITUDE, 93° 3′. PERIOD OF OBSERVATION, THIRTEEN YEARS.

	January.	March.	May.	July.	September.	November.	December.	Winter.	Year.
Temperature, degrees Fahr.—									
Average or normal	12.9°	28.5°	58.8°	71.8°	58.4°	30.1°	18.7°	16.6°	43.7°
Mean of warmest	24.3	41 2	68.7	82.8	70.7	40.2	28.2		
Mean of coldest	5.8	22.2	48.3	62.7	50.7	23.8	12.2		
Average daily range	19.5	19 0	20.4	20.1	20.0	16.4	16.0		
Highest or maximum	49.0	68.0	94.0	100.0	94.0	72.0	56.0		
Lowest or minimum	−31.0	−22.5	24.0	46.0	30.0	−24.5	−39.0		
Humidity—									
Average mean relative	72.1%	69%	60.5%	69.9%	70.7%	72%	74 3%	72.4%	69.1%
Precipitation —									
Average in inches	1.07	1.64	3.72	3.22	3.26	1.42	1.28	3.42	29.94
Wind—									
Prevailing direction	N. W.	N. W.	S. E.	S. E.	S. E.	N. W.	N. W.	N. W.	S. E.
Average hourly velocity in miles	7.8	9.2	9.6	7.2	8.2	8.3	7.5	7.8	8 4
Weather—									
Average number of clear days	8	8.3	8.8	10.6	9.1	6.5	8.8	25.6	106.2
Average number of fair days	13	12.0	14 2	15.8	13.8	13.7	12.8	36.2	159.9
Average number of clear and fair days	21	20.3	23.0	26.4	22.9	20.2	21.6	61.8	266.1

St. Louis, constituting the first stage, is one of beautiful and grand scenery. The distance is about 800 miles. EDWARD O. OTIS.

Saint Regis Springs.—See *Massena Springs.*

Sajodin is a compound of calcium, iodine, and behenic acid. It is a colorless, soapy powder, without odor or taste. It is a chemical unit containing twenty-six per cent. of iodine and 4.1 per cent. of calcium; insoluble in water, alcohol, and ether. On incineration it develops abundant iodine fumes. Exposed to light sajodin becomes yellow superficially without undergoing decomposition toward the center of the mass. It is a product resulting from an effort to obtain a substitute for potassium and sodium iodide, one which would possess the therapeutic value without the disturbing collateral effects. Sajodin is said to pass unchanged through the stomach and consequently is without effect upon that organ; it does not cause the nausea or loss of appetite and slowly decomposes in the intestines from where it is utilized. It is said not to cause iodism.

Sajodin is applicable in all cases where the iodides are employed, and in from fifteen to forty-five grains (1.0–3.0) daily contributes to the organism less of iodine than when the iodides are given. It is recommended in tertiary syphilis, arteriosclerosis, asthma, chronic bronchitis, goiter, and glandular enlargements.

R. J. E. SCOTT.

Salacetol—salantol, $C_6H_4.OH.CO.OCH_2.COCH_3$—is a compound of acetone and salicylic acid containing seventy-one per cent. of the latter. It occurs as fine acicular crystals or scales insoluble in cold water, slightly soluble in cold alcohol, and freely soluble in hot alcohol, ether, and chloroform. In its action it resembles salol, the analogous compound of phenol and salicylic acid, and like it separates into its components in the intestine. The dose is fifteen to forty-five grains (1.0–3.0). W. A. BASTEDO.

R. J. E. SCOTT.

Salicin.—(*Salicinum*, U. S. P., B. P.), $C_{13}H_{18}O_7 = 285.33$. This is a neutral principle obtained from several species of *Salix* and *Populus* (Fam. *Salicaceæ*).

Salicin is easily prepared from willow bark by extracting with water, precipitating tannin, etc., with litharge, evaporating and crystallizing out the salicin, and purifying by re-solution and repetition of the process. From populin it is prepared by boiling with lime water or barium hydroxide. It can also be prepared synthetically. The following is the official description:

Colorless, silky, shining, crystalline needles, rhombic prisms, or a white crystalline powder; odorless, and having a very bitter taste.

Soluble in 21 parts of water, and in 71 parts of alcohol at 25° C. (77° F.), in 3.3 parts of water at 80° C. (176° F.), and in 22 parts of alcohol at 60° C. (140° F.); insoluble in ether and chloroform.

It melts at 201.4° C. (394.5° F.). Upon ignition, it is consumed, leaving no residue.

Its aqueous solution is levogyrate and neutral to litmus paper.

On heating a small portion of salicin in a test-tube until it turns brown, then adding a few cubic centimeters of water, and afterward a drop of ferric chloride T. S., a violet color will be produced.

Sulphuric acid produces a red color, which disappears upon the addition of water.

Upon gently heating 0.1 gram of salicin with 0.2 gram of potassium dichromate and 2 c.c. of dilute sulphuric acid, the odor of salicylic aldehyde will be developed.

Sulphuric acid containing a trace of molybdic acid produces with salicin a violet color, changing to a deep brownish red. Sulphuric acid containing a trace of potassium iodate produces a dark red color, changing to deep purple. Sulphuric acid containing about one-fifth of its volume of solution of formaldehyde produces a deep purplish-red color.

If to a small quantity of salicin a few drops of nitric acid be added, the liquid evaporated to dryness, and the resulting yellowish residue treated with ammonia water and heated upon a water-bath with a fragment of potassium cyanide, a blood-red color will be developed.

The aqueous solution of salicin is not precipitated by tannic or picric acid T. S., nor by mercuric potassium iodide T. S. (absence of, and difference from, *alkaloids*).

Salicin is a glucoside, yielding, upon treatment with dilute acids or a powerful galvanic current, glucose and saliretin, or saligenin. It is readily convertible into salicylic and related acids and numerous other compounds. In the system it is partly converted into salicylic acid, so that its effects are very similar to those of that substance; but, since the percentage thus changed appears inconstant, its action is very irregular. Between two and three ounces of it are recorded as having been taken with no marked effect, though far smaller amounts are often very active. Although its chemical reactions outside of the body are thus of great interest, they lend but little assistance in determining its physiological action, and its therapeutics is almost wholly empirical. As indicated above, its action is, weakly and irregularly, that of salicylic acid.

Salicin has undoubted antipyretic power although less than is possessed by quinine or salicylic acid; its antiperiodic action is much less than that of either of them. As a remedy in rheumatism, salicin has also been obliged to yield to the more useful salicylic acid. As a tonic, in small doses, it is occasionally used, but is far inferior to gentian or quinine. The dose is ʒi. ad ʒiss. (4.0–6.0), repeated every three hours; as a tonic gr. iss. ad gr. iij. (0.1–0.2) is sufficient.

HENRY H. RUSBY.

Salicylamide.—A compound prepared from salicylic acid by the introduction of the amidogen radical. Its chemical formula is $C_6H_4,OH,CONH_2$. The benefit of the combined action of this stimulating radical had already been demonstrated in chloralamide, and the same advantage was looked for in salicylamide. It forms in colorless crystals and in thin transparent plates, melting at 142° C. It is soluble in alcohol, ether, chloroform, readily soluble in hot water, and in 250 parts of cold water.

Salicylamide was proposed as a substitute for salicylic acid and its salts but it has failed to replace the older drug and is now rarely employed.

It is recommended for all conditions in which the salicylates are indicated. The dose advised is about fifteen grains daily, in divided doses of three to five grains. BEAUMONT SMALL.

Salicylic Acid and the Salicylates.—Salicylic acid, chemically *ortho-oxybenzoic acid*, $C_6H_4.OH.COOH$, takes its name from the principle *salicin*, found in willow bark, from which substance it is possible to make salicylic acid by fusion with potassium hydroxide. Salicylic acid in the condition of the ethereal salt, *methyl salicylate*, constitutes about ninety per cent. of oil of gaultheria (wintergreen), and occurs also in other plants. Salicylic acid can be made from oil of gaultheria, but at present almost all the acid used in medicine is made, by the process of Kolbe, from phenol. The principle of this process consists in the forcing of a molecule of carbon dioxide upon the molecule of phenol, an addition which just

converts one molecule of the phenol into one of salicylic acid. In this process, phenol and a concentrated solution of soda are first evaporated to dryness, and over the product, heated, a stream of dry carbon dioxide is made to pass. As a result, one-half of the phenol used is converted into salicylic acid in the condition of sodium salicylate, which salt, on decomposition by treatment of its aqueous solution with hydrochloric acid, yields salicylic acid under its own form. Kolbe's process, by reason of its cheapness, has practically superseded all others for the procurement of salicylic acid.

It will thus be seen that both the natural and the artificial acids are prone to impurities. Their purification, especially that of the synthetic, is a matter of much importance. Phenol is the commonest and one of the most serious impurities, as are the creosotic acids (see below) frequently occurring in the artificial variety. Salicylic acid is official in the United States Pharmacopœia under the title *Acidum Salicylicum*, Salicylic Acid. It occurs in fine, light, perfectly white needle-shaped crystals, or in a white crystalline powder. A reddish tinge in a sample of the acid signifies impurity, and such a sample should be rejected. Salicylic acid is permanent in the air; is, when pure, free from odor of phenol, but has a sweetish taste, with an acrid after-flavor. It dissolves in 308 parts of water and in two parts of alcohol at 25° C. (77° F.), in fourteen parts of boiling water, and is very soluble in boiling alcohol; it is also soluble in ether, absolute alcohol, and chloroform. Although salicylic acid is but feebly soluble in cold water, it dissolves freely in many saline solutions. Thus the pharmacopœial *solution of ammonium acetate* will dissolve twenty-five per cent. of salicylic acid; a twelve-and-a-half-per-cent. aqueous solution of potassium acetate will dissolve twelve and a half per cent. of the acid; a twelve-and-a-half-per-cent. solution of potassium citrate in equal volumes of glycerin and water will dissolve six per cent. All of these solutions possess the sharp stinging taste of the uncombined acid. A serviceable and permanent solution of the acid, and one that instead of being sharp to the taste has a pure bitter flavor only, can be made as follows: Dissolve two parts of borax in twelve of glycerin by the aid of heat; add one part of salicylic acid, continue the heat, and stir until the acid dissolves. Almost all solutions of salicylic acid, either immediately or after a while, turn of a reddish or of a smoky color, resembling that of solutions of phenol.

Salicylic acid is incompatible with strong oxidizing agents, like potassium permanganate, and with chlorine, bromine, iodine, ferric salts, carbonates, the most of which it decomposes, and spirit of nitrous ether. A soft or semi-liquid mass is formed with exalgin, antipyrin, phenacetin, urethane, and other synthetics, as well as with lead acetate and sodium phosphate. The salicylates give precipitates with strong solutions of most alkaloidal salts, as well as with strong acids. Lime water also yields a precipitate.

Salicylic acid, taken into the mouth, has not much taste, proper, but speedily and quite suddenly after the tasting a sharp stinging seizes the *throat*, often severe enough to bring tears to the eyes. Similarly, a little of the dry acid snuffed up the nostrils will sting quite strongly. The acid brings sharp pain to cuts and abrasions, but, swallowed, is much less irritant to the stomach than its effects on the throat would lead one to suppose. Large doses, so taken, may upset digestion and cause a strong sensation of heat, and even actual burning pain, but no serious or lasting results follow. The acid is rapidly absorbed from the stomach into the circulation, presumably in saline combination, and thereupon exerts the peculiar influence characteristic of the salicylates.

Salicylic acid was at first used as an internal medicine for the procurement of the therapeutic effects of the salicylates; but now, and very properly, salicylates themselves, because of their freedom from the locally irritant action of the uncombined acid, have superseded the acid for this purpose. The present medicinal application of the acid is for local purposes as a deodorant, detergent, or so-called antiseptic—purposes which salicylic acid fulfils by reason of its having a fairly potent germ-sterilizing faculty. (See Salicylic Acid in article *Disinfectants*.) For general local use, the solution of the acid in a glycerin solution of borax is convenient, this solution bearing any necessary dilution with either water or alcohol without precipitation. A dilution representing a two-per-cent. solution of acid is one very commonly employed.

Salicylates.—In saline combination, whether with metallic or ethereal bases, the local pungency of free salicylic acid disappears while yet the faculty for constitutional action remains. As already said, it is probable that the acid, when taken as an internal medicine, enters the circulation only after conversion into a salicylate, so that, as a matter of fact, what is commonly called the constitutional action of salicylic acid is, so far as we know, the action of a salicylate. The constitutional effects in question are as follows: After a full dose a non-pyrexial subject experiences, in about fifteen minutes, a moderate reddening of the face with a sense of fulness of the head, or perhaps even a pronounced headache, and a buzzing or roaring in the ears precisely similar to what occurs in cinchonism. Almost simultaneously free perspiration begins, and, according to dose, there is more or less tendency to a reduction of pulse rate, of respiration rate, and of body temperature. Tests for salicylic acid will reveal the presence of the substance in the urine, the saliva, and the sweat. The urine, furthermore, will be discolored, appearing brown by reflected and green by transmitted light, from the presence of indican or of pyrocatechin. It will also contain a something that will reduce copper salts in copper test solutions (Brunton), and will show an increased amount of urea and uric acid. In overdoses, salicylates readily irritate the kidneys, setting up albuminuria; may derange the cerebral faculties, causing hallucinations and delirium; and may dangerously or even fatally depress the functions of heart and lungs, determining collapse or death by failure of respiration. These several untoward effects occur very irregularly, and, according to Squibb, in "a very large proportion" of instances are determined, not by the salicylic acid, but by a *contaminating acid* very commonly present in market samples of salicylic acid, and hence in salicylates derived therefrom. The constitutional effects of salicylates, which are valuable in medicine, do not appear in experimentation with a subject in health. They consist, in general, in a reduction of fever temperatures, and, in particular, in an abatement of pains in fibrous tissues, notably the pains in acute articular rheumatism. The antipyretic power of salicylates is second to none, in all the three elements of quickness, degree, and duration of reduction of temperature. For a full antipyretic effect, however, considerable dosage is necessary—considerable enough to cause disagreeable sweating, *tinnitus aurium*, depression of pulse and respiration rate, and, every now and then, actual toxic symptoms. Other antipyretics, therefore, which act more kindly, are preferable, except in rheumatism. The antirheumatic faculty of salicylates is unapproached by any other known medicine, so that, as is well known, salicylates constitute a standard set of medicines for the treatment of acute rheumatism. Under salicylate medication the fever lessens, pains abate, and the disease runs a shorter as well as milder course. It is therefore particularly as remedies for rheumatism and, though not so surely, for gout that salicylates are prized in medicine.

The salicylates in *common medical use* for the purpose of salicylate medication are the salicylates, respectively, of *sodium*, *lithium*, *ammonium*, *strontium*, and *methyl*. The salicylates, respectively, of *physostigmine*, *quinine*, and other alkaloids, are used for the sake of the medicinal action of the respective bases only. For *phenyl salicylate*, see article PHENYL SALICYLATE.

Sodium Salicylate, $NaC_7H_5O_3$. The salt is official in the United States Pharmacopœia under the title *Sodii Salicylas*, Sodium Salicylate. It occurs as an amorphous powder, white, without odor, and having a sweetish, saline, and slightly alkaline taste. It is permanent in the air, dissolves readily in water, glycerin, and boiling alcohol. In cold alcohol it requires 5.5 parts for solution. It should be kept in well-stoppered bottles, protected from heat and light. Sodium salicylate is the most commonly used salicylate, and is a very important medicine. It is easily made *in solution* by mixing salicylic acid and a sodic carbonate in the presence of water, whereupon sodium salicylate results, and remains in solution, and carbon dioxide gas escapes in effervescence. From this solution the salt can be obtained by evaporation to dryness, carefully conducted. Extemporaneous preparation of the medicine *in solution* being easy, Squibb points out an advantage of such extemporaneous making of the salt in all cases in which the prescriber or the dispenser may not be certain of the purity of the market article. The point is that it is not possible to establish the purity of a given sample of *sodium salicylate* except by an elaborate chemical analysis, whereas a good sample of *salicylic acid* is immediately recognizable by the simple fact of its *crystalline condition*. Hence, in making one's own sodium salicylate from a selected well-crystallized sample of salicylic acid, purity is assured. And in the instance of this salt purity is important, since, as above said, there is probably good reason to lay many of the untoward effects of salicylates to the odor of the contaminating acid of salicylic acid. Squibb recommends the following formula for the preparation of a solution of sodium salicylate of a strength convenient for use as a medicine: "Take of salicylic acid, well crystallized, 437 grains = 28.32 grams; bicarbonate of sodium, 270 grains = 17.5 grams; water, free from iron, a sufficient quantity. Put the acid into a vessel of the capacity of a pint, add four fluidounces = 120 c.c. of water, stir well together, and then add the bicarbonate of sodium in portions with stirring, until the whole is added and the effervescence is finished. Filter the solution, and wash the filter through with water until the filtered solution measures six fluidounces, or 180 c.c. This solution contains ten grains (= 0.65 gram) of the medicinal salicylate of sodium in each fluidram (= 3.75 c.c.). If made from good materials, the solution before filtration is of a pale, amber color, but as most ordinary filtering paper contains traces of iron, the filtered solution is often of a deeper tint." The proportions of the ingredients for this solution are estimated so that the solution shall be neutral, but, "owing to the varying proportions of hygrometric moisture in the materials," the neutrality may not always be absolute. According to Squibb, a well-made sample of sodium salicylate, prepared by use of a well-crystallized sample of acid, is always, when evaporated to dryness, *white*, and is free from all *odor of carbolic acid*, unless it has been shut up for a long while in a bottle. Even then, however, the odor should be but very faint—only perceptible on close examination, and should disappear upon exposure of the sample to air. *Solutions* of sodium salicylate of good quality should have none of the carbolic-acid smell.

Sodium salicylate is used almost exclusively as an internal medicine, being commonly held to be lacking in the germ-sterilizing faculty which gives salicylic acid, as such, its applicability as a local antiseptic. For the purposes of internal salicylate medication, as set forth above, the salt is thoroughly effective, and, if made from a well-crystallized and therefore fairly pure sample of salicylic acid, rarely produces untoward effects in reasonable doses. So large a quantity as seventy-seven grains (5.0) has been given at a single dose in rheumatism without producing serious derangement, but the ordinary dosage for an antipyretic or antirheumatic effect does not exceed twenty grains (1.3) repeated every two hours, for three or four doses, or until a distinct impression is produced, followed by doses of half the quantity every hour or two thereafter, so long as the influence of the medicine may be required. The medicine is readily enough taken in simple aqueous solution, but if the faint, mawkish taste of the salt be objectionable, the addition of twenty per cent. of glycerin and the flavoring with a drop or two of oil of gaultheria will render the mixture perfectly palatable.

Lithium Salicylate, $LiC_7H_5O_3$. The salt is official in the United States Pharmacopœia under the title *Lithii Salicylas*, Lithium Salicylate. It occurs as a whitish powder which deliquesces on exposure to the air. It dissolves freely in water and alcohol, and resembles the sodium salt in taste. It should be kept in well-stoppered bottles. The effects of this salt are similar to those of sodium salicylate, with the possible superaddition of medicinal virtues, in rheumatic or gouty cases, derived from the basic element. The dose is similar to that of the sodium salt.

Ammonium Salicylate, $NH_4C_7H_5O_3$. The salt is official in the United States Pharmacopœia under the title *Ammonii Salicylas*, Ammonium Salicylate. It occurs in "colorless, lustrous, monoclinic prisms, or plates, or a white, crystalline powder; odorless, and having at first a slightly saline, bitter taste, with a sweetish after-taste. Permanent in dry air. Soluble in 0.9 part of water, and in 2.3 parts of alcohol at 25° C. (77° F.); freely soluble in boiling water and in one part of boiling alcohol. It should contain not less than ninety-eight per cent. of pure ammonium salicylate, and should be kept in well-stoppered bottles, protected from heat and light" (U. S. P.). The effects of this salt are similar to those of sodium salicylate, but the ammonium salt is more quickly absorbed. The pharmacopœial dose is four grains (0.25 gram).

Strontium Salicylate, $Sr(C_7H_5O_3)_2 + 2H_2O$. The salt is official in the United States Pharmacopœia under the title *Strontii Salicylas*, Strontium Salicylate. It is "a white, crystalline powder; odorless, and having a sweetish, saline taste. Soluble in eighteen parts of water and sixty-six parts of alcohol at 25° C. (77° F.), in 3.5 parts of boiling water, and in 10.5 parts of boiling alcohol. It should contain not less than 98.5 per cent. of pure strontium salicylate, and should be kept in well-stoppered bottles, protected from heat and light" (U. S. P.). The effects of this salt are similar to those of sodium salicylate. The pharmacopœial dose is fifteen grains (1.0).

Methyl Salicylate, $CH_3C_7H_5O_3$. This salicylate is an ethereal body which constitutes nine-tenths of the substance of oil of wintergreen and practically the whole of the oil of betula, both of which oils are themselves official medicines. Under the title, however, *Methylis Salicylas*, Methyl Salicylate, the United States Pharmacopœia recognizes the salicylate as made in the laboratory by distilling salicylic acid or a salicylate with methylic alcohol and sulphuric acid. Methyl salicylate is a colorless or slightly yellowish liquid, with the characteristic odor and taste of oil of wintergreen. It dissolves freely in alcohol. It should be kept in well-stoppered bottles protected from light. Methyl salicylate acts like the salicylates generally, with the usual pungent qualities of the volatile oils. In larger doses—half an ounce or more—it is dangerously and even fatally

poisonous, causing intense irritation of the stomach and intestines with constitutional symptoms of the salicylic influence. In doses of from five to fifteen minims it makes a very efficient salicylic medicine for rheumatism, and is, with many, the favorite salicylate. It may be administered in emulsion or in capsules.

EDWARD CURTIS.
R. J. E. SCOTT.

Saliformin.—See *Hexamethylinamina*.

Saline Solutions.—A saline solution is a solution of any salt. As generally used the term means a *physiological* salt solution, *i.e.* a solution of sodium chloride of the same specific gravity as the blood; this is approximately a *decinormal* solution, but is often called (wrongly) *normal* salt solution. Strictly speaking, a normal solution of any salt is one which contains a quantity of the salt in grams equivalent to its molecular weight, to the liter. Thus normal sodium chloride solution would contain 58.5 grams of that salt to the liter, which is equivalent to 5.85 per cent.; whereas physiological salt solution contains about one-tenth of this amount, or about 0.6 to 0.7 per cent. As to the uses of saline solution, see *Hypodermoclysis*.

R. J. E. SCOTT.

Salins Moutiers.—See *Brides-les-Bains*.

Salipyrin.—A proprietary compound containing 57.7 parts of antipyrin and 42.3 parts of salicylic acid. It was introduced as a substitute for the salicylates in the treatment of rheumatic affections and influenza. The dose is from fifteen to thirty grains.

BEAUMONT SMALL.

Saliva.—COMPOSITION.—The salivary glands may be *albuminous*, as the parotid in man and mammals and the submaxillary in the rabbit, *mucous* glands, as many of the small glands in the buccal cavity and the sublingual and submaxillary gland of some animals and *mixed* glands, as the submaxillary glands of man. The albuminous glands contain cells rich in protein but lacking in mucin. On the other hand, cells of the mucous glands are rich in mucin and contain but little protein. As the name implies the mixed glands contain both mucin and protein in varying amounts. Saliva is a mixture of the secretions of the parotid, sublingual and submaxillary glands to which is added the secretion of the buccal glands.

The composition of saliva varies according to its origin, and may even vary under the conditions attendant upon its collection. Submaxillary saliva may be collected in man by the introduction of a cannula into Wharton's duct. The submaxillary secretion may be excited by an emotion, by mastication, and by irritation of the mouth, especially with acid substances. In man submaxillary secretion is clear, thin, inclined to be a little ropy, and froths easily. Toward litmus it exhibits an alkaline reaction. It has a specific gravity of 1.002–1.003 and contains 3.6–4.5 solids per M. It contains mucin, traces of protein, diastatic enzyme, ptyalin, alkali chlorides, sodium and magnesium phosphates, and bicarbonates of the alkalies and calcium are present together with small amounts of potassium sulphocyanide.

The sublingual saliva in man is clear, mucilaginous, has a more intense alkaline reaction than submaxillary saliva and in it are found mucin, ptyalin, and potassium sulphocyanide.

Human parotid saliva is thin, less alkaline than submaxillary saliva and contains a little protein but no mucin. Ptyalin is present, the specific gravity varies between 1.003–1.012 and the solid from 5 to 16 parts per M. Sulphocyanide is not a constant constituent.

Mixed saliva is a colorless fluid, opalescent, frothy, slightly ropy, without special odor or taste. A turbidity is caused by epithelium cells, mucous and salivary corpuscles, and food residues. On exposure to air it becomes cloudy owing to the formation of calcium carbonate. It is generally alkaline to litmus, although it may be acid sometimes after a meal. The specific gravity varies between 1.002 and 1.008 and the solids between 5 and 10 parts per M. In addition to the form elements mentioned above the solids consist of protein, mucin, oxidases, ptyalin and maltose, and inorganic substances. The latter are alkali chlorides, bicarbonates of the alkalies and calcium, phosphates and traces of sulphates, nitrites, ammonia and sulphocyanides, the latter of which average about 0.1 per M. In the saliva of nonsmokers small quantities, 0.03–0.04 per M., of sulphocyanides are present, whereas from ordinary smokers the amount may rise to 0.2 per M. The significance of the presence of sulphocyanides is little understood although at present it would appear that excretion by way of saliva is one of the paths by which sulphocyanides taken into the body in the food or formed within the organism are eliminated. The relation to smoking is not constant.

SECRETION.—The salivary glands receive nerve supply from both the sympathetic and cranial nerves. In the case of the submaxillary gland the sympathetic fibers are derived from branches of the cervical sympathetic which ramify on the facial artery, and the chorda tympani nerve furnishes the cranial fibers. For a short way the latter fibers run in company with the lingual nerve, and after leaving this run along the duct of Wharton to the gland. Nerve cells connect the hilus of the gland with the fibers. The so-called "submaxillary" ganglion, a small collection of nerve cells, lies in the triangle between the chorda tympani nerve, the lingual nerve, and the duct. Fibers of the chorda tympani which supply the sublingual gland are connected with these ganglion cells.

Upon stimulation of these two sets of nerves different effects may be observed. In the dog when the chorda tympani is stimulated there is an active dilatation of the vessels of the gland, together with the outpouring of a watery secretion poor in mucin and form elements. On the other hand, stimulation of the sympathetic causes constriction of the vessels of the gland accompanied with a scanty flow of very thick viscid saliva, containing a large amount of form elements and mucin. In accordance with the differences observed as a result of the stimulation of these two sets of nerves it has been supposed that they have two distinct functions—the chorda tympani being vasodilator and concerned in water secretion, the sympathetic vasoconstrictor and concerned in the secretion of organic substances. A second nomenclature has been supplied to denote the same idea, that is, the division of these nerves into trophic and secretory fibers. The chorda tympani is assumed to control the secretion of water and salts whereas the sympathetic fibers are assumed to exert a direct influence upon the metabolism of the cells whereby the organic constituents of the secretion are formed. It has been stated by other observers that the influence of the two types of fibers are identical so far as the gland itself is concerned but that the differences in the character of the saliva obtained is conditioned by the vascular changes taking place. On the other hand, it must be mentioned against such a view that although atropine paralyzes the secretory fibers of the chorda tympani, it has no effect on those fibers derived from the sympathetic.

In the parotid gland there is also a double nerve supply. Fibers from the cervical sympathetic and

cerebrospinal fibers which run in the auriculotemporal branch of the fifth nerve, although undoubtedly having their origin in the glossopharyngeal, run through the tympanic branch of this nerve (nerve of Jacobson). In the rabbit and dog stimulation of the cerebrospinal fibers causes a copious flow of limpid saliva possessing a low specific gravity. A scanty flow of saliva containing no mucin, but relatively rich in protein and enzyme is produced by stimulation of the sympathetic in the rabbit. With the dog no secretion is obtained after sympathetic stimulation.

Paralytic Secretion.—For a long time it has been known that section of the chorda tympani nerve on one side causes the submaxillary gland to enter into a state of continued secretion which may last for several weeks leading ultimately to a distinct atrophy of the gland. This secretion has been designated "paralytic secretion." When section of the sympathetic fibers is made in an analogous manner no secretory activity is manifested.

Normal Mechanism of Salivary Secretion.—Under usual conditions the secretion of saliva is produced by the reflex stimulation of the secretory nerves. The stimulus is furnished by the presence of food in the mouth, by acids, or by the movements of mastication. The sensory nerves concerned are the branches of the fifth and glossopharyngeal nerves which are distributed over the mucous membrane of the mouth and tongue. It is probable that a center exists in the medulla whose function it is to control or regulate salivary secretion. The exact location of such a center has not been established. This center may be rendered active by stimulation of the sensory fibers of the sciatic, splanchnic, and vagus nerves. Also various psychical stimuli such as those induced by thought of food and the sensation of nausea may be accompanied by a flow of saliva. Inhibition of the center may be illustrated by the well-known absence of saliva as a result of stimuli generated by sensations of fear, anxiety, or embarrassment.

Digestive Action.—Probably the most important function of the saliva is that of moistening the food and thus aiding in reducing it to a consistency suitable for swallowing. Mucin also perhaps acts as a lubricator along the esophagus, and by bringing into solution dry substances renders them capable of calling forth stimulation of the nerves of taste which play an important rôle in gastric secretion. In carnivora saliva has no digestive action. In herbivora and man it is capable of transforming boiled starch into a mixture of dextrins and maltase—the latter being changed to dextrose by a maltose present. From recent investigations it has been shown that the entrance of salivary digestive products into the stomach does not lead to an immediate arrest of the digestion as was previously stated. On the contrary, the evidence available indicates that salivary digestion in the stomach may proceed for one-half hour or longer. Like other enzymes temperature exerts an appreciable influence upon the rate of salivary digestion—the optimum temperature being that of the body. At 0° C. the activity of ptyalin is suspended and at 65° C. to 70° C. is entirely destroyed. Under usual conditions saliva shows an alkaline reaction to litmus, but ptyalin acts as well or even better in a neutral medium. Strong alkali, however, retards or inhibits its action. Traces of free acid, to the extent of only 0.003 per cent. is sufficient to prevent any action of ptyalin upon starch. Stronger acids not only inhibit its activity but also destroy the enzyme.

Frank P. Underhill.

Salivary Glands and Ducts, Diseases and Injuries of the.—Congenital Anomalies.—These comprise absence, hypertrophy, or abnormal location of one or more of the salivary glands; partial or complete stenosis of one or more of the ducts; the presence of a duct outlet at an abnormal site; congenital fistula of a duct or gland; and cysts of the glands or ducts. Complete absence of both parotids has been reported by Poirier; and of both submaxillary glands, by Gruber. Indemans reports a case of congenital hypertrophy of all the salivary glands associated with congenital lymphomata of the neck. A congenital and progressive hypertrophy of the sublingual glands has been recorded by Braquehaye and Sabrazès. Bilateral swelling of the parotids has been observed in the new-born. Turner reports a case in which the submaxillary glands were not in the digastric triangle but were on the dorsal surface of the mylohyoid adjacent to the sublingual gland. Gruber and Cruveilhier have separately recorded instances in which the parotid occupied a position corresponding to that of the accessory parotid, simulating on account of its size a tumor formation. Congenital atresia is most apt to occur in the case of Wharton's duct, involving as a rule the outlet of the duct. Bochdalek has observed an instance of abnormal orifice of Wharton's duct at a point eleven-twelfths of an inch behind the sublingual caruncle. An interesting case of congenital salivary fistula has been described by Gherini: in a young girl saliva flowed from two fine openings at the inner border of the sternomastoid a few centimeters above the sternum. Cysts of any of the salivary glands or of their ducts may occur as the result of partial or complete stenosis of the duct. Ranula is frequently of congenital origin. The Blandin-Nuhn glands lying on each side of the frenum of the tongue, and the glandulæ incisivæ opening on the gingival margin at the base of the lower central incisor teeth, which glands are analogous in their structure to the salivary glands, are sometimes the seat of congenital cysts.

Disturbances of Secretory Activity.—The amount of saliva secreted normally in twenty-four hours has been variously estimated as from 390 to 2000 grams. During health the reaction is alkaline. The disturbances of secretion may be classified under the three headings: hypersecretion, hyposecretion, and chemical and other changes.

Hypersecretion.—There is a normal increase in the secretion of saliva during the taking of food and the act of chewing, during hunger, and upon the mere contemplation of foods, particularly if these are of an acid or a succulent nature. A marked increase in secretion occurs as the result of any one of a large number of causes. It may occur in disease of the salivary glands, as in the case of mixed tumors involving these structures. Essential sialorrhea occurs in nervous individuals following trauma, strong emotional outbreaks, and infectious diseases. It may be compared to gastrosuccorrhea which is also of nervous origin. Salivation is a common manifestation in hysteria, neurasthenia, and epilepsy. In an instance of salivation occurring after an epileptic seizure, Féré measured 100 grams of saliva secreted in a few minutes. Salivation occurs in exophthalmic goiter, paralysis agitans, tabes, labioglosso-laryngeal paralysis, and facial paralysis, and as a reflex phenomenon in diseases of the larynx and those of the genito-urinary apparatus. Salivation has been noted as a precritical phenomenon in pneumonia. It occurs in rabies, occasionally in the acute exanthemata, especially smallpox, sometimes in pancreatic disease, during pregnancy, sometimes at the menstrual period, during dentition, and as the result of the action of certain drugs and other substances. Ptyalism may be caused by mercury, gold, copper, the iodine compounds, jaborandi, muscarine, and tobacco.

Ptyalism may be of such mild degree as to cause no

special inconvenience but in its pronounced types it may become exceedingly annoying. The constant swallowing of saliva may be so fatiguing that the patient permits the saliva to flow from the mouth, in which case an obstinate eczema of the face, neck, and chest may result. Sleep may be interfered with and a decided loss of weight may result from the constant drain upon the body. The salivation produced by mercury is, as a rule, associated with a severe stomatitis, but sometimes this is absent. In the treatment of ptyalism, apart from the removal or mitigation of the original cause, the bromides and atropine may be given, the latter if necessary up to physiological doses.

Hyposecretion.—The secretion of saliva is diminished during pyrexia; after excessive drain of the body fluids, as in the diarrhea of cholera; following the administration of certain drugs, as opium and belladonna; as the result of emotional disturbance, particularly fear; in the course of grave constitutional disorders, as septicemia and Bright's disease; and as the result of inflammation of the salivary glands, as in mumps. The arrest of salivary secretion in constitutional diseases is a sign of grave prognostic omen. In the hypertrophic senile parotitis described by Birch-Hirschfeld there is a pronounced arrest in the salivary secretion. Asialia or absolute suppression of the functional activity of the salivary glands may be the result of functional or organic nervous disease.

Xerostomia, dry mouth, first described by Jonathan Hutchinson, is the result of a suppression of the secretions of the mouth and salivary glands. The tongue is red and dry, and sometimes cracked; the mucous membrane of the rest of the mouth is dry and shining; and mastication and swallowing are interfered with. The general health is apparently not affected. Most of the cases are said to occur in women. There is apparently some nervous element at fault. The treatment recommended is the free use of glycerin locally and the cautious administration of jaborandi or pilocarpine.

Chemical and Other Changes in the Salivary Secretion.—The saliva which is normally alkaline may acquire an acid reaction in dyspepsia, oral sepsis, ulcer and cancer of the stomach, gout, articular rheumatism, chronic plumbism, diabetes, and typhoid fever. The odor of the saliva may be fetid in scorbutus, mercurial stomatitis, and severe toxemias and infections. In uremia, uric acid and urea may be excreted in the saliva. As regards the presence of sugar in the saliva in diabetes contradictory findings have been reported by different observers. The saliva which normally contains a number of formed elements consisting of desquamated epithelial cells, disintegrating leucocytes and gland cells, and coagulated clumps of mucin, may during inflammatory conditions of the salivary glands contain in addition polynuclear and large mononuclear leucocytes, and lymphocytes.

Injuries.—These include contused, incised, and lacerated wounds of the glands and ducts. The sublingual and submaxillary glands are less exposed to traumatism than is the parotid, and for this reason wounds of the former are relatively rare. Gunshot and saber wounds of the face frequently involve the parotid gland or its duct. A relatively common type of injury in Germany is that inflicted during students' duels. The parotid duct is more apt to be involved if the direction of the wound is at right angles to the direction of the duct. Recognition that the parotid gland is injured depends upon the topography of the trauma more than upon the actual appearance of the wound for the character of the tissues involved is obscured by the flow of blood. At a later stage the discharge of saliva from some part of the wound confirms the diagnosis of injury of the gland or duct. Injury of the gland substance, if uncomplicated, is followed by no untoward consequences, but injury of the duct or of one of its branches may result in the formation of a salivary fistula. The discharge of saliva from the wound does not necessarily indicate that a salivary fistula will remain, and even if such sinus be left after the healing of the wound, in the majority of instances complete closure is effected spontaneously in a short time. Injuries of the parotid may involve the facial nerve and the external carotid artery or their branches, and the external jugular vein or its tributaries. Any of these structures, particularly the facial nerve, may be wounded during the course of operations on the parotid gland. The treatment of incised and lacerated wounds of the salivary glands demands, apart from the arrest of hemorrhage and the usual antiseptic precautions, an effort to secure primary union by the accurate apposition of the edges of the wound. If these are unduly ragged, preliminary paring may be necessary. The parts should be firmly bandaged so as to restrict the movements of the jaw. For the same purpose and also for the purpose of diminishing the secretion of saliva, talking and chewing should be interdicted for from five to seven days. The diet must, of course, be liquid or semi-solid and free from acidulous or spicy substances. Wounds of the salivary glands heal readily and even if a duct is injured or severed the latter undergoes spontaneous repair if the edges of the wound in the duct are brought and kept in apposition. If the normal continuity of the duct is not restored a salivary fistula will probably result. Sometimes after union of the superficial tissues has taken place there develops a soft swelling of the deeper parts. This is the result of the escape of saliva from an unhealed duct and constitutes what is known as an aseptic salivary accumulation. This may subside spontaneously, may discharge periodically throughthe normal duct outlet and reaccumulate immediately afterward, or may require a plastic operation upon the wounded duct for its permanent eradication. Subcutaneous injury of the parotid duct may occur, in which instance there results a swelling similar to the one described above.

Salivary Fistula.—This may be defined as an abnormal communication between a salivary gland or duct and the surface of the skin or the mucous membrane of the mouth. It may be congenital but is usually the result of traumatism. Suppuration or malignant disease in a salivary gland only very seldom leads to the formation of a fistula, for in either of these instances there is likely to be an atrophy of the secreting structures of the gland. Salivary fistulæ may be divided into those of the gland proper and those of the duct, the latter being the more serious. In the majority of instances gland fistulæ heal spontaneously. Those of the parotid gland almost always open externally on the skin. Fistulæ of the submaxillary and sublingual glands as a rule open into the mouth, and inasmuch as they cause no inconvenience have no surgical interest. The fistulous opening is usually minute and in the midst of a small mass of granulation tissue. Its connection with a salivary gland is recognized by the clear fluid exuding from the opening, the flow being greatly increased during a meal. A duct fistula is to be distinguished from a gland fistula: first, by the location of the opening; second, by the fact that in the former the outflow of saliva is much greater; third, in the case of the duct fistula the discharge of saliva from the normal opening in the mouth is either absent or greatly diminished; and fourth, as the result of the use of a probe the direction of the fistulous tract can generally be made out. *Salivary gland fistulæ* that do not heal spontaneously may be treated in any one of the following ways: (1) The part should be kept at rest by a suitable bandage and the functional activity of the gland should be inhibited by the administration of atropine in doses of $\frac{1}{100}$ grain three times a day. (2) The fistulous tract may be cauterized with silver nitrate or with the galvano-

cautery. (3) Firm compression of the gland may favor spontaneous closure of the fistula. (4) The tract may be freshened with the knife and then sutured. (5) The opening may be covered with a cutaneous flap. (6) In intractable cases the portion of the gland involved may be extirpated. (7) By means of a plastic operation a new outlet may be formed for the saliva. In the treatment of duct fistulæ any one of the first three methods mentioned above may be effective, more so, if the portion of the duct opening into the mouth is kept patent by the regular use of a bougie. In the treatment of permanent *fistulæ of the duct* any one of the following methods may be used. (1) By means of a plastic operation the normal continuity of the severed duct may be restored (method of Nicoladoni). (2) The external fistula in converted into an internal one by the formation of a new duct opening into the mouth. For this purpose a number of methods have been devised: (*a*) The cheek is perforated at the site of the fistula and the opening into the mouth is kept patent by the use of a drainage tube (method of *ponction unique*). (*b*) The fistula is excised by an eliptical incision reaching halfway through the thickness of the cheek, and through the depths of this wound two openings are made with a needle, 0.5 centimeter apart, penetrating the mucous membrane of the mouth. A silk thread is passed through both openings and tied tightly within the mouth. This is the so-called *procédé de la double ponction* which was first employed by Deguise. The new canal is formed by a necrosis of the tissue surrounded by the ligature. (*c*) The central end of the duct may be transplanted into the mucous membrane of the mouth (method of v. Langenbeck). (*d*) By means of a plastic operation a new duct may be formed from the oral mucous membrane. (*e*) In cases in which any of the above methods has failed extirpation of the entire gland or of the portion of the gland communicating with the fistula may be necessary.

Foreign Bodies.—A large variety of foreign bodies may gain access to any of the salivary ducts, but chiefly to the duct of the submaxillary gland. The most common instances of foreign body include shreds of cellulose, bits of straw, pieces of toothpick, cereal grains, fishbones, toothbrush bristles, etc. The most immediate and the principal symptom of the entrance of a foreign body into one of the ducts is a sharp pain. If the foreign body is not removed there results an inflammation of the duct in its neighborhood. This may be the result of the mechanical irritation but is usually the sequence of bacterial infection. The inflammation tends to spread, involving the entire duct and ultimately the gland itself. Obstruction of the duct with or without infection leads to salivary stasis with the resulting tumefaction of the secreting gland. In rare instances foreign bodies may remain in the ducts for a long time without giving rise to any symptoms. They may be expelled spontaneously. They may be the starting-point of calculous formation, in which case they provide the nucleus for the calculus. They may give rise to an abscess formation in the duct or gland and may be discharged with the pus after the abscess has been opened spontaneously or by operation. The diagnosis of the presence of a foreign body in a salivary duct or gland may be made upon the history of the occurrence of a sudden sharp pain near the outlet of the duct; the detection of the foreign object by the introduction of a fine probe into the duct; by actually seeing the offending agent projecting from the mouth of the duct or feeling it through the mucous membrane; and in the case of metallic objects, by means of the *x*-rays. The treatment is removal of the foreign body by means of a fine forceps or probe, by pressure with the finger over the duct, or, if these methods fail, by making an incision over the foreign body and then extracting it.

Sialolithiasis.—Salivary calculi are not extremely rare, some four hundred or more cases having been reported in the literature. The stones which consist chiefly of calcium phosphate and calcium carbonate are formed commonly in the ducts and sometimes in the gland substance. The most frequent site of the formation of stones is Wharton's duct; next in order comes Steno's duct; and last the ducts of the sublingual gland. According to statistics quoted by Küttner 61.4 per cent. of all salivary stones belong to Wharton's duct and the submaxillary gland, 20.4 per cent. to the parotid and duct, and 18.2 per cent. to the sublingual and its excretory ducts. Men are much more frequently affected than women and the age of greatest incidence is middle life. The stones vary in size from a grain of sand to a walnut, the largest being those formed in the gland substance. The usual size is that of a pea. They may be smooth and elongated, like a date-pit, which is commonly the shape of stones formed in Wharton's duct; or rough and irregular, as in the case of stones formed in the gland. Longitudinal or spiral furrows may be present on the surface of the stone. The calculous formation may consist of a thin incrustation of the walls of the ducts and their fine ramifications. Definite stones may be single or multiple, usually the former. As a rule, one duct or one gland may be the seat of stone formation. Following the spontaneous expulsion of a calculus or its removal by operative means there is a recurrence of stone formation in a small percentage of cases. The physical characteristics of a salivary calculus comprise a deposit of calcium carbonate and calcium phosphate about a matrix of organic matter including bacteria. This also constitutes the nucleus of the calculus. In consistency the stone may be hard or soft. In color it is grayish white or yellowish.

The *cause* of sialolithiasis is a bacterial infection of a duct or gland together with the inflammatory changes in either of the latter which are associated with or follow this infection. A trauma of the duct or gland or the presence of a foreign body may be the starting-point of a calculus. The presence of the latter gives rise to inflammatory changes in the immediate neighborhood. If the stone is situated in the duct there is a thickening of the wall about the calculus with or without a local abscess formation, and if the duct is partly or wholly obstructed there is a dilatation of the proximal portion of the duct. The inflammation may spread to the surrounding tissues. Sometimes a localized abscess in Wharton's duct perforates into the tissues at the floor of the mouth, giving rise to an extensive abscess in this region. A fistula opening on the cheek or in the mouth may result from the perforation of an abscess arising from the presence of a stone, and sometimes this may be spontaneously evacuated through the fistula. The inflammatory changes in the duct may spread to the gland which then becomes enlarged and indurated and sometimes undergoes suppuration.

The *symptoms* of sialolithiasis present a varied clinical picture. In rare instances a stone may be extruded spontaneously from the outlet of a duct without having given rise to any previous symptoms. Sometimes the localized or diffuse inflammation of a duct or gland with or without abscess formation may be the first manifestation of the presence of a calculus. This may sometimes be found partly extruding from the mouth of the duct, or it may be felt through the mucous membrane overlying the duct or even through the tissues of the cheek. In some instances a localized swelling or thickening of the duct may be felt and on pressing this swelling a drop or two of pus may exude from the outlet of the duct. The most common clinical picture of sialolithiasis is the occurrence of periodical attacks of pain in the region of the affected duct or gland, accompanied by a sudden swelling of the gland. These attacks have been referred to by French writers as "les coli-

ques salivaires." They come on usually while the patient is eating. The pain is quite severe; in the case of the submaxillary gland or duct it is referred to the floor of the mouth on the affected side, in that of the sublingual gland or duct to the tongue, and in the case of the parotid to the region of the gland or duct or to the angle of the jaw. The distention of the gland is the result of salivary stasis from obstruction of the duct. The onset at mealtime is to be attributed to the increased production and flow of saliva under the stimulus of eating. Sometimes the mere thought of food precipitates an attack. This subsides gradually within a few hours to a few days. The attacks tend to return at intervals of several days to several months, the later intervals becoming shorter and shorter. If the duct is wholly and permanently occluded, the salivary stasis may result in an extreme enlargement of the corresponding gland. If there is an associated infection suppuration ensues. If there is no infection the back pressure on the glandular alveoli causes an atrophy of their cells which results in a shrinkage of the gland, the glandular portion being replaced by connective tissue. Another occasional symptom of salivary calculus is the discharge of pus (pyorrhea salivalis) from the gaping and reddened orifice of the duct.

The *diagnosis* of sialolithiasis may be based upon the history of attacks of salivary colic; upon the associated symptoms of infection; and upon actually seeing the stone or feeling it with the finger or with the sound. Bimanual palpation may be performed with a finger of one hand on the floor of the mouth and a finger of the other hand on the outside of the cheek. If the stone cannot be felt either with the finger or with a fine probe passed into the duct, which latter procedure may be prevented by a marked swelling of the mucous membrane of the duct, then a fine needle may be passed directly through the tissues. The *x*-rays may render a distinct service. In the differential diagnosis one must exclude foreign body; sialodochitis; sialoadenitis; recurrent swelling of the parotids; alveolar periostitis; angina Ludovici; chronic inflammatory tumor of a salivary gland; malignant, tuberculous or syphilitic disease of the latter; and bone tumors.

Treatment.—If possible the stones should be removed by way of the buccal cavity. According to Küttner, "the exceptions to this rule are (1) if an external fistula leads to the concretion, (2) if this lies in an external abscess, and (3) when the parotid or submaxillary gland itself is the seat of the trouble." If the stone lies near the orifice of a duct it may sometimes be pressed out by the fingers or removed with a forceps or probe. If, as is usually the case, the stone lies more deeply in the duct the overlying tissues must be incised and the stone extracted. A stone lying deep in a sublingual duct or in the gland itself may be removed, although with difficulty, by an incision through the mucous membrane. If a duct is wounded a salivary fistula may remain but does no harm. If there are a number of stones in the sublingual gland complete extirpation of this structure may be the simplest procedure. Stones in the submaxillary or parotid gland can be approached only from the outside. This is frequently attended with considerable difficulty particularly if the stones are firmly embedded in connective tissue. According to Küttner, "in the case of the submaxillary gland recurrences may best be avoided in such cases by removing the entire, often very adherent organ. Total extirpation of the parotid is, of course, not indicated; in its place the surgeon must carefully extract all stones and resect these portions of the gland which have undergone particularly severe changes. The facial nerve must be carefully protected."

Acute Inflammation.—This has been subdivided arbitrarily into the so-called specific type of acute sialoadenitis, of which mumps or epidemic parotitis (see article *Mumps*) is the best known example, and the so-called secondary or symptomatic type of acute sialoadenitis. Acute inflammation of the salivary glands or of their ducts may occur as the result of any one or more of a large number of causative factors, traumatic, toxic, or bacterial, the most important of which is the last. The chief cause is an ascending infection traveling from the mouth upward through a salivary duct into the corresponding gland. The parotid is the gland which is involved in the great majority of the cases. Any one or more of a large variety of bacteria may be the exciting cause of the inflammation. The cases of acute sialoadenitis may be classified as follows: (1) Epidemic sialoadenitis or mumps which usually involves the parotid but may involve any of the other salivary glands alone or in addition. (2) Sialoadenitis sublingualis epidemica (Hegler). (3) Sialoadenitis resulting from injury of the duct or gland; from infection and ulceration of the buccal mucosa; from the presence of foreign bodies in the duct or gland; from sialolithiasis; and from the direct extension of inflammatory processes in neighboring structures, as from a tooth abscess, middle-ear disease, etc. (4) Sialoadenitis occurring as a complication in any of the acute infectious diseases and in general pyogenic infections. (5) Sialoadenitis sequent upon wounds of and operations upon the abdomen or any of its organs; or secondary to diseases of the abdominal organs, such as peritonitis, perityphlitis, gastric ulcer, or to diseases of the genito-urinary apparatus. (6) Sialoadenitis occurring in marantic states, in old age, and in infancy. (7) Sialoadenitis secondary to facial paralysis, diabetes, and chronic metallic poisoning.

The most important point to be recognized in the pathogenesis of all of the above types of acute inflammation of the salivary glands is the fact that these are invaded by bacteria from the mouth when their resistance is diminished as the result either of local injury, of constitutional disease or dyscrasia, of general infection, or of reflex influences from the abdominal or pelvic organs.

Sialoadenitis sublingualis epidemica is the name given by Hegler to an acute inflammation of the sublingual glands that he observed in epidemic form. The disease occurred among the female nurses in a hospital, of whom eight were affected. Hegler believes that this condition is closely allied to, but caused by a microorganism distinct from that giving rise to mumps.

The most common of the secondary types of acute sialoadenitis is the parotid inflammation ("parotid bubo") occurring in the course of the acute infectious diseases, chiefly typhoid fever, pneumonia, scarlet fever, and typhus. The inflammation is not, as was once thought, a metastatic one; the infection is an ascending one from the mouth, the most common causative microorganism being the staphylococcus. The degree of inflammation may vary from a mild type to one of unusual severity or virulence. The gland swells rapidly, becomes extremely tense and tender, and may finally be the seat of suppuration. In the majority of cases resolution occurs without suppuration. In a series of 323 cases analyzed by Heineke suppuration occurred in only 137 or 42.42 per cent. With the onset of inflammation in the parotid the symptoms of the primary disease increase in intensity. Suppuration, when it occurs, begins in the vicinity of the glandular end of the main duct and extends peripherally by way of the branches of the main duct toward the glandular acini. At first the areas of suppuration are discrete but these eventually unite to form one abscess cavity. If not evacuated by operation this finally burrows toward the surface of the gland and perforates neighboring structures. The most common site of perforation is the external auditory canal at the junction of its bony and car-

tilaginous portions. The abscess may discharge on the surface of the cheek or through Steno's duct into the mouth; it may burrow inward and form an abscess beneath the lateral wall of the pharynx (parapharyngeal abscess); or the pus may follow the great vessels of the neck into the mediastinum and give rise to a mediastinal abscess. In the treatment of acute inflammation of the parotid one should not hasten to employ surgical measures, for, as mentioned above, resolution occurs in more than half of the cases. Of course, when fluctuation is present incision and drainage are indicated. In some cases suppuration may be present without any evidence of fluctuation, in which instance the constitutional symptoms provide the best guide for the surgeon. There is a rare type of acute gangrenous inflammation of the parotid in which early surgical intervention is necessary.

Chronic Inflammation.—This when compared with the acute form is relatively rare.

Chronic Sialoadenitis.—This may be a sequence of an acute inflammation, as in those cases of chronic enlargement of a salivary gland, chiefly the parotid, following mumps. A frequent cause of persistent inflammation is the presence of a calculus or foreign body. Chronic parotitis is also observed in chronic nephritis and in secondary syphilis. Chronic sialoadenitis is characterized by the presence of a diffuse swelling which increases slowly in size and which is subject to acute inflammatory exacerbations. Slow spontaneous recovery is the rule. The treatment is the use of dry warmth, the application of tincture of iodine, and the internal administration of the iodides.

Chronic Inflammatory Tumor.—This condition was first described by Küttner. In all of his cases the submaxillary gland alone was involved. This gland contained a round or elongated firm tumor varying in size from that of a hen's egg to that of an apple. The skin was slightly adherent to the mass which was only slightly movable over the deeper parts on account of extensive adhesions. "The tumors are the result of a chronic interstitial inflammation of a salivary gland; they sometimes contain in their interior small foci of granulation tissue or occasional minute abscesses." In all of Küttner's cases the tumors showed a tendency to enlarge steadily and to implicate the surrounding tissues. The diagnosis of this condition is difficult inasmuch as the tumor cannot be distinguished clinically from a malignant growth. The treatment is total extirpation of the tumor.

Chronic Sialodochitis.—Chronic inflammation of a salivary duct may result from the presence of a calculus or foreign body in the duct; or from a persistent trauma, as carious or jagged teeth at the level of the orifice of Steno's duct. The latter cause probably accounts for the fact that the parotid duct is more frequently involved than the duct of the submaxillary gland. The orifice of the duct is swollen, reddened, and gaping and on pressure being exerted over the duct a drop or two of pus may exude from its outlet. The disease is chronic. Whenever the duct is blocked a swelling of the gland results from salivary stasis. Sometimes the duct can be felt as a thickened cord. The symptoms resemble those of calculus or foreign body but the paroxysms do not occur as frequently as with either of the latter. Eventually the diseased duct becomes dilated forming an elongated tumor. Air may collect in it giving rise to a distinct crepitation that may be felt and to the occasional discharge of a frothy fluid from the duct outlet. Brasher has described a case in which a swab taken from the interior of the parotid duct yielded a pure culture of *Micrococcus catarrhalis*. A vaccine prepared from this organism was administered; the patient remained free from the attacks for one year after which they returned. Neuhof has reported two cases of sialodochitis occurring in children. The parotid gland was enlarged, nodular, and adherent and the mouth of Steno's duct was embedded in stenosing cicatricial tissue.

The treatment of chronic sialodochitis is said to be far from satisfactory. An effort should be made to remove any known causative factor, such as a carious or jagged tooth that may injure the mouth of Steno's duct. If this is obstructed relief may be afforded by the introduction of a fine probe. The injection of mild antiseptic solutions into the duct may be of value and possibly also a moderate degree of massage over the duct particularly if this is distended with air. If any special microorganism is isolated from the duct an autogenous vaccine may be administered. If the mouth of the duct is occluded it should be slit open. This is especially indicated if there are frequent attacks of salivary retention.

Sialodochitis Fibrinosa.—This condition was first described by Kussmaul in 1879. It is characterized by a periodical swelling of the salivary glands, chiefly the parotid, the result of a chronic inflammation of the duct. The swelling comes on suddenly while the patient is eating and is accompanied by pain of various degrees of severity, and sometimes by a rise of temperature and other constitutional symptoms. The attack lasts for several days, the swelling subsiding gradually. At the termination of an attack there is expelled from the duct of the affected gland a fibrinous plug which corresponds in shape to the lumen of the duct. In one of the cases reported in Kussmaul's original description the patient experienced for one or two days preceding the termination of an attack a pronounced salty taste in the mouth and with the expulsion of the fibrinous cast there was a flow of markedly salty saliva. The attacks recur at intervals of several days, weeks, or months. In Remouchamp's case the patient, a man eighty-six years old, had suffered from the disease for eighty years. The condition is usually though not necessarily bilateral. The causation is veiled in obscurity. Possibly there is some constitutional factor at fault. Kussmaul attributes the attacks to a neurosis, somewhat comparable to that giving rise to fibrinous bronchitis. Heineke perceives further a resemblance to membranous enteritis. In Remouchamp's case the saliva contained pus cells, large nucleated leucocytes, streptococci, and short Gram-positive rods, and the blood showed a moderate leucocytosis. This case would seem to indicate an infective element in the causation of fibrinous sialodochitis. The treatment would then be the same as that of the other type of chronic sialodochitis.

Recurrent Swelling of the Parotids.—Within recent years a number of cases of this condition have been reported. Some of these may be grouped with the cases of chronic sialodochitis and fibrinous sialodochitis described above; others may be the result of a mild sialolithiasis; still others may be of gouty origin. At any rate there are some cases of recurrent parotid swelling in which no causative factor has as yet been discovered.

Sympathetic Parotitis.—This is the name given by Moszkowicz to a condition in which the injury and resultant inflammation of one parotid gland is followed by the swelling of the other uninjured parotid. He reports the case of a soldier who received a shrapnel wound in the right parotid and in whom four days later the left parotid began to swell. The condition is quite analogous to that described by Heineke in the case of calculus of the submaxillary duct; sometimes the gland on the opposite side which with its duct is free from a calculus, undergoes a tumefaction similar to that of the gland on the affected side. In this condition there is operative some nervous reflex comparable to that underlying sympathetic ophthalmia.

Mikulicz's Disease.—This was described in 1888 by Mikulicz as a symmetrical affection of the lacrymal

and salivary glands, all of the organs of the head belonging to the type of the salivary glands undergoing a slow, uniform swelling. Various observers have reported in addition to the enlargement of the salivary and lacrymal glands an enlargement, respectively, of the palatine glands, the Blandin-Nuhn glands, and of the buccal and labial glands. The disease occurs in young adults who are otherwise healthy. The swellings increase slowly until after several years the glands may be twice their original size. Although the disease is, as a rule, symmetrical it may not be equally severe on both sides. The pathological process never spreads beyond the gland capsule; the tumor is firm, sometimes soft but not fluctuating and freely movable with reference to the surrounding tissues. The surface is smooth or lobulated. There are no inflammatory symptoms: pain and tenderness are absent. The only ill effects are the disfigurement, occasionally an interference with speaking and chewing, and sometimes a dryness of the mouth and conjunctivæ. In some cases the teeth fall out. The glands may attain a considerable size and then remain stationary. Following an intercurrent febrile disease they may recede. They may also sometimes respond to treatment. In some cases reported by Hirsch there was a moderate general enlargement of the lymph nodes, and in Osler's case there was an enlargement of the spleen.

The cause of this peculiar disease is unknown. Its most prominent histological feature is a marked infiltration of the affected glands with round cells. Mikulicz, Tritze, and Kümmel have perceived in this infiltration "a new formation of lymphadenoid tissue which is spread around the acini as centers and which leads to destruction of the specific gland tissue" (Küttner). Tritze has regarded the process as an "adenoid proliferation of the lacrymal and salivary glands," while Hirsch has interpreted it as a "cirrhosis of the lacrymal and salivary glands." Most of the authors who have described cases of this disease attribute it to some unknown infection ascending to the glands through the excretory ducts. Thursfield, in a recent clinical review, perceives a relationship between this disease and the true leucemias to which its histology is closely similar. In the treatment good results have been reported from the use of arsenic and the iodides, and from the local application of the x-rays. If these measures fail and if there are marked disfigurement and functional disturbances, the excision of the enlarged glands, with the exception of the parotid, must be considered as a last resort.

Gaseous Tumors of Steno's Duct and of the Parotid Gland (Glassblowers' Disease).—Among glassblowers and musicians there sometimes develop cystic swellings of Steno's duct and more rarely of the parotid gland from the entrance of air into and its subsequent confinement in these structures. These swellings may be the size of a walnut or an egg. There is usually a coincident infection of the duct or gland, so that the tumors may contain a mixture of air, saliva, and pus.

Actinomycosis of the salivary glands may arise in these structures primarily, the infection ascending by way of the excretory duct; or it may spread secondarily from the soft parts or bones in the neighborhood.

Tuberculosis.—This may occur as an extensive involvement of a gland, the area affected being grayish white and brittle. There may be large caseous foci or abscesses surrounded by edematous, brittle, or indurated gland tissue. Rarely there may be a circumscribed tuberculosis resembling a tumor, cold abscess, or salivary cyst. The disease is a local one occurring generally in non-tuberculous individuals and developing insidiously. The symptoms are an enlargement of the affected gland with, as a rule, no subjective symptoms. Attacks of neuralgia radiating from the growth and facial paralysis may occur. The prognosis is said to be favorable. The treatment is excision of the diseased areas. If the submaxillary gland is affected this should be extirpated.

Syphilis.—The salivary glands are rarely involved in syphilis. In most of the cases reported the disease affected the parotid gland. Gumma is the usual type, but the interstitial fibrous form of syphilis may occur. The parotid may be affected in cases of early syphilis, in which it occurs as a firm, nodular tumor, with the skin covering the gland edematous and reddened, and the preauricular lymph nodes enlarged and sharply marked off. The more common type of syphilitic involvement of the salivary glands develops slowly and without symptoms until a distinct tumor is formed after two or three months. Softening, ulceration, and the formation of a salivary fistula may occur. There may result salivation and difficulty in chewing and swallowing. There may be tenderness on pressure over the tumor. In the diagnosis it is possible to mistake a gumma for a malignant tumor. In the former other manifestations of syphilis are almost always present. A positive Wassermann reaction may afford an important clue. The parotitis of early syphilis may resemble a simple acute parotitis but in this the inflammatory symptoms are more marked. The differential diagnosis between gumma and tumor may be difficult; as is also the case in the diagnosis between syphilis, chronic inflammations, and tuberculosis.

Cysts.—These may involve the ducts or glands and may be temporary or permanent. They may be simple retention cysts ("tumor salivalis" of von Bruns) which undergo a periodic filling and emptying, or may be true cystic formations. The former may result from an inflammation or a cicatricial stenosis of the duct, from the presence of a foreign body or a stone in the latter, or from its compression by a tumor. Cysts of the ducts are most apt to occur in the ducts of the submaxillary and parotid glands, forming thin-walled, painless soft swellings that reach a certain size and then remain stationary or rupture spontaneously. To this group belong the congenital cysts of Wharton's duct and of Blandin-Nuhn's gland. The methods of treatment include the formation of an internal salivary fistula; incising the cyst from the mouth; excising a piece of the cyst wall and then sewing together the margins of the incision in the mucous membrane and in the cyst wall; and, if the duct is not, or only slightly, occluded, dilating the duct by means of bougies gradually increasing in size.

Cysts of the salivary glands are rare, those of the sublingual glands (ranula) occurring more frequently than those of the parotid and submaxillary glands. They are the result of a chronic interstitial inflammation of the connective tissue which leads to a compression of the smaller ducts and their consequent cystic dilatation. Small cysts thus formed may unite to make larger ones. Encapsulation results from the reactive proliferation of the surrounding connective tissue. These cysts are usually small, single, and unilocular and contain a clear stringy fluid. Clinical symptoms arise only after a cyst has grown to a considerable size. A sudden enlargement may take place. The diagnosis may be easy if the cyst is superficial and if fluctuation can be detected; but in the case of small deep-seated cysts of the parotid exploratory puncture may be necessary. It is important to exclude cystically degenerated benign and malignant tumors, real tumors that sometimes give evidence of fluctuation, and the cystic type of salivary tuberculosis. In the treatment of cysts of the salivary glands the best results have been obtained with puncture followed by the injection of tincture of iodine; of liquefied zinc chloride, drop by drop; or of carbolic acid either concentrated or dilute. Extirpation is

better than incision, particularly in the case of the submaxillary gland.

Tumors.—These include connective tissue, mixed, and epithelial tumors. The first comprise angioma, lymphangioma, lipoma, pure fibroma, pure myxoma, and sarcoma. The mixed tumors constitute a group by themselves. The epithelial tumors include adenoma and carcinoma.

Connective-tissue Tumors.—Angioma is rare and should not be mistaken for an ordinary subcutaneous angioma which it resembles clinically. The treatment is extirpation, the injection of alcohol, or electrolysis. Lymphangioma of the parotid has been observed; it appears as a prominent, fluctuating, compressible, and transparent tumor. The treatment is extirpation, if this is possible. Lipoma may develop in the interlobar connective tissue of a salivary gland, constituting a true lipoma of the latter, or it may develop in the capsular space. Fibroma is rare. Myxoma probably does not occur in its pure type; the myxomatous element may, however, predominate in a mixed tumor. Sarcomata are rare, but occur as fibrosarcomata, spindle-cell sarcomata, round-cell sarcomata, and melanosarcomata. Fibrosarcoma is relatively benign, forming a rounded tumor that may attain the size of a fist. The surface may be smooth or lobulated. Being encapsulated, fibrosarcomata may be extirpated with ease. This is also the case with spindle-cell sarcomata which are, however, often of an extreme malignancy and demand extirpation of the entire gland.

Mixed Tumors.—These are the most important of all the salivary tumors, being found more frequently in the parotid than in the submaxillary gland, and probably not at all in the sublingual. They are, as a rule, well encapsulated and contain cellular, sarcomatous, and carcinomatous portions, mucous tissue, and inclusions of cartilage. The last may occasionally predominate. Cystic formation frequently occurs; calcification and ossification may also, though more rarely, be present.

The tumor may develop within the interior of the gland, or on its surface; it may grow outward in any direction from any of the gland borders with which it may be continuous or connected by a thin pedicle. There are two opposite theories as to the origin of mixed tumors: according to one of these theories the tumors are endotheliomata of connective-tissue origin; according to the other theory these tumors contain epithelial as well as connective-tissue elements. Mixed tumors may occur congenitally and in old age but usually arise between the twentieth and fortieth year of life, more frequently in males than in females. The tumors grow slowly and may attain a considerable size; those of the parotid may grow to be as large as a man's head. They may be rounded, oval, or elongated; smooth or lobulated; if cartilage is present, distinctly nodular; and varying in consistency from one of firmness to one of semi-fluctuation. A characteristic of these tumors is their free mobility under the skin and upon the deeper parts. They are rarely tender on pressure and, as a rule, cause little disturbance unless they have attained a great size or have undergone a malignant change. The last occurs in eleven per cent. of the cases of mixed tumors of the submaxillary gland. The most important sign of sudden malignancy is a pronounced acceleration in the growth of the tumor. The treatment is radical extirpation of the growth; if this involves the submaxillary gland this should be removed as well.

Epithelial Tumors.—These include adenoma and carcinoma. The adenomata differ clinically but little from the mixed tumors. Carcinomata are rare, involving most frequently the parotid and less often the submaxillary gland. They are subdivided clinically into two groups: scirrhus and medullary carcinoma. The former develops late in life and is characterized by the cicatrical contraction or induration of the tissues surrounding the tumor. The condition is analogous to that of scirrhus carcinoma of the breast. In medullary carcinoma the skin is not retracted; early suppuration and even hemorrhage may occur. Facial paralysis is a frequent result of scirrhus carcinoma of the parotid. The pain is usually severe; and depending upon the size and mode of extension of the growth there are disturbances of hearing, speaking, chewing, swallowing, and breathing. In the diagnosis, which is not easy, one must differentiate these tumors mainly from inflammatory processes, lymphosarcomata, and branchial carcinomata. The prognosis is bad and even after operation a permanent cure is hardly to be expected. The treatment is total extirpation of the diseased gland together with diseased lymph nodes and other secondary foci.

Alexander Spingarn.

Bibliography.

For a complete bibliography of this subject up to 1913 the reader is referred to the exhaustive monograph by Herman Heineke on "Wounds and Surgical Diseases of the Salivary Glands" in Deutsche Chirurgie, Lieferung 33, 2-Hälfte, 2-Teil; Stuttgart, 1913. In this work the bibliographical references fill sixty-three closely printed pages and include more than 3000 books and articles.

Salix.—*Willow. Saule blanc,* Fr. Cod.—When it was official, this drug was defined by the United States Pharmacopœia as "the bark of *Salix alba* L. and of other species of *Salix* (fam. *Salicaceæ*)." Salicinum now entirely replaces it in the Pharmacopœia. The species named is the common *European white willow,* now quite extensively naturalized in North America. It is a large tree with, when old, a very thick, irregular trunk, dividing near the ground into several great limbs. Only the bark of the younger branches should be collected.

Willow bark is in fragments or quills, from one-twenty-fifth to one-twelfth of an inch (one to two millimeters) thick, smooth; outer surface somewhat glossy, brownish or yellowish, more or less finely warty; under the corky layer green; inner surface brownish white, smooth, the fibers separating in thin layers; inodorous; bitter, and astringent.

Constituents.—Besides ordinary plant constituents, willow contains the following three glucosides: *tannin,* about ten per cent.; *salicin* (which see), about two per cent.; *helicin* ($C_{13}H_{16}O_7+\frac{3}{4}H_2O$). The properties and uses of the drug depend almost wholly upon the salicin contained, and our article on the latter substance should be consulted. As an antiperiodic, the bark is employed in doses of an ounce or more, in the form of fluid extract, or, as is more common in domestic practice, a decoction or infusion. It is often used as a tonic in doses of about one-fifth or less of this amount, the powdered bark being often used for this purpose; also as an intestinal astringent. Salix has sometimes produced good results as an anthelmintic. The powdered bark was formerly considerably employed as a vulnerary, salicylic acid having now entirely replaced it for this purpose in medical practice.

Allied Drugs.—The genus Salix contains about one hundred and sixty species, many of which have been employed like *S. alba.* The plants fall naturally into two classes, the one characterized by the yellow, the other by the purple color of their young shoots. The latter are said to contain more salicin, sometimes above three per cent., the former more tannin.

Populus L. is the botanical name of the Poplars, Popples, Cottonwoods or Aspens, a number of which, both European and American, are used, in the form of their barks and leaves, as willow bark is used. These drugs contain the same constituent as the willows, besides the closely allied glucoside *populin* or *benzoyl-salicin.*

The buds of *P. balsaminifera* L. and *P. candicans* Ait. are known as balm of Gilead buds. Their scales are thickly coated with a very pleasant balsamic scented oleoresin, which possesses mild aromatic, diuretic, expectorant, and vulnerary properties.

HENRY H. RUSBY.

Salol.—See *Phenol Salicylate.*

Salol-camphor.—CAMPHOL.—These two substances, when mixed in certain proportions, alter their physical state and become an oily, colorless liquid, insoluble in water, freely soluble in ether, chloroform, and oils. It is prepared by adding twenty parts, by weight, of powdered camphor to thirty parts of salol, and warming gently until fusion is complete. BEAUMONT SMALL.

Salophen.—(*Acetyl-para-amido-salol*). A patented compound which is, chemically, salol in which one atom of hydrogen in the phenyl group is replaced by the monivalent group $N_2H(CH_3O)$. Salicylic acid is present to the extent of fifty-one per cent. The acid secretion of the stomach has no effect upon it, but when it comes in contact with the pancreatic ferments it is decomposed into salicylic acid and acetyl-para-amido-phenol.

It is the formation of this latter compound instead of the phenol which is the principal advantage of salophen over salol. It was introduced as a substitute for salol and salicylate compounds.

BEAUMONT SMALL.

Saloquinine, the salicylic acid ester of quinine, $C_6H_4.OH.CO.O.C_{20}H_{23}N_2O$, is a mild substitute for quinine with added analgesic properties. Its advantages, as stated by Overlach, are that it has no disturbing effect upon the digestive or urinary organs or the nervous system, does not produce cinchonism, and is tasteless. He employed it in sciatica in gr. xxx. (2.0) doses with good effect. Tauszk has used it in supraorbital neuralgia, influenza, the pains of locomotor ataxia, muscular rheumatism, acute articular rheumatism, and typhoid fever. He recommends it as an efficient antineuralgic with mild antipyretic action. In doses of gr. viij.–xlv. (0.5–3.0) daily, no vertigo or tinnitus was complained of, though in some cases mild sweating was observed.

Fitch, Sternberg, and von Kolozsvary speak highly of its use in malaria, large doses gr. v.–xx. (0.3–1.3), being administered several times a day. Being free from taste it is easily taken by children.

The salicylate of saloquinine is "rheumatin."

W. A. BASTEDO.
R. J. E. SCOTT.

Salpingitis.—See *under Oviducts.*

Salsomaggiore.—This resort is pleasantly situated in northern Italy, Lat. 44° 48′ N., Long. 27° 38′ E., two hours' ride by rail south from Milan. It lies in the valley of the Po, surrounded by low hills covered with the vine, maize, and mulberry trees. To the south rises the Apennine range.

The village itself is picturesquely situated at an elevation of about 500 feet, and contains 1,200 inhabitants. It is said to be unusually healthy, and is well supplied with good drinking-water.

The climate is temperate, the heat being never unduly excessive, and the sun is hidden by the hills before five o'clock in the summer.

The country round about is very attractive and affords many interesting excursions either by road or by rail. From here Bologna, Parma, Modena, and other spots of interest are readily reached by rail.

The accommodation is excellent, there having been opened in 1900 "The Grand Hotel des Thermes," with 300 rooms and fitted with all modern equipments in the way of sanitation and comfort. There are music, billiard, and reading-rooms, elevators and electric lighting, and the baths can be taken in the hotel itself, each floor being provided with special bathrooms for that purpose. The charges are not excessive. The season extends from April 1 to November, although July and August are the least desirable months in which to visit the spa.

Salsomaggiore is one of the two best-known spas in Italy, the other being Bagni di Lucca. The waters are what are known as muriated iodobromine, locally called "salso-iodic," and are furnished by numerous artesian wells. Their natural temperature is 57.2° F. For the "cure" either the "salso-iodic" or the mother water, made by extracting the salt by evaporation, is employed. The analysis of the water is as follows:

IN 1 KGM. OF WATER FROM SALSOMAGGIORE THERE IS:

	Grams.		Grams.
Potassium chloride..	0 000	Aluminum chloride.....	0.0590
Sodium chloride.....	153 990	Magnesium chloride...	0.0057
Lithium chloride....	0.735	Magnesium bromide...	0.3037
Ammonium chloride·	0.637	Iodide of magnesium..	0.0663
Calcium chloride....	15.848	Borate of magnesium..	0.0116
Strontium chloride..	0.256	Bicarbonate of iron...	0.0778
Magnesium chloride	5 584	Sulphate of strontium	0 6033
Iron chloride	0 033	Silicate	0 0230

Hot baths, mud baths, and inhalations are used in the treatment, which occupies from two to three weeks. The temperature of the baths is from 95° to 98.6° F., and the salso-iodic water is generally employed, although salso-iodic water mixed with the mother water can also be used. The duration of the baths is from fifteen to sixty minutes, and after the bath the patient goes to bed and rests. It is recommended that the cure be repeated again during the year, and followed up for two or three years. An after-cure in the mountains is advised.

There is an inhalation hall where this method of treatment is pursued for various affections of the respiratory tract, such as bronchitis, pharyngitis, laryngitis, etc.; for chronic eye affections, such as conjunctivitis, iritis, and keratitis; and for certain skin diseases. The diseases for which the baths are recommended are chronic rheumatism and gout; various gynecological affections, such as metritis, salpingitis, ovaritis, perimetritis, and sterility; anemia; convalescence from protracted illness; infantile rachitis; neurasthenia; bone and joint tuberculosis; tertiary syphilis, and some forms of neuralgia and neuritis. Massage and Swedish gymnastics, electricity, and various forms of douches are also employed. The mud baths, which are given in conjunction with and apart from the baths, are used especially for rheumatoid arthritis. The mud obtained from the deposit of the tanks at the well (rich in salt, iodine, bromine, lithium, and petroleum), is applied to the affected parts as hot as can be borne, and is left on for about twenty minutes. It is then removed and generally followed by a bath of medicated water.

Besides the arrangements for baths in the "Grand Hotel," there are bath-houses (*stabilimenti*) where every precaution is taken as regards cleanliness, sanitation, and disinfection. All laundry linen is carefully disinfected and sterilized after being used.

Salsomaggiore can be reached from London in about thirty hours. In going from Milan to Florence one alights at Borgo San Domino, and takes a half-hour's ride in a branch train to Salsomaggiore

For a charming description of the excursions about this spa, one is referred to "Salsomaggiore and Its Surroundings," by Lady Colin Campbell.

EDWARD O. OTIS.

Saltillo.—See *Mexico.*

Salt Lake City.—This city and the great region of the Salt Lake basin deserve consideration as a health resort of no mean degree, particularly as a place of residence for the consumptive. This basin of a former great inland sea, a huge remnant of which is the existing Salt Lake, has an average elevation of 4,300 feet, and is bounded on the east by a range of mountains and on the west and south by a desert. It is, then, a plateau of moderate elevation fed by the pure air from the mountains and the desert, and possessing a "maritime" quality from the presence of such a large body of salt water as the great Salt Lake, which covers an area of 2,360 square miles. Such an elevation, moreover, gives the peculiar climatic conditions incident to height above sea-level. The air is pure, cool, and dry; the sensible temperature is not oppressive, on account of the dryness of the atmosphere; the rainfall is small; high winds are absent, and the sunshine is abundant. Further, the softness of the air is a striking feature, very evident to one who first sets foot in this region, and giving a delightful sense of restfulness. The principal place of importance and resort is Salt Lake City, latitude 40° 45′ N., longitude 111° 50′ W., containing 92.777 inhabitants, and located 4,348 feet above sea-level. The city occupies an extensive area, is well built and attractive, with wide and well-shaded streets, and possesses an efficient sanitary system and excellent water works. The accommodations are good, there being several modern hotels. The soil is adobe. Irrigation is used, the water being carried in ditches along the sides of the streets.

"Salt Lake City," says Solly ("Medical Climatology"), "is one of the three Western cities of good size possible for the residence of those to whom a sunny climate is necessary and who desire to settle in an active business center. The other two large cities are Denver, which shares with Salt Lake City the advantage of altitude, and Los Angeles, which is equally sunny but exposed to ocean influence."

At the Salt Lake Hot Springs Sanatorium sulphur and salt baths can be taken; and on the border of the lake, thirteen miles distant, reached by train, is the Salt Air Bathing Resort, well appointed, with nearly 1,000 bathrooms. Here one can enjoy the strange experience of bathing in water containing nineteen per cent. of salt, and so buoyant that one can float in it with a considerable portion of his body out of water. The lake is very shallow for a long distance from the shore, and it is a laborious task to wade to deep water. The temperature of the water is comparatively high.

Standart ("The Climate of the Great Salt Lake Basin," Transactions of the American Climatological Association, vol. vii., 1890) calls attention to the fact of the longevity of the inhabitants of this region, which he attributes to the influence of the climate; and he narrates the incident of a gathering of old folks representing three per cent. of the adult population of the great Salt Lake basin, where there were a thousand people who had attained the age of seventy years or over.

Good hunting and fishing are to be had in the mountains and streams round about, and there are many short excursions to mountain resorts lying on the banks of attractive lakes. A few miles from the city, reached by an electric road, is Fort Douglas, a military post, from which is an extensive view.

From the climatic table it will be seen that the temperature partakes of the characteristics of that of elevated regions. The diurnal range is large and it does not appear to be very cold in winter or excessively hot in summer. According to Solly, the average number of days above 90° F. is 30, and below 32°, 109. The average annual range as given by Standart is 93.5°. The average relative humidity is very low and the rainfall small, indicating a very dry atmosphere. The prevailing wind is from the northwest, and the average hourly velocity 5.3 miles for the year. The number of clear and fair days is 277, which means a large amount of sunshine.

EDWARD O. OTIS.

CLIMATE OF SALT LAKE CITY. LATITUDE, 40° 45′ N.; 111° 50′ W. ELEVATION, 4,348 FEET. PERIOD OF OBSERVATIONS, TEN TO SIXTEEN YEARS.

	January.	March.	May.	July.	September.	November.	Spring	Summer.	Autumn	Winter	Year.
Temperature, degrees Fahr.—											
Average monthly temperature.	29.0°	49.0°	57.5°	75.4°	64.3°	38.6°	49.5°	71.5°	51.3°	31.9°	51.3°
Mean of warmest	35.7	50.6	69.3	88.0	75.4	46.2	59.5	85.3	60.9	38.8	61.0
Mean of coldest	20.7	32.2	47.3	63.3	52.4	28.3	39.6	60.8	39.0	24.0	41.2
Average daily range	15.0	18.4	22.0	27.7	23.0	17.9	19.9	24.5	21.9	14.8	19.8
Highest or maximum	48.8	63.9	83.3	95.0	87.5	61.4	72.9	94.7	74.9	50.4	
Lowest or minimum	−6.1	21.6	35.6	51.6	53.1	18.8	28.9	49.2	30.0	0.2	
Humidity—											
Average relative	61%	52%	45%	37%	37%	47%	49%	37%	43%	61%	48%
Precipitation—											
Average in inches	1.49	1.74	2.08	0.53	0.36	1.40	6.36	2.16	3.82	4.39	16.73
Wind—											
Prevailing direction	S. E.	S. E.	N. W.	N. W.	N. W.	N. W.	N. W.	N. W.	N. W.	S. E.	N. W.
Average hourly velocity	4.07	5.6	6.2	5.6	5.4	4.0	6.0	5.8	4.9	4.1	5.3
Weather—											
Average number of clear and fair days	19.8	20.5	23.7	28.3	27.3	21.5	64.4	83.3	73.2	56.3	277.2

Salt Lake Hot Springs.—See *Hot Springs, Utah.*

Salt Sulphur Springs.—Monroe County, West Virginia.

POST-OFFICE.—Salt Sulphur Springs. Hotels.

ACCESS.—Via Chesapeake and Ohio Railroad to Ronceverte, where carriages meet visitors for springs.

These well-known springs have been under the present management for many years, and have become justly esteemed as one of the most charming and homelike of the Virginia Mountain resorts. The location is 2,000 feet above the sea-level, and is surrounded by the usual beautiful scenery and wholesome climate of the Alleghanies. The hotel buildings are chiefly of brick and limestone. The largest, built of stone, contains seventy-two pleasant rooms, and has wide piazzas, 200 feet long, overlooking the lawn. The parlor and great ballroom are also in this building. There are accommodations for 300 guests. The springs are three in number, known as the "Old" or "Sweet" Spring, discovered in 1802; the "Salt Sulphur," discovered in 1805; and the "Iodine" Spring, known since 1821. We present analyses of the Salt Spring and the Iodine Spring, the former by Dr. P. B. Tindall, the latter by Dr. D. Stewart:

	Salt Sulphur. Grains in 100 cubic inches.	Iodine. Grains per gallon.
Calcium sulphate	36.765	68.0
Magnesium sulphate	7.833	20.0
Sodium sulphate	9.682	24.0
Calcium carbonate	4.445	33.0
Magnesium carbonate	1.434	7.0
Magnesium chloride	0.116	28.0
Sodium chloride	0.683	1.50
Calcium chloride	0.025	0.56
Iodine	Trace.	0.63
Bromine	.....	0.65
Iron sesquioxide		1.06
Alumina		0.18
Sodium and lithium phosphate	.....	0.73
Silicic acid	.....	1.76
Potassium carbonate		2.33
Sodium carbonate	.....	10.80
Iron peroxide, divided from protosulphate	0.042	.....
An azotized organic matter, blended with sulphur, about	0.004	.....
Earthy phosphates	Trace.	

Temperature variable from 49° to 56° F. Solid matter produced by evaporation from 100 cubic inches weighed, after being dried at 212° F., 81.41 grains. Volume of each of the gases contained in a free state in 100 cubic inches:

	Cubic inches.	Cubic inches.
Sulphureted hydrogen	1.10 to 1.50	19.19
Nitrogen	2.05	4.37
Oxygen	0.27	0.62
Carbonic acid	5.75	36.40

These are valuable waters, containing as they do a large proportion of active mineral ingredients. Both contain a sufficient quantity of the purging sulphate to render them cathartic in their effects. The iodine spring contains a fair proportion of iron and is said to contain the largest per cent. of iodine and bromine of any spring so far analyzed. These are rare ingredients of sulphur waters. This water resembles those of Challes, in Savoy, and possesses alterative properties. It proves especially beneficial in scrofulous and syphilitic diseases. The waters of both of these springs are useful in abdominal engorgement, chronic constipation, chronic metallic poisoning, functional hepatic disorders, rheumatic affections, gout, and scaly skin diseases. Cases of bronchial troubles and early phthisis also do well at this resort.

Emma E. Walker.

Salumin, aluminum salicylate, $Al_2(C_6H_4OHCOO)_6 + 3H_2O$, is a reddish-white powder, insoluble in water and alcohol, and soluble in alkalies. It is employed as an astringent dusting-powder in catarrhal conditions of the upper air passages. It is known as "salumin (insoluble)." With ammonia it forms aluminum ammoniosalicylate, $Al_2(C_6H_4ONH_4COO)_2 + 2H_2O$, which is readily soluble in water and is used in the nose and throat as an astringent spray or gargle. This compound is called "salumin (soluble)."

W. A. Bastedo.
R. J. E. Scott.

Salvia.—Sage. The dried leaves of *Salvia officinalis* L. (fam. *Labiatæ*).

This is a half shrubby, gray-hairy perennial, the stems dying down to within a foot or so of the ground in the fall, but branching very freely into herbaceous flowering branches, which are quadrangular and attain a height of two or three feet. The leaves are opposite, the flowers in a mixed spike, with two-lipped, pubescent, bell-shaped calyx, and a conspicuously labiate, blue corolla, with a ring of hairs at the base, inside; upper lip of the corolla concave, notched at the apex, the lower three-lobed; the central one much the largest and longest. Perfect stamens two, with widely divergent anther cells, but one of which in each stamen is perfect. Ovary four-lobed. Fruit of four nutlets. Sage, like so many others of our household mints, is a native of southern Europe. It has, however, been cultivated for centuries and transplanted to all temperate countries. Leaves rather long and stoutly petioled, the blades three to seven centimeters (about one to three inches) long and nearly half as broad, oblong or slightly broader below the middle, rounded or subcordate at the base, mostly blunt at the summit, crenulate, thickish, gray green, and densely hairy, especially underneath, very strongly veined, the veins finely reticulate, often pinkish or purplish, as is the petiole; aromatic in odor and taste, the latter also bitter and somewhat astringent.

Sage owes its very characteristic odor and its properties as an aromatic drug to a peculiar volatile oil (less than one per cent. in the fresh, up to 2.5 per cent. of the dried leaves). It also contains an unknown bitter substance and apparently tannin, together with resin and a little gum. Oil of sage is a commercial article, and is of a yellowish or greenish-yellow color, with a specific gravity of about 0.92. Its chief constituent has been called salviol, but it is now considered identical with thujone, the active constituent of Arbor vitæ, and this occurs also in some other volatile oils. A small amount of cineol is also contained.

Sage resembles the rest of the Mint family in its general action; it is aromatic, a gastric stimulant, and by reason of its bitterness also tonic. It is also, what not all aromatics are, mildly astringent. In large quantities of hot water, like many other mints, it is given as a sudorific in the beginning of feverish colds, etc. Sage is useful in mouth washes and as a gargle. It is, however, almost entirely a domestic remedy, and even as such but little used of late, although formerly in high repute. It is one of the ingredients of the formerly official aromatic wine (*Vinum Aromaticum*), an old-fashioned liniment.

W. P. Bolles.

Sambucus.—Elder.—Elder-berry Flowers. "The flowers of *Sambucus canadensis* L. (fam., *Caprifoliaceæ*). This plant is a medium-sized or small shrub, with smooth, upright rather simple stems, which are soft and herbaceous in the upper part. Their woody ring is very narrow; their pith very large, and much used for holding small objects for microscopical section-cutting; leaves opposite, petiolate, pinnate, large; leaflets ovate-acuminate, serrate, rarely pinnate; flowers small, in large, compound, five branched, flat-topped cymes, regular, pentamerous; calyx minute; corolla cream colored, urn shaped, with spreading lobes; stigmas three; ovary inferior, ripening to a purple black, shining, spherical, juicy, berry-like drupe containing three minute nutlets. The elder is a common plant in moist places over a large portion of this continent, and is represented by nearly related species in many other parts of the world.

The flowers should be gathered in full bloom, and dried without heat. They then form a cream-colored or very pale yellow mass, which grows darker with time. They have a peculiar, rather agreeable odor, and a sweetish and slightly bitter taste. Their important constituent is a volatile oil, with which occur resin, gum, wax, and sugar.

The use of our elder was unquestionably derived from that of the black elder (*S. nigra* L.) of Europe, which is almost exactly like it in sensible properties. The American has tufts of microscopic hairs in the forks of the branchlets of the inflorescence and in the sinuses of the calyx teeth, while the *S. nigra* has not. Elder is slightly aromatic, and when given in hot infusion is also diaphoretic. Its employment is confined almost entirely to household medication. The twenty-per-cent. infusion may be given *ad libitum*.

The flowers are the least active portion of the plant.

The fruits of this and related species, though used in pastry and largely in wine-making, are laxative in the uncooked state, and have been seen to intoxicate fowls. The young buds are powerfully cathartic or even emetic, as is the bark of the root. The leaves have been used for fly poison. The bark of the stem is a useful diuretic and hydragogue cathartic, emetic in overdoses. (See also *Poisonous Plants.*)

HENRY H. RUSBY.

San Antonio.—The southwestern portion of Texas is regarded as the especial health resort region of this State, and San Antonio, occupying a central position in this region, can be taken as illustrating its climatic characteristics. San Antonio (elevation 650 feet) is the chief city of this district, and is situated in lat. 29° 27′ North, about 130 miles inland from the Gulf of Mexico. It has a population of 96,614 composed of Mexicans, Germans, and Americans. The Mexican element presents many attractive and picturesque features, in the architecture, street life, and suggestions of bygone days in the old missions. The historic incidents connected with the life of the city also enhance the charm and fascination of the place; for there is the famous Fort Alamo, the Thermopylæ of Texas.

The country is undulating, with no mountains nearer than thirty or forty miles, and the soil of the city is adobe. There is a pure water supply, and a more or less effective sewerage system. Seventy-five miles of paved streets, electric street railways, several hospitals and several large public parks. There are a number of hotels, boarding-houses, and restaurants, but the accommodations for invalids are said to be doubtful. Probably the most satisfactory plan would be to keep house in one of the more eligible suburbs of the city. There are many opportunities for outdoor life, in horseback riding, driving, etc. The climate is a mild winter one but uncomfortably hot in summer, although the nights are comparatively cool.

From the meteorological table we see that while the winters are mild, nearly as warm as the autumn at New York City, the diurnal variation is large; and also while the summer days are hot—many days above 90° F.—the nights, as has been said, are comparatively cool. The average annual rainfall for the eight years was 25.27 inches; and for twenty-one years, 30.6 inches (Solly, "Medical Climatology"). Occasional "northers" occur at San Antonio, but they do not last long. The average relative humidity is 65.5 per cent. for the year, which, considering the high temperature, means a moist atmosphere. The average number of cloudy days during the year is 90; and the average number of clear and fair days, 275.

Such a climate as this, while it is not an exceptionally excellent one in its various characteristics, yet affords an outdoor life in the winter in a mild and pure atmosphere. For the consumptive in good general condition, and with the disease not far advanced, and who, moreover, is willing and able to "rough it" more or less, this region can be recommended. It does not, however, in the writer's opinion, possess the advantages of Southern California or of many resorts in the southern pine belt, either in the matter of climate or in that of accommodations. Almost every resort has its enthusiasts, and the following quotation from an article upon southwestern Texas by Dr. T. K. Taylor in the Transactions of the American Climatological Association, 1888, may be said to have been written by one such. "For delicate children," Dr. Taylor says, "who require the invigorating influences of moderately cool weather and active outdoor life, that climate is all one could wish during the winter season, while the spring, with its multitude of flowers, its fragrant breezes, its genial sunlight, and its evenings with their soft sweet repose, give one a better idea of an earthly paradise than any place we have ever seen, or hope to see in this broad land."

San Antonio can be reached by three lines of railroad.

EDWARD O. OTIS.

CLIMATE OF SAN ANTONIO, TEXAS. LATITUDE, 29° 27′ N.; LONGITUDE, 98° 28′ W. PERIOD EIGHT YEARS.

	January.	March.	May	July.	September.	November.	December.	Year
Temperature, degrees Fahr. –								
Average or normal	51.5°	61.9°	74.9°	83.3°	77.5°	59.0°	54.9°	68.5°
Average daily range	19.8°	21.8°	19.6°	22.1°	21.2°	21.1°	20.5°	
Mean of warmest	62.8°	73.0°	85.2°	95.3°	89.4°	71.6°	65.7°	79.8
Mean of coldest	43.0°	51.2°	65.6°	73.2°	68.2°	50.5°	45.2°	58.8°
Highest or maximum	81.0	93.0°	97.0°	106.0°	103.0	88.0°	89.0	
Lowest or minimum	16.0°	21.0°	47.0°	66.0°	46.0°	32.0°	22.0°	
Humidity –								
Average mean relative	65.6%	62.1%	69.6%	64%	68.8%	65.3%	62.8%	65.5%
Precipitation –								
Average in inches	2.03	1.42	2.85	0.92	2.84	1.30	1.82	25.27
Wind—								
Prevailing direction	N.	S. E.	S. E.	S. E.	E., S. E.	N., S. E.	N.	S. E.
Average hourly velocity in miles	7.5	8.8	7.5	7.5	6.4	7.4	7.8	7.8
Weather –								
Average number of clear days	10.3	9.3	8.1	13.8	11	12.1	14.2	136.2
Average number of fair days	9.0	12.0	13.8	14.8	13	10.3	8.1	138.8
Average number clear and fair days	19.3	21.3	21.9	28.6	24	22.4	22.3	275.0
Average number of cloudy days	11.6	10.8	9.0	2.2	5	6.5	8.3	90.0

Sanatorium Treatment of Tuberculosis.—The sanatorium treatment of tuberculosis consists in: (1) Supplying the patient with pure fresh air night and day, under favorable climatic conditions, with a large amount of sunshine. (2) Proper and abundant nourishment adapted to individual needs. (3) Rest—absolute if fever exists—and for certain hours (rest periods) during the day for afebrile patients. (4) Carefully graded and supervised exercise for those who are on the road to recovery and who are afebrile. (5) General training and discipline in personal hygiene, disposal of the sputum, safe coughing, and in the general routine of treatment. (6) Treatment of various symptoms, medicinal or surgical, which interfere with or adversely affect the general plan of sanatorium life. (7) Mental diversion in the form of legitimate amusements, such as music, games, plays, etc., and simple occupations. (8) Hydrotherapy in one form or another, adapted to the

individual. (9) Constant medical supervision by one experienced in the treatment of tuberculosis.

Under whatever conditions or in whatever climate one treats curable cases of tuberculosis, the essential principles given above must be followed; but it is the consensus of opinion of all phthsiotherapeutists that they can more perfectly be carried out and with greater success in a sanatorium. This is true not only in dealing with pulmonary tuberculosis, but as well in surgical tuberculosis, that of the joints, bones, and glands, especially in children, at mountain or seaside sanatoria.

The establishment of sanatoria all over the civilized world, both public and private, is again evidence that this method of carrying out the "open-air" treatment has been found by experience to be the most successful. There are many obvious reasons why this should be so. The sanatorium is located, built and equipped for the express purpose to which it is devoted. A favorable climate is selected, so far as other conditions will permit, and a location chosen far from thickly populated centers and affording protection from high winds and giving the maximum exposure to the sun. The buildings are adapted for open-air life, such as the open pavilions or "lean-tos." They are equipped with all the material for dealing with a single disease, and all its varied symptoms. The physician-in-chief is selected for his experience, skill, and personal fitness for this especial work, and he is always at hand. The success of a sanatorium depends far more upon the right kind of a physician at the head of it than upon elaborate buildings, equipment or an ideal climate, and in choosing a sanatorium this should first be considered.

To carry out successfully the treatment as outlined, a daily routine must be established and sedulously followed, and to ensure this, training and discipline are required. Where all are doing the same thing, trying to get well, and the scheme of life is set to this one purpose, this training is more easily accomplished and is less irksome. In the home, on the other hand, the consumptive is doing the exceptional thing, and consequently it is more difficult and discouraging to live this exceptional life.

Another advantage of the sanatorium is that the patient is prevented from ignorantly doing things which might imperil his chance of recovery, as, for example, taking exercise when he ought to keep quiet, or taking too much or the wrong kind of exercise. Even if the patient is later to take his treatment at home or in an open health resort, the training for a few months in a good sanatorium enables him to more intelligently and more exactly follow out his treatment as he has learned it by example and practice. For persons of weak will or self-willed, the discipline of the sanatorium under a firm but sympathetic director offers the best if not the only chance of recovery. In the sanatorium the patient is freed from all responsibility regarding his care; he has only to do as he is told and in doing so he feels that he is availing himself of every favorable element in his case, and wasting no opportunity. When complications arise, such as hemoptysis, pleurisy, of tuberculous laryngitis, they can more efficiently and more quickly receive the proper treatment, for the physician is always at hand. Thus more serious conditions can often be averted by timely attention.

"Proper nourishment is the foundation and cornerstone of the treatment of consumption" says Dettweiler, and the selection of the food, as to its nutrient value, the amount, and its preparation, require the most careful consideration. In the sanatorium the director generally supervises this important part of the treatment, assisted by a trained dietitian. The kitchen department with a good cook is an indispensable requisite for a successful sanatorium. As Dettweiler used to say, "My kitchen is my pharmacy."

The larger sanatoria have an infirmary or a reception hospital in which patients suffering from acute relapses, complications or any intercurrent disease can be isolated and treated, and in which patients with acute symptoms on their arrival can be kept under observation for a week or two, and thus a more accurate estimate of their condition can be made, and the future treatment more intelligently arranged.

The application and proper regulation of rest and exercise is one of the fundamental constituents in the treatment of tuberculosis, and careful study of the patient and constant supervision is requisite if the maximum amount of good is to be obtained and harm avoided. As has been before stated, febrile cases should have absolute rest, as absolute as in a case of typhoid fever, for example, and this requires the constant services of nurse or attendant, who are always at hand in a sanatorium; moreover, more perfect open-air conditions, as in a shack, lean-to or the veranda of a cottage where the bed can be rolled out, are generally afforded in a sanatorium for such all-time rest patients than in the ordinary private house. When only periods of rest are prescribed for afebrile patients, and this rule is generally universal for all tuberculous patients, it is more surely observed and is less irksome when done in company with others as in a sanatorium. There are at least two and often four periods of rest, and the length will depend upon the individual condition. An hour before and after meals is advisable for all patients.

The question of exercise for the consumptive is one of paramount importance, for exercise is a two-edged sword; if taken at the wrong time and in the wrong way, it may do irreparable harm, whereas if carefully prescribed for suitable cases, and supervised, it has a valuable therapeutic effect. It is not enough to give the general direction to take a little exercise, leaving it to the judgment of the patient as to the kind and amount; but the kind, amount and time must be carefully determined and with equal care supervised.

Paterson, formerly the superintendent of Frimley Sanatorium, England, has worked out a method of graduated exercise or work for patients while undergoing treatment in the sanatorium who are without fever and whose general condition and appetite are good, and who appear to have established a good degree of resistance. The plan of Paterson consists of a series of graded exercises, each a little harder and longer than the previous one. Either the physician or a skilled assistant is constantly with the exercising squad to see that no one is overexerting himself. From his experience, Dr. Paterson concludes that graduated labor is a definite medical treatment for cases of pulmonary tuberculosis, and raises the general health and resisting power of the patient. This plan, or some modification of it, is now followed in many sanatoria.

There are many minor symptoms constantly occurring in the course of treatment of a tuberculous case which require attention and correction in order that the general plan of treatment may uninterruptedly go forward, and for which, if the patient were at home, he might not think it necessary to call in his physician. Such can at once receive attention by the physician of the sanatorium who is always on hand and who possesses the experience to deal most successfully with such symptoms. In the application of especial methods of treatment, such as tuberculin or artificial pneumothorax, when the patient needs to be under more or less constant observation, the sanatorium with its equipment obviously offers the best opportunities for such special treatment.

The clinical laboratory is now an essential in the

treatment of all diseases, and it is no less so in that of tuberculosis, when sputum, blood, *x*-ray examinations, and others are constantly required. All sanatoria of any size possess such laboratories and some a skilled bacteriologist or pathologist. Furthermore, facilities for surgical emergencies and throat treatment are provided and sometimes arrangements for dental surgery.

Hydrotherapy is another important element in the general treatment. The use of cold water in varying forms is a "hardening process" and aids in increasing the body resistance; nutrition and appetite are improved thereby. Not all patients, however, react to the application of cold water, or have to be gradually trained to its use. Each must be individually considered, and this can best be done by the experienced sanatorium physician. There are various methods of applying cold water and baths and the hydrotherapeutic equipment of the sanatorium affords a choice of the most suitable method for each individual.

The care of the patient's mental condition is an important matter in the general scheme of treatment, and in this, the personality of the physician plays a conspicuous part. He must be able to inspire his patient with hope, and a determination to follow out to success the sanatorium treatment. Some simple amusements must be provided, such as non-exciting games, music, story-telling, theatrical performances, etc.; or some occupation for the hands, such as book-binding, basket-making, wood-carving, knitting, clay-modeling, etc. This is done in some sanatoria at least, as in a workshop at the Adirondack Cottage Sanatorium. In others, recreation halls are provided and libraries. The writer recalls a visit to a private sanatorium in the Black Forest where a band gave afternoon concerts. As someone has wisely said, "The consumptive must be treated *in toto*, and his moral and mental education is quite as important as his bodily treatment."

Although the influence of climate in the treatment of tuberculosis is perhaps not now considered so important a factor as formerly, yet climate has a very definite value, and in the selection of a situation for a sanatorium, that one is chosen which possesses favorable climatic conditions, as, for example, localities in Colorado, New Mexico, Southern California, the dry regions of the Southwest, the Adirondacks, etc. The essential characteristics of a favorable climate for tuberculosis are pure aseptic air, abundance of sunshine, freedom from dust and high winds, and a relatively low humidity. Altitude is of value on account of the greater purity of the air, the more intense sunshine and its more stimulating effect. There are other conditions also that have to be considered in locating a sanatorium, such as the character of the soil, the drainage, water supply, etc.

As will be seen from what has been said above, the sanatorium when properly located and equipped and under the charge of a competent and experienced physician affords the most favorable conditions for the successful treatment of pulmonary tuberculosis, conditions which can rarely be equalled or surpassed in any private house.

There are certain alleged disadvantages of a sanatorium which should be mentioned, although they are more imaginary than real. First: it is not infrequently asserted that the aggregation of so many consumptives in various stages of the disease exercises a depressing influence. The testimony, however, of those who have been inmates and of the physicians of the sanatorium is quite the contrary. The patients encourage one another, and the physician-in-chief inspires all. Anyone conversant with sanatorium life can testify to the general air of cheerfulness which pervades the institution; this is particularly noticeable at mealtime in the general dining room, as has been observed again and again by the writer.

Another objection is the danger of reinfection from one another. Abundant proof is at hand to dispel this apprehension. Most scrupulous care is taken to destroy the sputum and to protect the patient from contamination through coughing or infected articles. The examination of the dust in various sanatoria has shown that it does not contain tubercle bacilli.

A valuable incidental influence of the sanatorium is the dissemination of the knowledge of proper hygiene and of the prevention of tuberculosis by its graduates. They become enthusiastic teachers of the value of fresh air, good nutrition, rest, and, in general, of personal and domiciliary hygiene.

For children suffering from surgical tuberculosis, sanatoria in the mountains or the seaside offer most excellent opportunities for the open-air treatment, and the results are most satisfactory.

In conjunction with the regular treatment, heliotherapy is an additional and valuable adjunct. The reader is referred to the article upon this subject in vol. v. of this Handbook.

For children with lung or bronchial gland tuberculosis which is often closed, the sanatorium treatment is equally applicable and can be conducted either in a sanatorium devoted to children alone or in a special department of a general sanatorium. The treatment is essentially the same as with adults, only as many cases are closed and afebrile, the children are allowed exercise, and can receive a limited amount of school instruction.

In the selection of a sanatorium, the first consideration should be the competency, skill, and personality of the man at the head of it; second, the location as to favorable climatic conditions; third, the facilities afforded for open-air life; fourth, its reputation as to the provision of good food. Of course many patients of limited means will, of necessity, be obliged to go to their State Sanatorium, but such institutions are for the most part well conducted and adequately equipped, although they do not offer the luxuries of some private sanatoria.

It is well to bear in mind that the patient is not absolutely cured in the sanatorium, for that is often a matter of years; but he is put on the road to an arrest of his disease, so that he can continue the "cure" at home, and while doing so can often resume his occupation under hygienic conditions, having learned from his experience in the sanatorium how to live a healthy life.

It is not to be asserted that the sanatorium treatment is applicable for every consumptive; there are individual conditions in mind, body, or estate which might render it undesirable, but for the majority of curable consumptives, however, the sanatorium will give better and often quicker results than the treatment taken at home or in an open health resort. In either case, the essential principles of treatment must be the same.

A list of the sanatoria in the United States and Canada, both public and private, with their location, capacity, and rates, will be found in the "Tuberculosis Directory," published by the National Association for the Study and Prevention of Tuberculosis, 105 East Twenty-second Street, New York.

Edward O. Otis.

Sandalwood, Oil of.—(*Oleum Santali*, U. S. P., B. P., P. G.) A volatile oil distilled from the heartwood of *Santalum album* L. (fam. *Santalaceæ*).

Sandalwood is the product of a small tree of the East Indies. It has been highly valued from the most ancient times for the manufacture of objects which retain the fine fragrance of the wood for a very long time, and for use as incense. The trunk is small and its product is still further limited by the uselessness of the outer or sap wood. This is removed, either by trimming or by leaving it exposed to the action of

termites, which find it agreeable and nutritious, while the oleiferous heart wood is highly offensive to them. To discriminate between these two portions, the heartwood is often known commercially as "pink" or "red" sandalwood. This custom leads, in turn, to some confusion between this and red saunders, which is also often called red sandalwood.

Sandalwood occurs in small billets of a brownish yellow or reddish yellow externally and of a more decidedly pinkish tinge internally. It is very hard and heavy, and of a tough and splintery fracture, and emits, especially when heated, the characteristic odor of the oil.

The tree, on account of its very extensive collection and the careless methods employed, was long ago placed under government protection and is now cultivated upon a great scale. The distillation of the oil has also been carried on under government supervision, with the express object of preventing adulteration. In spite, however, of all precautions, such great difficulties have been encountered in securing a pure article of native distillation that many firms prefer to incur the heavy expense of importing the wood and distilling it here or in Europe. The yield of oil from a wood of first quality is said to be about five per cent. The wood itself finds no employment in medicine.

The oil, which must contain not less than ninety per cent. of alcohols, calculated as santalol, is thus described in the Pharmacopœia: pale yellow, somewhat thick liquid, having the characteristic odor of sandal wood.

Specific gravity: 0.965 to 0.980 at 25° C.

The optical rotation varies from −15° to −20° in a 100-millimeter tube at 25° C.

It is soluble in five volumes of seventy per cent. alcohol, forming a solution which is slightly acid to litmus.

Assay.—Proceed as directed for menthol under *Oleum Menthæ Piperitæ*, using ten mils of oil of santal. Use the following formula in calculating the percentage of santalol in place of that given for menthol under *Oleum Menthæ Piperitæ*,

$$\text{Percentage of santalol} = \frac{B - (A \times 0.021)}{A \times 11.11}$$

In which A is the result obtained by subtracting the number of milliliters of half-normal sulphuric acid V.S. required in the titration from the number of milliliters of half-normal alcoholic potassium hydroxide V.S. originally taken, and B is the weight of acetylized oil taken.

Oil of sandalwood belongs to that class of volatile oils commonly denominated "terebinthinate." Like copaiba, which it resembles in many respects, it is often called a balsam, though the term is very incorrect, neither benzoic nor cinnamic acid being contained. It is said to consist almost wholly of the alcohol $C_{15}H_{26}O$ and the aldehyde $C_{15}H_{24}O$.

Action and Use.—The absorption and elimination of this oil are rapid, the latter occurring chiefly through the kidneys and the lungs, so that it might be classed as a stimulating and disinfectant diuretic and expectorant, with some astringent properties also. Its administration is frequently followed by discomfort in the stomach and dryness of the throat, and occasionally by vomiting and colic.

Disagreeable eructations and its taste are complained of by some patients, but on the whole it is less unpleasant than copaiba. Its elimination by the kidneys, which is sometimes accompanied by a feeling of tension there, changes the odor of the urine, and causes it to become cloudy with acid, in the same way as copaiba does; alcohol, by clearing up this cloudiness, which is caused by a resinous precipitate, will distinguish it from albumin. The sandalwood products in the urine exert upon vesical, and especially gonorrheal, inflammations a beneficial action very similar to that exerted by copaiba or cubebs. Sandal wood therefore is frequently employed as an elegant substitute for these drugs. Reports differ widely as to the relative value, as antiblennorrhagics, of copaiba and sandalwood oils, but the preponderance of evidence appears to be in favor of the former. Sandalwood oil is especially serviceable in recent acute cases, with considerable discharge.

The oil is frequently given dropped upon sugar or shaken up with mucilage, but is far more largely taken enclosed in gelatin capsules, either pure or mixed with copaiba or cubebs. The dose is ♏v.–xx. (0.3–1.2) four or five times a day, and its administration should be continued for a week or so after the symptoms have disappeared.

Allied Products.—Eight or nine species of *Santalum* are known, all natives of the East Indies. Various attempts have been made to utilize the products of several of these species, as well as somewhat similar products, though not of this genus, from the West Indies and South America; but none of them possess the fine odor or other characteristics of the genuine, and it is doubtful if they now find their way into commerce. Henry H. Rusby.

Sand-flies.—A name applied to various small biting flies, belonging to the genera: *Culicoides*, *Simulium*, or *Phlebotomus*. A. S. P.

Sands, Henry Berton.—Born in New York City, Sept. 27, 1830. He studied medicine at the College of Physicians and Surgeons in that city and received the degree of Doctor of Medicine from the same institution in 1854. Two years later, on his return from Europe, he was appointed Demonstrator of Anatomy—a position which he held until 1867, when he was chosen to fill the Chair of Anatomy. In 1877 he was elected Professor of Surgery. He was Attending Surgeon (at different periods of time) at the following hospitals: New York Eye and Ear Infirmary, St. Luke's Hospital, Bellevue Hospital, Strangers' Hospital, Roosevelt Hospital, and New York Hospital. He died Nov. 18, 1888.

Of his contributions to medical literature the following deserve to receive special mention: "Case of Cancer of the Larynx, Successfully Removed by Laryngotomy," 1865; "Aneurysm of the Subclavian, Treated by Galvano-Puncture," 1869; "Esmarch's Bloodless Method," 1875; and "Treatment of Intussusception by Abdominal Section, 1877. A. H. B.

San Francisco.—The metropolis of the Pacific coast is situated upon the northern end of a peninsula in latitude 37° 47′ N. and longitude 122° 23′ W. On the west, north, and east the city is surrounded by water. The Pacific Ocean washes the extreme western side of the city, a fine ocean driveway extending from the Cliff House to the overflow basin of Lake Merced. The Golden Gate (the name was applied by General Fremont while looking westward from what is now Oakland) is a water passage about a mile wide, connecting the Pacific Ocean and the bay of San Francisco. The harbor is generally conceded to be one of the beautiful harbors of the world. The bay extends twenty-five miles north and forty miles south of the city. There are numerous islands in the bay, and on some of these, as, for example, Belvedere, business men of San Francisco have elaborate summer homes. The coves and lagoons are favorite anchorages for house boats or arks.

The city of San Francisco covers an area of 46.5 square miles. Within the city limits are many hills varying in elevation from forty-six meters (150 feet) to 286 meters (938 feet). The highest elevation is

Mount Davidson, closely followed by Mount Sutro formerly known as Blue Mountain (920 feet). The Twin Peaks are, respectively, South 919 feet, North 918 feet. Other hills are Telegraph, Russian, Nob, and Rincon. In 1850 the city was nothing more than sand dunes and sand hills; and even at the present time in the extreme western end of the city these shifting sand stretches can still be seen. The climate is peculiar; the reasons for which are to follow. The winds are somewhat too rigorous for invalids, but for healthy people they are very stimulating. Overcoats and heavy wraps are worn in midsummer as well as in winter. Indeed heavy underclothing can be comfortably worn every day in the year.

The climate is a moist one, the mean relative humidity exceeding eighty per cent. The term relative humidity, however, is misleading and while generally used, means nothing unless the temperature be also given. It does not indicate a fixed quantity of water vapor. Thus at San Francisco while the relative humidity is high throughout the year, in summer owing to low temperature the absolute weight of water vapor per unit volume is less than at inland points. Absolute humidity and vapor tension are relatively low. During the morning hours, especially in summer, the sidewalks look as if a light shower had prevailed, but in reality the dampness is due to condensation of fog. The prevailing direction of the wind is from the northwest, and on summer afternoons the wind blows with great regularity. Between the hours of 1 and 7 P.M. the wind is from the west, with an average velocity of forty-five meters per second or twenty miles per hour. From May until September little if any rain falls, and no matter how overcast or threatening the morning may seem, within a few hours, generally before ten o'clock, there is bright sunshine. Great banks of low fog roll in through the Golden Gate on summer afternoons. There is probably no other part of the Pacific coast where such a strange mixture of marine and continental climates can be found. The topography is so remarkable that marked climatic contrasts occur within short distances. Thus at any of the ferries one may see sealskin coats and white duck garments together, because the traveller needs warm garments crossing the bay and in the city; while at Sausalito, San Rafael, San Mateo, or any of the suburbs, summer clothing is necessary. It must be remembered that the great Sacramento-San Joaquin Valley, a basin 500 miles in a north-and-south direction and fifty miles wide, lies due east of San Francisco, and that on summer afternoons there is often a difference of 30° C. (55° F.) in temperature in a distance of fifty miles.

Owing to the proximity of the Pacific the temperature in San Francisco is very equable. A native of San Francisco cannot say off-hand which is the warmest and which the coldest month of the year; because the range is very small. The mean annual temperature determined from the records of forty-two years is 13° C. (56.1° F.). May and November have practically the same temperature. The mean temperature for July is 13° C. (56° F.) and for December 10° C. (50° F.). The highest temperature ever recorded was 38° C. (101° F.) and the lowest − 2° C. (29° F.). Abnormally warm and cold periods last, as a rule, about three days.

For more detailed climatic data consult The Climate of San Francisco, McAdie, Bulletin 44, U. S. Weather Bureau, 1913, Gov't Printing Office, Washington, D. C.

The sunshine is less in San Francisco than at localities a few miles away, which is due to the prevalence of fog. The city is considered a very healthy one because it is washed by water and well ventilated by the strong winds. It is worth noting that children escape the disorders incident to hot weather in Eastern cities. Women and children have as a rule ruddy complexions, bright eyes, and a good carriage. Natives of San Francisco are in general large and well formed. The climate is, however, too moist for those affected with renal, rheumatic, and pulmonary troubles. The summer climate is bracing and acts as a tonic in cases requiring such treatment.

The residents of San Francisco go inland during May, June, and July to get warm; while strangely enough country people come to the city to get cool at this time.

The city is supplied with water by the Spring Valley Water Company, and notwithstanding the long period of dry weather each year there has never been any water famine. Nor has there ever been any epidemic traceable to the character of water supplied. It is planned to supply the entire Bay section with water from the Sierras 150 miles east. The Hetch-Hetchy valley in the Tuolumne watershed will yield a bountiful supply of pure mountain water. The temperature is a little too cool for ocean bathing, but there are large bath-houses at the beach and in the city where salt-water bathing can be had every day in the year. Many of the clubs have large swimming tanks for the use of members.

The average rainfall based on records covering a period of sixty-four years is 585 millimeters (twenty-three inches), and this falls chiefly from November to March. In the past eighty-four years there was one January when rain fell on twenty-four days; the average number of rainy days in a midwinter (or so-called rainy season) month is about ten. Physicians sending patients to the Pacific coast should remember that marked differences in temperature, humidity, air movement, and sunshine occur within short distances. Near the Bay of San Francisco this peculiarity of climate is particularly noticeable. Within one hour's ride by boat or rail, from San Francisco, there is often a difference of twenty degrees in temperature at the same moment of time and equally great differences in other climatic features.

San Rafael offers a pleasant shelter from the winds of the coast, while the cities of the Santa Clara valley have just enough of the sea breeze to be delightful summer abodes. Or one can, by going to Mount Tamalpais (elevation 2,500 feet), rise entirely above the fog belt and bask in sunshine with temperatures of about 30° C. (86° F.)., while at sea level, under the fog, the temperatures are about 13° C. (55° F.).

ALEXANDER MCADIE.

Sanguinaria.—*Bloodroot. Red Puccoon.* "The dried rhizome of *Sanguinaria canadensis* L. (fam. *Papaveraceæ*), collected after the death of the foliage" (U. S. P.). The plant is a low perennial of eastern North America, with a thick, fleshy, horizontal rootstock, from which one or two leaves and a single handsome white flower appear early in the spring, enclosed at the base by several sheathing scales. An opaque, orange-colored juice is found in all parts of the plant, especially in the rhizome, where it is very abundant and dark. The dried rhizome is about five centimeters (two inches) long, and one centimeter in diameter, slightly flattened, indistinctly annulated, and evidently shrunken and wrinkled. It is reddish brown externally, variously bent and twisted, and now and then branched. It breaks with a short fracture, and displays a pink surface, finely dotted with dull red points; this surface becomes dark by exposure, and finally is uniformly brownish red. Odor slight, disagreeable. Taste bitter, acrid, nauseous, and persistent. Powder sternutatory.

The principal constituent is the alkaloid *sanguinarine* ($C_{20}H_{15}NO_4$), discovered and named by Dana in 1829. When pure it is in white crystalline needles or tufts, insoluble in water, but easily dissolved by alcohol, ether, oils, etc.; it forms with the principal acids beautiful salts of brilliant orange or red color.

The powder excites violent sneezing. Its taste, when dissolved, is that of the rhizome intensified. Chelerythrine ($C_{21}H_{17}NO_4$) exists in smaller amounts and yields yellow salts. Small amounts of at least two other alkaloids exist, with irritant resin, starch, citric and malic acids.

Action.—The several alkaloids of bloodroot have very dissimilar actions when used separately, but that of sanguinarine is overpowering and determines that of the drug. It is a most powerful irritant, locally and systemically. It was formerly used as a caustic for morbid growths, and has had many uses as a counterirritant. It is powerfully irritant to the mucous membranes, and sialagogue. It is a powerful and even fatal emetic and cathartic. Systemically, it irritates both the spinal and cerebral centers, producing tetanic convulsions and intoxication or violent delirium. It depresses muscular fiber, and this at length greatly depresses both the circulation and the respiration.

These properties can be utilized, by small doses, in improving both appetite and digestion, and in producing expectorant effects, the latter either by internal administration, or by inhalation of very weak preparations, or by application to the throat. It was formerly a much-used emetic in doses of gr. xv. to lx., but this use is now considered barbarous. It is very little used at the present time, and then chiefly as an expectorant, in doses of (gr. iij. to viij.) (0.2 to 0.5). Its excretion is accompanied by stimulation of intestinal and renal secretion and of peristalsis. It is also a stimulating emmenagogue. A fluid extract and a fifteen per cent. tincture, each containing a little acetic acid, are official. H. H. Rusby.

San Remo.—This is an Italian town of about 18,000 inhabitants, seven and a half miles east of Bordighera and eighty-four miles west from Genoa. Express trains from Paris run direct to San Remo via Marseilles in about twenty-four hours. It is one of the most frequented resorts of the Italian Riviera, and lies upon a small bay formed by Capo Verde and Capo Nero. In the rear are a series of hills and mountain ranges, affording protection from the winds of the north and conducing to the warmth and equability of the climate.

Climate of San Remo. Latitude, 43° 48′, for the Season November to April Inclusive, for Varying Periods.

	November.	December.	January.	February.	March.	April.	Season.
Temperature, degrees Fahr.—							
Average or normal	53.54°	49.25°	47.23°	50.19°	52.0°	67.0°	51.55°
Average daily range	10.7°	10.4°	10.0°	7.8°	12.1°	12.2°	11.1°
Mean of warmest	61.4°	55.5°	53.0°	56.8°	60.5°	64.6°	58.6°
Mean of coldest	50.7°	45.1°	43 0°	49.0°	48.4°	52.2°	47.5°
Highest or maximum	66.4°	61.9°	58.9°	62.3°	67.1°	71.3°	
Lowest or minimum	44.2°	43.0°	36.4°	37.0°	41.4°	45.6°	
Humidity—							
Average relative	73 4%	66.4%	68 7%	68.8%	70.1%	69.8%	69.6%
Wind—							
Prevailing direction	N.E., N.W	N.E., N.W	N.W., N.E.	N.E., E.	N.E., W.	W.	N.E., N.W.
Strong winds (average number days on which they prevailed)	2.7	1.7	3.7	5.7	3.0	7.0	21.7
Moderate winds (average number days on which they prevailed)	3.3	4.0	3.7	5.7	10.0	11.3	38.0
Precipitation—							
Average in inches	5.29	1.13	2.68	1.81	1.18	2.13	14.5
Sunshine—							
Days of sunshine	24.3	28.3	27.3	25.6	29.6	29.0	164.0
	h. m.	h. m	h. m.	h. m	h. m.	h. m.	h. m.
Mean daily sunshine	7 45	6 46	6 26	8 11	8 50	9 12	7 56

The original town is old and quaint, with narrow, steep streets and picturesque architecture. To the east and west is the new town, where are situated the hotels and villas for the winter residents. The English and Americans frequent the west end, and the Germans the east; it was here that the Emperor Frederick III of Germany spent the last winter of his life at the Villa Zirio.

In both the east and the west portions of the town are attractive and extensive promenades along the water, shaded by palms, eucalyptus, and pepper trees, that to the west called the Corso dell' Imperatrice, and that to the east the Corso Federico. These promenades afford about the only level walks, for, immediately on leaving the sea, the ascent of the hills begins, so that an invalid is restricted to a limited space about the seaside, unless he rides or is strong enough to walk up hill.

The vegetation is varied and luxuriant and of a tropical and semi-tropical nature—here flourish the olive, lemon, fig, and a great variety of flowers and plants. One is especially impressed with the beauty and abundance of the roses and geraniums. The excursions among the hills and valleys are many and varied and through most attractive scenery, with olive, lemon, and orange groves and a profusion of flowers and plants on every hand. The drinking-water is excellent, and the natural drainage must, from the situation of the town, be good. There are also well-built drains running from the new town into the sea or to the mouth of the mountain torrents which flow through the narrow valleys to the sea. The soil is of clay, which renders it somewhat damp after a severe rain. The accommodations are abundant and good, although, as at most of the other Riviera resorts, they are somewhat expensive. There are competent physicians and all the other requirements of a first-class health resort.

The so-called winter season extends from November to April. The chief characteristics of the climate during this winter season are mildness, dryness, and sunshine, with a brilliant blue sky and sea. There is more or less wind, as throughout all the Riviera, and it is sometimes cold. The hills and mountains afford protection from the north wind, but the east and the southeast winds prevail. Occasionally the northeast wind blows in winter, as does also the Mistral. Dr. Hassall ("San Remo, Climatically and Medically Considered," London, 1883) concludes his discussion of the winds by saying that "San Remo, and indeed the whole of the western Riviera, must be regarded as windy. The winds, doubtless on some occasions, interfere with the comfort and movements of some invalids, and they constitute a drawback of what is otherwise an excellent climate; but," he wisely adds,

"one must remember that the winds play a very important part, particularly in warm climates, in purifying the air, and exert also for the most part tonic effects on the system."

The accompanying meteorological table, compiled from data given by Hassall, will convey a fairly accurate idea of the various climatic data for the winter season. It will be seen that the average temperature is a high one and varies but little from month to month, except in April, when it is appreciably higher. The average daily range is moderate, but in the shade and in the early morning and shortly after sunset the air by contrast is cold, and invalids must avoid either suddenly going from the sunshine into the shade or being out after sunset.

The relative humidity is the least—66.7 per cent.—at 3 P.M. The mean number of days on which rain falls is 30, and the mean rainfall 14.05 inches for the whole season. The days on which the sun shines are on an average 164 out of a possible 181, and the mean duration of the sunshine is seven hours and fifty-six minutes. To the inhabitant of northern Europe or the northeastern portion of the United States such an amount of sunshine can hardly be appreciated until experienced. There are many winter resorts, however, in America which afford an equal or greater amount of sunshine, accompanied with a mild temperature. Such are found in Southern California, Arizona, New Mexico, Texas, and in various portions of the pine belt of the South.

The general effect of such a climate as that represented by San Remo is thus portrayed by Dr. Hassall (*loc. cit.*): "Owing to the mildness of the climate," he says, "there is less wear and tear and less strain. The several functions are performed in a more moderate and uniform manner. There being less expenditure of power and less waste, a small quantity of food is required, and the stomach has less work to do. The circulation, in particular the heart and its vessels, is exempt from the strains entailed by extremes of heat and cold, and which in themselves are often injurious and not unattended with danger." The action of the sun on the human body is very complex; the effects are not confined to the warmth derived from its calorific rays; the luminous and chemical rays all exert powerful effects. The sun acts as a stimulant to most of the bodily functions—to elimination, secretion, and absorption; it determines many chemical changes, and promotes sanguification and the coloration or bronzing of the skin."

With regard to the class of invalids likely to be more or less benefited by this climate, the following may be mentioned: those suffering from pulmonary tuberculosis in its inception or not far advanced, unaccompanied with fever; certain more advanced but very chronic cases, especially in persons past middle life, in regard to whom the only hope is to prolong and make life comfortable; those suffering from chronic bronchitis, chronic laryngitis, emphysema, and asthma; cases of diabetes and Bright's disease; persons suffering from rheumatism and scrofula; the feeble and aged; convalescents from acute diseases or from an operation, and all that great army of persons who find existence in the cold changeable climate of the North a constant struggle. The plethoric and those who have a tendency to cerebral hyperemia, those with atheromatous arteries, and those suffering from functional nervous disorders, such as neuralgia, insomnia, or hysteria, should not come here.

San Remo can now be easily and comfortably reached from America by steamer direct to Genoa from New York or Boston. Here, as in all health resorts, the selection of a residence and the manner of life to be pursued can be satisfactorily determined only by consulting a local physician, which should always be the first thing to be done by the invalid on arrival at any health resort. EDWARD O. OTIS.

Santa Catalina Island, Cal.—This very attractive insular resort, with a delightful climate both winter and summer, lies off the coast of Southern California about twenty-five miles distant. It is reached in three hours and a half from Los Angeles by railroad to San Pedro Harbor, and from thence by steamer. The island is twenty-three miles long, and with an average width of four miles in the southern part and two miles in the northern. It is mountainous in character, rising to the height of 3,000 feet, with deep valleys or gorges, and a great transverse depression running partly through it and forming a bay or anchorage on either side. The shores are bold, high cliffs, broken here and there by tiny bays or coves, with a sandy beach. Upon one of these coves, on the eastern side (called Avalon Bay), is situated the little town of Avalon, the only settlement on the island and the chief place of resort. Here are a number of good hotels, many boarding-houses, and, in the summer, tent villages with macadamized streets and rows of shade trees, where furnished tents can be rented—a popular mode of living at this season. There are also opportunities for camping in the many recesses of the island.

The climate exhibits the essential characteristics of that of the shore opposite, modified somewhat by local conditions: the rains here are said to be less frequent than on the mainland, the sea breeze is not so strong, and there is not so much fog. "They (the channel islands, of which Catalina is the principal one) are bathed in sunshine when the mainland opposite is enveloped in fog." The reader is referred to the article upon *Los Angeles* and the meteorological table therein contained for climatic details applicable in the main to the climate of Santa Catalina. The average July temperature at Santa Catalina is 65° F. In August the highest mean temperature observed at six in the morning was 72°; the highest at noon, 78°; the lowest, 69° F. The water temperature at noon, 76° F. The average relative humidity is sixty-seven per cent. It is never uncomfortably warm in summer or too cool in winter. For both seasons it appears to be an admirable climate.

For a summer resort it is very popular and very much visited, and in the height of the season there are often five or six thousand people on the island; indeed, one of the objections to this resort for an invalid is the crowd of summer excursionists. As a genuine health resort it would appear to be more suitable and in many ways more attractive in the winter, for it is then "that the true beauties of this isle of summer are seen. The rains, which, curiously enough, are less than on the mainland, change the brown hills to a vivid green, and we have an emerald in an azure setting. Myriads of flowers spring up, and the face of the island is changed as if by magic. . . In February and through the winter months Catalina is still an island of summer" (C. F. Holden, in *California Magazine*, December, 1892, quoted by Solly).

The outdoor attractions are many and varied. There are golf links in the Grand Canyon; various excursions among the mountains and valleys; a stage road across the island winding along the mountain-side, affording delightful views of sea and land; boating, fishing, and bathing. The fishing is a feature of the place, and here are caught the large black sea bass, the leaping tuna, the yellowtail, and the barracuda. The water is so transparent that the bottom can be clearly seen at a depth of from fifty to one hundred feet, and for this purpose glass-bottom boats are much in use, from which the most varied and fascinating sea vegetation, as well as a variety of fish life, can be seen. There is also wild-goat shooting from horseback in the fastnesses of the mountains.

Altogether, a region affording so many attractions of climate, scenery, water and land sport as that of Santa Catalina can hardly be imagined. Moreover, it has the great advantage of being an all-the-year-

round resort. The sanitary regulations are said to be excellent, being under the supervision of a resident physician and health officer. Especial attention is paid to the sanitary condition and cleanliness of the tent villages. The bathing and swimming in the bay of Avalon are very delightful, both on account of the temperature of the water and on account of the absence of wind and surf.

EDWARD O. OTIS.

Santalum Album.—See *Sandalwood, oil of.*

Santalum Rubrum.—RED SAUNDERS, U. S. P. The heart-wood of *Pterocarpus santalinus* L. f. (fam. *Leguminosæ*).

This article, often called ruby wood or red santal, is the product of a small tree of India, collected chiefly in the Madras Presidency, and now mostly from cultivated plants. The wood is imported in billets three or four feet long and from two to eight or nine inches in diameter, the bark and sapwood having been removed. It is of a bright blood-red color within, but darker upon the surface, becoming at length nearly black with age and exposure. For pharmaceutical use, it is usually cut into chips or rasped into powder. It is almost odorless and has only a slight astringent taste. Its coloring matter is santalin or santalic acid, crystallizing in minute red prisms, soluble in alcohol, ether, alkalies, and a few essential oils, but not in water, which is scarcely colored by red saunders. The article is essentially a dye-stuff, being without physiological or medicinal power and used purely for coloring purposes, as in the compound tincture of lavender, which contains about one per cent. of it.

H. H. RUSBY.

Santa Ysabel Sulphur Springs.—San Luis Obispo County, California. Bath-house. Bungalow.

These valuable springs are located three miles southeast of Paso Robles, on the line of the Southern Pacific Railroad, by which they may be reached. The location is a very delightful one, being in a small canyon about one mile east of the Salinas River. It is surrounded on all sides by the rolling hills covered with groves of gigantic oaks, towering pines, and clustering manzanitas. The atmosphere is sweet and balmy, and ranges from about 60° to 75° F. all the year round. The elevation is 1,000 feet above the sea-level, and the distance from the coast is about thirty miles. The soil of the neighboring land is exceedingly fertile, producing almost every known variety of fruit, as ascertained from the United States Experiment Station close by. The main warm sulphur spring flows 20,000 gallons per hour. The waters are clear and sparkling, lightly sulphureted and freely carbonated. The waters are tonic, antacid, diuretic, aperient, and sedative.

Hypothetical combination.	Parts per million.	Grains per gallon.
Potassium chloride	7.1	0.42
Sodium sulphate	201.3	11.76
Sodium chloride	222.6	13.00
Potassium bromide	Trace.	
Potassium iodide	Trace.	
Calcium phosphate	Trace.	
Calcium bicarbonate	13.4	0.78
Ferrous bicarbonate	11.86	0.11
Magnesium bicarbonate	9.00	0.53
Sodium bicarbonate	552.00	32.24
Silica	52.50	3.07
	1,069.76	61.91

Gases.	Cubic centimeters per liter of water.	Cu. inches per gallon of water.
Hydrogen sulphide	5.3	1.22

The cold springs, being less densely impregnated with mineral ingredients, possess these qualities in a lighter degree than the warm. The waters have been found highly useful in a wide range of affections, embracing disorders of the liver, stomach, and bowels, catarrhal affections of the kidneys, chronic rheumatism, glandular indurations, obstinate syphilitic infection, and chronic cutaneous diseases. There are other valuable springs on the property, including a warm sulphur mud spring. This hot sulphurous mud is excellently adapted for bathing purposes. A devastating fire destroyed the hotel in 1906.

The foregoing analysis of the water of the sulphur spring at the bath-house was made by Professor M. E. Jaffa and Mr. Dennis R. Hogland.

With its natural advantages of climate, soil, and surroundings, Santa Ysabel resort promises to be one of the pleasantest inland watering-places in that section of the country. EMMA E. WALKER.

Santonica, U. S. P.—LEVANT WORMSEED; *Flores Cinæ*, P. G.; *Flores Artemisiæ, Semen Contra, S. Sanctum.* The dried unexpanded flower-heads of *Artemisia pauciflora* (Ledeb.) Weber (fam. *Compositæ*). Although the plant yielding these flower-heads is well known, there is great difference of opinion among botanists as to its specific reference. By many it is regarded as a variety of *A. maritima* L. of southern Europe. The German Pharmacopœia still refers the drug to *A. cina* Berg. The drug is collected in the Turkestan deserts, and most of it, and the best, is at once consumed there in the manufacture of santonin, the percentage of santonica exported being steadily on the decrease. Several related and similar, but hairy products have occasionally been imported from India and Africa, and chenopodium is occasionally sold for it. The drug is also subject, through imperfect cleaning, to the presence of pieces of branchlets and leaves, and dirt of various kinds; yet it is usually clean and of fine quality. It deteriorates readily on being kept, especially if not carefully protected in a closed and dark container. In proportion as the greenish-gray tinge has changed to a brown, it may be regarded as having thus deteriorated. The drug is thus described:

A yellowish green (at length greenish brown) somewhat glossy, mobile mass; having a strong and peculiar, somewhat camphoraceous odor and an aromatic and bitter taste; heads two to four millimeters (one-twelfth to one-sixth inch) long, oblong ovoid, slightly flattened, obtuse, consisting of an involucre of about twelve to eighteen closely imbricated, glandular scales with broad midribs, enclosing four or five rudimentary florets.

With gum, a little resin, and ordinary plant constituents, three specific bodies exist in santonica. Its one and one-half to two per cent. of volatile oil consists chiefly of cineol, and is somewhat like oil of eucalyptus in properties. Santonin, of which there is usually not more than two per cent., as the drug occurs here, is the active anthelmintic agent and is described under that title. A small and variable amount of artemisin occurs, obviously resulting from the oxidation of santonin.

Although santonica possesses, in correspondingly lower degree, the anthelmintic properties of santonin, the latter alone is used for that purpose. As an aromatic bitter, santonica is occasionally used in doses of gr. v.–xxx. (0.3–2.0). There is no official preparation. HENRY H. RUSBY.

Santonin.—*Santoninum,* U. S. P.; Br.; P. G.—$C_{15}H_{18}O_3 = 246.15$. A neutral principle obtained from santonica.

The source of this substance is described under *Santonica.* It is extracted as a compound of lime by boiling in water or macerating in dilute alcohol to which lime is added. The calcium is then separated from the santonin by the addition of acetic or hydro-

chloric acid to the solution, and the santonin is purified by appropriate processes. Although now rarely intentionally adulterated, commercial santonin is very apt to be but imperfectly purified, and to contain artemisin. It is thus described by the Pharmacopœia:

Occurring in colorless, shining, flattened rhombic prisms, or as a crystalline powder; odorless, and nearly tasteless when first put into the mouth, but afterward developing a bitter taste; permanent in the air, but turning yellow on exposure to light. Santonin which has become yellow may be converted into colorless crystals by recrystallization from alcohol.

One gram of santonin dissolves in 43 mils of alcohol, 1.7 mils of chloroform and in 110 mils of ether at 25° C.; also in 6.5 mils of boiling alcohol; very slightly soluble in water at 25° C.; slightly soluble in boiling water.

Its solutions are neutral to litmus and are levorotatory.

It melts between 169° and 171° C.

Heat about 0.5 gram of santonin with five mils of alcoholic potassium hydroxide T.S; a red color is developed.

Shake about 0.01 gram of antonin with a cold mixture of one mil each of sulphuric acid and distilled water, heat the solution to 100° C., and add a minute trace of very dilute solution of ferric chloride; a violet color results.

Incinerate about one gram of santonin; not more than 0.1 per cent. of ash remains.

Two mils of sulphuric acid added to about 0.1 gram of santonin produces not more than a faint, yellow color (*readily carbonizable organic impurities*).

Boil about two grams of santonin with eighty mils of distilled water and five mils of diluted sulphuric acid, allow the liquid to become cold and then filter it. The addition of mercuric potassium iodide T.S. or of iodine T.S. to ten mils of the filtrate, mixed with ten mils of distilled water, produces no cloudiness, even after standing for three hours (*alkaloids*).

Action and Uses.—Although santonin produces very pronounced and in some ways remarkable physiological effects, it is very little used in those directions. It is actively diuretic, the action being dependent chiefly if not wholly upon local irritation, for it is excreted by the kidney. On this account it is occasionally employed as an emmenagogue. The urine is at the same time colored yellowish brown, or, if decomposed, purplish red. Upon the centers it acts as a motor excitor, this action being followed by depression, and there are evidences of cerebral congestion. Vision is most strongly and peculiarly affected, all objects appearing yellow or greenish yellow, sometimes bluish at first.

It is occasionally administered in small doses, one-half to one grain, for correcting dimness of vision, especially that resulting from tobacco poisoning. With this exception, its sole use is that of an anthelmintic, destroying lumbrices and ascarides, especially the former. Advantages possessed by it over most other anthelmintics are its small bulk, freedom from bad taste, and availability for use in the form of confections, which are easily administered to children. Also in its favor is its slight solubility, on account of which it remains in the intestine sufficiently long to act upon the parasites and is then dejected without entrance into the circulation. This property cannot, unfortunately, always be depended upon, since, for reasons but little understood, it sometimes becomes unexpectedly absorbed, with poisonous effects. It must therefore be given with caution, and its effects should be kept under observation by the physician. Its administration should in all cases be followed by a cathartic, chiefly in this case as a precaution against poisoning. Unlike some poisonous substances, its absorption is not favored, but rather inhibited, by fats. Great caution should be observed in administering it to very young children. The dose of santonin for a child of five or six years is gr. ss. to gr. i. (0.03–0.06). Adults may take from gr. ij. to gr. iv. (0.12–0.25). Henry H. Rusby.

Santonin-oxim.—A derivative of santonin, obtained by the action of hydrochlorate of hydroxylamine, in alcoholic solution, upon santonin. Its chemical formula is $C_{15}H_{18}O_2NOH$, that of santonin being $C_{15}H_{18}O_3$. It is a white crystalline substance, having a melting-point of 323° F. It is scarcely soluble in water, but soluble in alcohol and ether, and in weak alkaline or weak acid solutions.

Santonin-oxim is recommended as a substitute for santonin, as it is said to be free from any toxic properties. This is explained by the statement that it is not absorbed from the alimentary canal. The dose as an anthelmintic is the same as santonin.

Beaumont Small.

Santorini, Giovanni Domenico.—Born at Venice, Italy, in 1681. His early studies in medicine were conducted under the guidance of Malpighi and Bellini, who very soon recognized his special aptitude for the work. In 1703 the Physico-Medical College of Venice promoted him from the position of agrégé to that of full Professor of Anatomy. His lectures were very popular, and they continued to attract large audiences up to the time of his death in 1737.

Santorini, according to the statement of Dezeimeris, belongs to that small number of anatomists whose published works are more and more appreciated for their accuracy the more frequently one has occasion to consult them for information with regard to points of special interest or with regard to matters concerning which one happens to be particularly well informed. Not a few of Santorini's works became known to the public only after he had been dead a long time. A number of anatomical structures bear Santorini's name, such as Santorini's cartilage, S.'s concha, S.'s dust, S.'s muscle, S.'s veins, etc. Of his published writings the following deserve to receive special mention: "Observationes anatomicæ," Venice, 1724 (Leyden, 1739); and "Jo. Dom. Santorini septemdecim tabulæ, quas nunc primum edit atque explicat, iisque alias addit de structurâ mammarum et de tunicâ testis vaginali Michael Girardi," Parma, 1775. A. H. B.

Sapo.—Soap.—When natural fats or oils are decomposed by treatment with salifiable bases, they split up into the alcoholic body *glycerin* on the one hand, and a series of *acids* on the other—principally oleic, palmitic, and stearic acids, in varying proportions, according to the nature of the fat, which acids then unite with the base used in effecting the decomposition of the fat, to form salts—oleates, palmitates, or stearates, or all combined, as the case may be. Such salts are generally called *soaps*, but in common parlance the name soap is applied only to the fatty salts of the alkalies—potassium, sodium, and ammonium—which, in contradistinction to the soaps derived from earthy and metallic bases, are soluble in "soft" water and in alcohol. Of the alkali soaps, furthermore, ammonium soap is used only in the preparation called *ammonia liniment*, or *volatile liniment* (see *Ammonia*), so that the soaps in common use as such are narrowed down to sodium and potassium soaps.

Between sodium soaps and potassium soaps, as distinct classes, the broad distinction is that sodium soaps tend to be comparatively hard, and potassium soaps soft, so that the phrase *hard soap* is applied generically to sodium soaps, and *soft soap* to potassium soaps. But the consistence of soaps is also markedly affected by the nature of the fat used in the manu-

facture in the way that fats rich in olein, as is the case with oils, tend to yield softish soaps, whereas those rich in stearin and palmitin, typified by the solid fats, such as tallow, furnish soaps of greater consistence.

Soaps are bodies of a well-known characteristic odor and disagreeable alkaline taste. They dissolve in alcohol and in "soft" water, but in "hard waters they suffer decomposition by the calcium salts present, and the resulting lime soap floats in insoluble flocculi on the surface of the water. Soaps are, in general, decomposed by acids, by earthy bases and salts of the earths, and by the heavy metals. The useful property of soaps is that they attack grease, dirt, and dried animal débris, probably by virtue of their free alkalinity, and so affect those substances as to render them soluble in water, and thus readily removable.

The kinds of soap official in the United States Pharmacopœia for use in technical medicine are as follows: Under the simple title, *Sapo*, Soap, is recognized "soap prepared from sodium hydroxide and olive oil." Such a soap corresponds to what is commercially called *Castile*, or *Spanish*, soap, and is an opaque, white substance, hard, but when fresh easily to be cut. It has the simple, characteristic smell of soap and an unpleasant alkaline taste. It dissolves readily in water and in alcohol. If the soap, as first separated in the making, be not purified, it presents a marbled appearance from contaminating streaks of an insoluble iron soap. This unpurified soap is stronger than the purified, white soap, since in the process of purification the soap combines with more water.

Castile soap is locally detergent, and, by virtue of its free alkalinity, mildly irritant to tender surfaces. Taken internally, it is innocent in moderate quantity, and tends only to relax the bowels and neutralize acid in the *primæ viæ*. Locally, free ablutions of soap and water are beneficial in certain forms of skin disease, such as acne, and, as regards internal giving, the principal application of soap is as a ready and innocent alkali to administer in cases of poisoning by any of the strong acids. A strong aqueous solution —one part of soap to four or five of water—should in such cases be very freely administered pending the arrival of more powerful and appropriate alkaline antidotes. Soap and water is also much used as a cathartic enema, but in sensitive conditions of the rectum may irritate. Pharmaceutically, soap is much used as an excipient in pill composition, but due regard must be paid to its chemical susceptibilities, as above detailed. From Castile soap are made the following official preparations: *Emplastrum Saponis*, Soap Plaster, is compounded of soap, one part, and lead plaster, nine parts, mutually incorporated when in the fluid condition, and the product evaporated to the proper consistence. Soap plaster is a feebly active plaster, devoid of specific medicinal properties. *Linimentum Saponis*, Soap Liniment, is compounded of soap and camphor with a little oil of rosemary, made into a liniment with dilute alcohol. This preparation makes an excellent gently stimulant embrocation, and takes the place of the *camphorated soap liniment*, or so-called *opodeldoc* of older revisions of the Pharmacopœia, an article substantially the same in composition as the present, but prepared from the common white soap made of animal fat, instead of from Castile soap.

The second variety of official soap is entitled *Sapo Mollis*, Soft Soap, and is made from potassium hydroxide and linseed oil. It is a soft, unctuous substance of a brownish-yellow color. *"Green soap"* or *"German soap"* is a soft soap made in Europe and formerly imported into America. Its greenish color is due to impurities in the oils from which it is made.

Soft soap is more strongly alkaline, and therefore more detergent on the one hand, and more irritating to sensitive tissues on the other, than the hard sodium soaps. Severe pain is easily excited upon tender surfaces, such as that of an eczematous patch of skin, by applications of soft soap. The medicinal use of the soap is as a detergent and "alterative application in certain forms of skin disease, notably in eczema rubrum. The part is commonly washed with the soft soap, and afterward dressed with some bland substance, such as ointment of zinc oxide, From soft soap is prepared the *Linimentum Saponis Mollis*, Liniment of Soft Soap, of the U. S. P.; this is the well-known Tincture of Green Soap.

EDWARD CURTIS.
R. J. E. SCOTT.

Saponaria.—SOAP ROOT, *Soapwort.* "Bouncing Bet." (*Saponaire officinale*, Cod. Med.). The dried root of *Saponaria officinalis* L. (fam. *Caryophyllaceæ*). This plant is a well-known European perennial herb, freely naturalized in North America, and often a troublesome weed around the edges of gardens, along roadsides, and in rich waste places. It is about two feet high, with ovate, opposite, usually sessile, three- or five-nerved leaves, and cymes of large whitish or pink flowers terminating the branches. All parts of the plant, but especially the roots, contain saponin in large amount, and its properties are very similar to those of soap bark, considered above, though it is scarcely so active as that drug. It is commonly employed in the household in the form of a viscous, suds-like solution for washing or sizing. It is also more or less employed, though less than formerly, as a stimulating expectorant, like senega, or as an alterative, like sarsaparilla. The ordinary dose is ʒss.–ii. (2.0–8.0), and it is mostly employed in the form of the decoction, one ounce to the pint.

Levant soap root, from various species of *Gypsophila*, of the same family, occurs in pieces of a large root, often two inches in thickness, of a pale yellowish- or brownish-white color. Its constituents, as well as its properties and uses, are similar to those of the ordinary soap root. It is rather more active, however, than the latter. Many other related plants have a similar composition and use.

HENRY H. RUSBY.

Saponification.—Fats are ethereal salts and when fats are decomposed by means of an alkali they are said to be saponified, *i.e.* transformed to soap. Saponification is therefore the decomposition of an ethereal salt by means of an alkali into the corresponding alcohol, usually glycerin, and the alkali salt of the acid contained in the ethereal salt. The term saponification has come to mean not necessarily the formation of a soap, but the hydrolysis of a fat, whereby glycerin and a fatty are produced. Thus tripalmitin would yield glycerin and palmitic acid.

$$\underset{\text{Tripalmitin}}{C_3H_5(OC_{15}H_{31}CO)_3} + 3H_2O = \underset{\text{Glycerin}}{C_3H_5(OH)_3} + 3C_{15}H_{31}.COOH.$$
Palmitic acid

This hydrolysis may be induced by steam under pressure, long-continued contact with air and light; by the action of certain bacteria and by fat-splitting enzymes or lipases. F. P. UNDERHILL.

Sappey, Marie Philibert Constant.—Born at Cernon, France, in 1810. He studied medicine at the University of Paris and received his doctor's degree in 1843. Not long afterward he was made an Agrégé of the Surgical Sciences and Chief of the Department of Anatomical Work. In 1860 he began to deliver lectures on anatomy, and in 1868 he was

chosen Professor of Anatomy, as the successor of Jarjavay. In 1887 he was elected President of the Academy of Medicine of Paris. He died March 15, 1896.

Sappey was one of the leading anatomists of France in the nineteenth century. His skill in making permanent anatomical preparations was quite extraordinary, and the work which he did in elucidating the anatomy of the lymphatic system entitles him to receive great credit. Of his published writings the following are specially worthy of mention: "Traité d'anatomie descriptive, avec figures dans le text," 3 vols., 1847–63 (a second edition in 4 vols. was published during the years 1867–74); "Recherches sur la conformation extérieure et la structure de l'urèthre de l'homme," 1854; "Anatomie, physiologie, pathologie des vaisseaux lymphatiques considérées chez l'homme et les vertébrés," 1874; and "Atlas d'anatomie descriptive," 1879. A. H. B.

Saranac Lake.—See *Adirondacks.*

Saratoga Springs.—Saratoga County, New York.

Post-office.—Saratoga. Hotels, boarding-houses, and cottages.

Access.—Saratoga is a station on the Delaware and Hudson Railroad, thirty-nine miles north of Albany and 183 miles north of New York. The trip may be made by steamers on the Hudson River to Albany or by lines of railroads, the New York Central and the West Shore to Albany, thence via Delaware and Hudson Railroad. Through trains run daily from New York during the season. From Buffalo and the West Saratoga is reached by way of the Delaware and Hudson Railroad and its Western connections, and from Boston and the East via the Boston and Maine Railroad to Albany and thence via the Delaware and Hudson Railroad. Automobile roads connect Saratoga with many points.

This famous resort has been perhaps, and probably will be again, the most celebrated watering-place in the United States, as it is undoubtedly in the Northern States, and it is, with the exception of Berkeley Springs in Virginia, the oldest in the country. The village is situated toward the eastern border of the State, at the southern termination of the Adirondack range of mountains, and at about the center of a valley extending from Ballston to Quaker Springs. The altitude of Saratoga is about 300 feet above the sea level, and the population is about 13,000. The accommodation for visitors of all classes is ample and excellent. The name Saratoga is derived from the Iroquois tribe of Indians, the word Saraghtoghie being said to signify "place of salt," and there is ample evidence to show that some of the springs here were known to and used by the aborigines many years prior to the advent of the European settlers. The well-known High Rock Spring on Willow Walk was apparently the first of these springs to be used by the whites. It is said to have been resorted to by Sir William Johnson as early as in 1767. In 1783, General Schuyler cut a roadway to the spring through twelve miles of forest, and thereafter the locality was visited by many notable people.

Saratoga presents many attractions besides the mineral springs and the grand hotels. The village has numerous elegant private residences, densely shaded streets, attractive walks, and beautiful drives. In the charming village park of ten acres are terraces, groves, lakes, the Italian Garden, the Congress and Columbian Springs, the Casino and the Trask Memorial. There are "three small State Reservation Parks in the Village; one surrounding the historic High Rock Spring and great cone of tufa, revealed to the White Man by the Indians in 1767; besides the forty-five-acre Lincoln Park and the 250-acre Geyser Park, two miles distant, wherein are many spouting and bubbling springs, a mile of Coesa Creek, and other attractive features." Among the numerous attractions in the neighborhood are the Saratoga Lake, nine miles long and four or five miles wide; Prospect or Waring Hill, said to rise 2,000 feet above the sea level; Chapman's Hill, and Hagerty Hill. Bemis Heights, the scene of the surrender of Burgoyne to General Gates, is in the town of Stillwater, fifteen miles distant. All these points and many others may be easily reached from Saratoga by carriage or by automobile.

The predominant ingredients of the Saratoga waters, as will be seen from the analyses, are the chloride of sodium, the alkaline carbonates, and carbonic acid gas. Some of them are, furthermore, quite heavily impregnated with iron. All contain one or more of the salts of lime. Owing to lack of space we shall be able to give the analyses of only a few of the 160 wells, bores and springs that the State now owns:

To quote from Dr. Albert Warren Ferris, superintending director of the Commissions of the State Reservation:

"*The mineral springs supplying drinking waters*, all alkaline-saline, are comprised within four principal classes: Laxative or cathartic waters, alkaline-saline with alkalinity comparatively predominating, chalybeate or iron waters, and table waters, all containing over 1.35 volumes of carbonic acid gas in solution, and therefore supersaturated.

"The saline-laxative or cathartic waters include Hathorn No. 1, Hathorn No. 2, Hathorn No. 3, Coesa, Peerless, Emperor, Congress No. 2, and Orenda. Hathorn No. 1 is the deservedly celebrated 'Hathorn,' laxative, alterative and tonic; Hathorn No. 2 and No. 3 have the same virtues in general, with greater mineralization and cathartic qualities; Coesa resembles Hathorn No. 1, but contains much more sodium chloride, more lithia and more bicarbonates; Peerless and Emperor are much less laxative and half as saline as Coesa, and contain more bromides, and the Emperor has one-fifth as much bicarbonate of sodium as Coesa; Congress No. 2, one of the famous bores of that name, has about half as much sodium chloride and a fifth less alkalinity than Hathorn No. 1, and is a very mild laxative, suitable for those who need mineral water repeatedly during the day; Orenda (formerly known as "Adams") is of surpassing merit as a laxative, tonic, chalybeate and alterative. Orenda is a fine-flavored water, full of gas as it issues from the earth, bearing an analysis very closely resembling that of the old Congress Spring water when it was at its best, forty or fifty years ago, fully as efficacious, and destined to become fully as popular.

"The alkaline-saline waters, those with increased alkaline content, comprise Geyser, Zalama, and Minnonebe. Geyser contains more sodium bicarbonate than sodium chloride, with more iron than most of the waters and a low magnesium content. Zalama (formerly "Clark No. 1") is used only for scenic effect, as a spouting spring. Minnonebe is mentioned later.

"The chalybeate or iron waters comprise Flat Well No. 2, New Red and Columbian. Flat Well No. 2 is a fairly strong saline, rich in calcium, and assays a large iron content. New Red is low in salinity, moderately calcic and chalybeate, now unavailable. Columbian is very lightly saline, lightly magnesic and calcic, and contains iron in small quantities.

The table waters comprise two springs; Geyser, already described and shown to be somewhat diuretic, and Minnonebe, with a larger proportion of sodium bicarbonate to total solids than any other of our waters, a low magnesium content, fair proportion of calcium and of chloride of sodium, and small iron assay, presenting a valuable water for use with meals, as an appetizer and assistant to digestion. The

TABULATED STATEMENT.

Of the Results of Analyses of Mineral Waters at Saratoga Springs, N. Y.

Made by the State Department of Health for the Commissioners of the State Reservation at Saratoga Springs.

Chemical Combinations.	Columbian.	Emperor.	Peerless.	Hathorn No. 1.	Hathorn No. 2.	Hathorn No. 3	Coesa.
Ammonium chloride	5.15	11.77	13.04	23.74	62.41	48.70	35 83
Lithium chloride	3.70	24 94	9.18	27.55	76.53	70.82	39.64
Potassium chloride	82.93	198 70	248.88	503 50	958.50	756 30	609 18
Sodium chloride	295.59	2,429.03	2,249.30	3,662.99	10,652.45	9,124.69	5,043 53
Potassium bromide	12.00	17.00	16.00	22.00	69.20	51.66	29.67
Potassium iodide	0.10	0.50	1.20	1.50	3.33	2.10	1.36
Sodium sulphate	59.34	4.88	21.30	6.54	5.48	10.04	8.37
Sodium metaborate	trace	trace	trace	trace	trace	trace	trace
Sodium nitrate	2 43	0.12	trace	0.12	trace	trace	trace
Sodium nitrite	trace	trace	trace	trace	trace	trace	trace
Sodium bicarbonate	358.76	169.83	590.16	490.05	697.75	526.32	850.34
Barium bicarbonate	2.00	2.44	6 44	10.45	56.66	34.70	13.56
Strontium bicarbonate	0.23	trace	0.68	trace	2.28	1.14	2.74
Magnesium bicarbonate	446.29	884.58	948.45	1,335.59	2,844.70	2,426.67	1,501.22
Calcium bicarbonate	878.58	2,069.59	2,059.20	2,288.92	3,991.18	3,504.67	2,786.01
Ferrous bicarbonate	29.24	13.61	12.34	27.26	21.37	18.34	25.48
Mangano-manganic oxide	none	trace	trace	none	trace	none	trace
Alumina	3.14	10.79	11.46	1.77	24.41	21.77	1.18
Silica	47.80	13.95	15.00	12.75	17.60	10.50	8.50
Total solids in solution	2,227.28	5,851.73	6,202.63	8,414.73	19,483.85	16,608 42	10,956.61
Temperature	8° C.	10° C.	9.5° C.	10° C.	11° C.		10° C.
Date of taking sample	1913 April 9	1912 June 19	1913 April 2	1914 May 18	1913 April 30	1913 Feb 6	1912 Dec. 13.

Chemical Combinations.	Orenda.	Zalama.	Minnonebe.	Geyser.	Flat Well No. 2.
Ammonium chloride	34.96	6.24	30.97	39.40	57.13
Lithium chloride	31.17	7.10	7.64	16.75	31.63
Potassium chloride	696.79	138.47	292.48	246.84	508 48
Sodium chloride	5,165.89	616.20	1,193.93	1,951.08	6,470.17
Potassium bromide	44.00	1.20	25.00	20 00	38.50
Potassium iodide	2.20	0.20	1.25	1.00	1.90
Sodium sulphate	4.10	7.00	5.78	19.36	4.26
Sodium metaborate	trace	trace	trace	trace	trace
Sodium nitrate	0.12	trace	trace	trace	trace
Sodium nitrite	0.015	trace	trace	trace	trace
Sodium bicarbonate	489.36	308.32	1,726.13	2,238.22	859.14
Barium bicarbonate	21.78	4.44		7.78	12.44
Strontium bicarbonate	4.56	1.37	trace	1.14	3 66
Magnesium bicarbonate	1,672.16	305.41	591.36	704.24	1,499.91
Calcium bicarbonate	2,606.83	1,137.96	1,155.96	1,728.78	2,786.01
Ferrous bicarbonate	20.00	13.90	17.49	30.08	849.00
Mangano-manganic oxide	trace	none	trace	heavy tr.	trace
Alumina	10.63	5.37	6.15	4.48	132.59
Silica	12.00	11 60	31.00	14.80	56.55
Total solids in solution	10,816.70	2,564.78	5,085.14	7,023.95	13,311.37
Temperature	11° C.	10.5° C.	10° C.	10° C.	10.5° C.
Date of taking sample	1913 May 14	1912 Dec. 16	1913 July 10	1912 July 3	Oct. 9, 1912, and partial, 1914

The results of the analyses are expressed in milligrams per liter. The waters of all the springs are at normal atmospheric temperature and pressure, supersaturated with carbonic acid gas.

Minnonebe is one-half as strong in alkaline carbonates as the Grande Grille French Vichy."

The Mineral Springs Supplying Bathing Waters.—The High Rock, Peerless, and Emperor are blended and used at the High Rock Bath House. The Hathorn No. 1 is supplied to the Saratoga Baths.

At the Saratoga Baths there is a large room exclusively used for the convenience of local and visiting physicians, where reports of the State Reservation Commission, geological charts, specimens of Saratoga rock, tufa from springs, geological bulletins published by the United States Government and by New York State, pictures of certain foreign spas, road maps, and so on, may be examined, and where all physicians are welcome.

The Laboratory of the State Reservation at Saratoga Springs, preserving close relations with the Laboratories of the State Department of Health, is in the large Hathorn Building, and here the analyses of the waters are made, as well as the bacteriological examinations, assaying of rock and mineral, and also determination of carbonic acid gas and of degree of radioactivity presented by the different waters. The radioactivity of Saratoga Waters is due to dissolved radium salts, to an unusual degree, as stated by the chemists of the United States Bureau of Mines, and is therefore persistent.

"The mineral waters used for bathing are especially useful in certain heart and arterial disorders and degenerations, nerve fag (neurasthenia), exhaustion following acute disease or surgical operations, in alcoholic or drug addiction, in gout, rheumatism, and arthritis, and in reducing obesity.

"The mineral waters used for drinking are principally useful in digestive disorders, certain stages of kidney disease, in anemia, and, partly because of the

radioactivity present, in gout, rheumatism, and arthritis."

The commission is equipping a building with appliances for giving the Nauheim treatment. This bathhouse is situated in Lincoln Park and is called the Lincoln Bath House.

In number and quantity of output, the springs at Saratoga probably have no equal in any other locality. When the State of New York develops its extensive plan for this great American spa, Saratoga Springs will afford opportunities for the practice of hydrotherapeutics equal to any other in the entire world. EMMA E. WALKER.

Sarcocystis.—A genus of sporozoan parasites. They infest the muscles, where they appear as elongated white bodies. Nine species are known, *S. lindemanni* being found in man. See *Protozoa*.
A. S. P.

Sarcodina.—A class of protozoans which includes all those which move and capture food by means of pseudopodia. It is subdivided into the Rhizopoda (amœbæ and foraminifera), Heliozoa, and Radiolaria. Many species are parasitic. See *Protozoa*.
A. S. P.

Sarcoma.—*Definition.*—Sarcoma is a term which has become established by long usage and one the significance of which is quite generally understood by the medical profession. It is employed broadly to designate non-epithelial tumors of malignant character, and in a more restricted sense to designate malignant tumors of mesenchymal or connective-tissue origin such as fibrosarcoma, chondrosarcoma, osteosarcoma and myxosarcoma. In the present article the broad definition will be adopted.

CLASSIFICATION.—In order to distinguish various types of tumors it is important that each be designated by name. It also appears desirable by collecting tumors into groups to show their genetic relationship and also indicate their structural and biological characteristics. Certain of the so-called classifications consist merely of lists of names which have appealed to the individual author. A list of names cannot be accepted as a classification. There has been a notable attempt to indicate, by the name applied, the genetic origin only of a tumor. Such nomenclature when carried out consistently proves unsatisfactory to the practising physician in that it may fail to furnish the desired information as to the biological nature of a given tumor. There is, however, no contraindication to the use of names which indicate the genetic origin of tumors provided that they are of such character as to indicate also their peculiarities of structure and behavior.

The only discoverable principle in recent attempts at tumor classification consists in the rationalization of terms on the basis of genetic origin. Several difficulties are, however, encountered. Confusion arises from lack of agreement with respect to origin. Names which to one author appear appropriate to another appear as misnomers. The ease with which names are coined and the failure to respect those in general usage tends to weary the patience of the profession, as old and familiar tumors continue to present themselves so to speak under aliases. Priority and general usage with respect to tumor nomenclature appear to have been quite generally disregarded.

Under such conditions it is obviously out of the question to expect to furnish a classification which will find general acceptance. It is to be hoped that some agreement may be reached by representative societies and institutions concerned in the study of tumors, and certain rules adopted for guidance in tumor classification which will comply with those of other branches of science and lead to the greater accuracy of statistical data. The following scheme is thus offered tentatively for the purpose of showing the possibilities and the importance of classification. Since all tumors are derived from *zoölogical* (possibly also *botanical*) species, it appears necessary in order to indicate further subdivisions, to reduplicate to some extent the grouping employed in zoölogical classification.

The tissues of a species may be organized to constitute an individual of the ordinary type or atypically organized to constitute a neoplasm.

Neoplasms may be divided into three groups or subclasses on the basis of the number of tissues which enter into their composition (Adami[1]). We then have *Teratomata*, composed of tissues derived from all three germ layers: *Teratoblastomata* composed of different types of tissue without all three germ layers being represented: and *Blastomata* or *Simple tumors* composed of a single tissue. Virchow[2] divided new growths into *Teratoid*, *Organoid* and *Histoid* tumors.

Blastomata will then fall into two or more divisions on the basis of their structural characteristics, those composed of epithelium as *Adenoma* and *Carcinoma* and those composed of cells of a non-epithelial character together with their products as *Fibroma*, *Sarcoma*, etc. Certain authors would include the endothelial with the epithelial, others with the non-epithelial tumors, and others would probably prefer to place them in a separate class. It should be pointed out in this connection that certain histologists (Lewis and Stöhr[3]) define endothelium as a form of epithelium. This division into epithelial, endothelial and non-epithelial may ultimately prove too arbitrary for final adoption but serves a distinct purpose for the present. It may possibly be preferable to substitute for these classes, others based on origin from the primitive embryonic tissues.

The non-epithelial tumors may be further subdivided into *orders* based to some extent on the generic origin but more especially on the differentiation of the tumor tissue.

Genera, in recognition of a terminology which has become quite generally adopted, must be based to a large extent on the biological peculiarities of the new growth, especially those relating to malignancy. It is necessary to discriminate between *true malignancy* based on the biological character of the tumor and *pseudo-malignancy* based on the situation of the tumor. A fibroma of the intestinal wall causing intussusception and death would serve as an example of the latter. Peculiarities other than these may be used in distinguishing genera and there is also no adequate reason for making all generic names of a single formal type.

The specific and variety names may be made to conform if desirable with the site of origin and with the additional peculiarities of the tumor, for example "*Carcinoma uteri*, var. *alveolare*."

The term *Sarcoma* will then apply to a number of *genera* which may be distinguished on the basis of a prefix indicating their generic origin, or it may be used without prefix to indicate a non-epithelial malignant tumor which does not show sufficient differentiation to classify more specifically. It may also be used to designate in a general way other malignant non-epithelial tumors to which some name other than sarcoma has been applied.

Class (I. Organized Tissues)
II. Neoplasmata
Subclass I. Teratomata)
(II. Teratoblastomata—Congenital Mixed Tumors)
III. Blastomata
Division (I. Epithelial Tumors)
(Endothelial Tumors?)
II. Nonepithelial Tumors
Order I. Fibroblastomata
Genus (1. Fibroma)
2. Sarcoma—round-cell, spindle-cell, etc.
3. Fibrosarcoma
II. Myxoblastomata
(1. Myxoma)
2. Myxosarcoma

III. Chondroblastomata
(1. Chondroma)
2. Chondrosarcoma
IV. Osteoblastomata
(1. Osteoma)
2. Osteosarcoma
V. Melanoblastomata
1. Melanoma, Melanotic sarcoma
VI. Leiomyoblastomata
(1. Leiomyoma)
2. Leiomyosarcoma, Malignant leiomyoma
VII. Rhabdomyoblastomata
1. Rhabdomyosarcoma, Rhabdomyoma
VIII. Lymphoblastomata
(1. Lymphoma, Lymphoblastoma)
2. Lymphosarcoma, Malignant lymphoma
3. Hodgkin's Disease?
IX. Myeloblastomata
1. Chloroma?
2. Myelogenous Leukemia?
3. Myeloma? (Possibly belonging with the lymphoblastomata)
X. Neurogliablastomata
1. Glioma
XI. Neuroblastomata
1. Neuroblastoma
XII. Chordoblastomata
1. Chordoma.

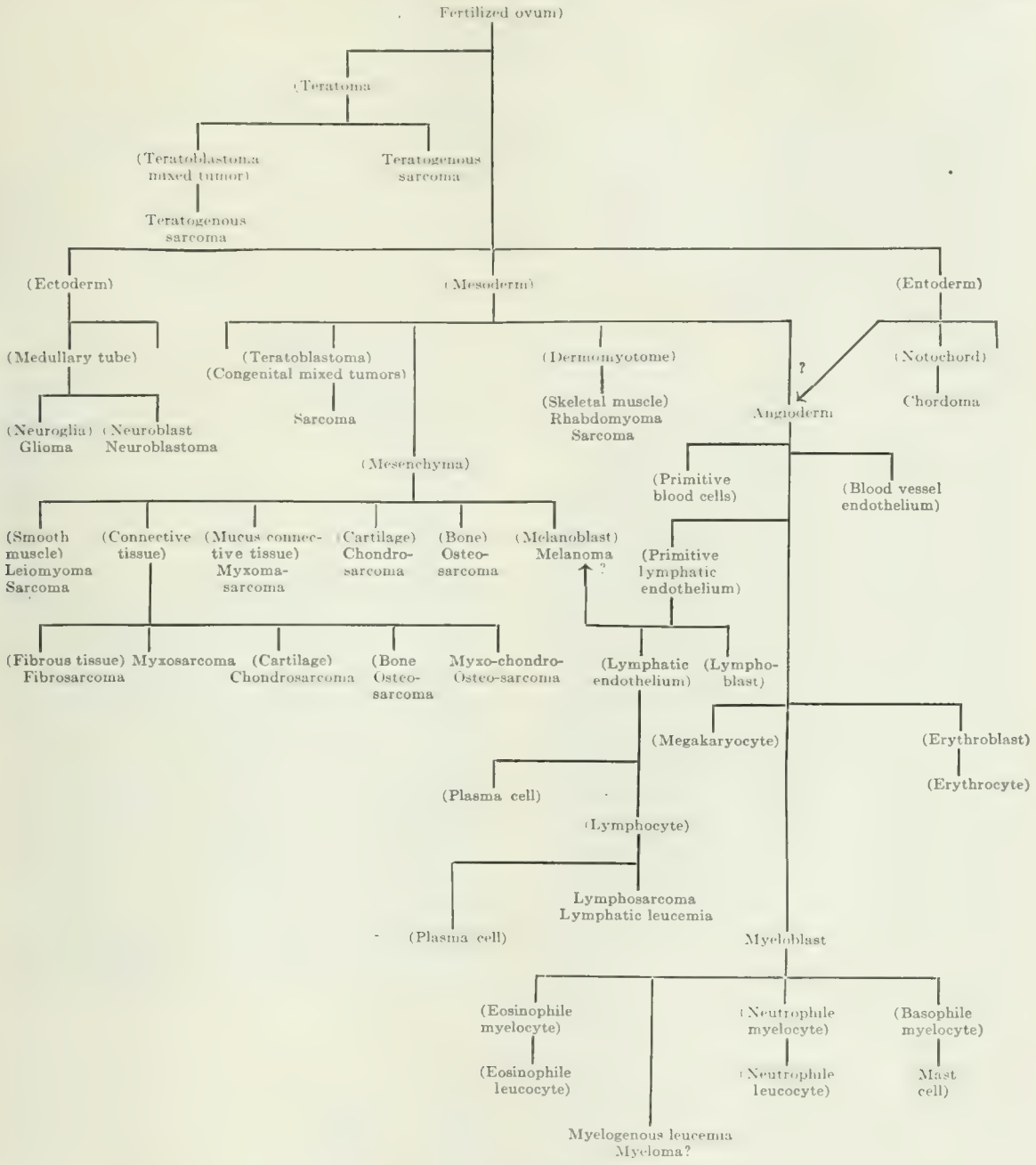
The above system of classification will be found to possess the advantage of a considerable degree of elasticity since any generic name which it may prove desirable to adopt may be included. It should be noted that this scheme is not carried to completion with respect to tumors other than sarcomata, although the more important branches are indicated in parenthesis. The author prefers not to substitute *blastoma* for the older ending *oma* in the generic names applied to tumors except possibly in a few instances. The former renders the terminology more cumbersome without adding proportionately to its explicitness. The term *carcinoma* for example has been in use for considerably over 2,000 years. To many minds it is a misnomer but this is also true of a great proportion of scientific names. Its meaning is so generally understood that it would be unnecessary to define it for the majority of the medical profession, so that there appears to be no justification for the substitution of the term *Epithelioblastoma* for this older and well-established name.

The following diagram (page 641) will indicate roughly the possible lines of differentiation of the various tissues concerned in the development of sarcoma. It will be noted that the tumors to which the term sarcoma is commonly applied are for the most part of mesodermal origin. The connective tissue even in adult life is capable of differentiating further along several different lines and this serves to explain satisfactorily the mixture of type seen in certain tumors of connective tissue origin. Apart from this there is apparently no departure from the regular lines of differentiation and the mixed tumors (teratoblastomata) evidently arise from primitive cells rather than from metaplasia of differentiated cells. Sarcoma of *teratogenous* origin occurs as the result of rapid growth of a nonepithelial tissue from a teratoid tumor. Sarcoma may also occur mingled with an epithelial tumor evidently of independent genetic origin, the so-called *Carcinoma sarcomatodes*. Such an occurrence is rare but has been noted in the thyroid, the uterus and the kidney. In the breast sarcoma has been known to develop from the stroma of Adenomata. The excessive growth of connective tissue in the intracanalicular forms is well known and is believed by many to be excited by products of the abnormal glandular epithelium with which it is in contact. Tumors are frequently met with in the mammary gland of the dog, in which cartilage as well as actively growing connective tissue and epithelium are intermingled. It is of interest to note that the successive transplantations of carcinomata of mice to other normal mice have in some instances been attended with unusual proliferation of the connective tissue surrounding the implant which finally resulted in sarcoma. Thus in the course of the transplantation, a mixture of carcinoma and sarcoma was first obtained and later through the disappearance of the epithelial tumor a sarcoma which could be continuously transplanted. [4, 5, 6]

Etiology.—Little is known concerning the causation of sarcomata whether they are considered collectively or individually. In certain types of sarcoma especially those originating in or around bones, there is frequently a history of acute injury immediately preceding the appearance of the tumor. When the probabilities of the coincidence of injury and of the appearance of sarcoma are taken into account in view of the distribution of each with respect to time and position, it is apparent that a certain number of such cases could very well occur on the basis of chance distribution irrespective of causal relationship. The evidence that sarcoma did not previously exist as radiographs have shown in a case of fracture of the bone, together with the subsequent appearance of sarcoma at the site of the fracture cannot, however, fail to carry weight. In case there is strong evidence that an acute injury is a factor in the development of sarcoma, the relatively greater importance of the peculiarity of the individual tissue should not be ignored. It is possible for the most perplexing questions to arise from the medicolegal aspect of such cases. The matter resolves itself into questions as to whether liability should apply to secondary or remote as well as to direct or immediate effects of injury, and as to whether it should hold in case the effect of the injury is modified by the peculiarity of the individual so that an injury which would not be serious for the great majority is in the case in question disabling or fatal. The modification, through internal environment, of the reaction of tissue to injury may have a definite bearing on this question. From the researches of Loeb[7] it has been shown that injury or foreign body affecting the uterine mucosa will under certain conditions stimulate cells to rapid growth and division so that placental tissue is formed, but, for this to take place, an internal secretion derived from the corpus luteum is necessary in addition to the injury. It has been suggested that in the occurrence of certain sarcomata following injury, there is similarly an internal determining factor.

As with carcinoma there are also with sarcoma a number of questionable or border-line conditions. Frequently there is a difference of opinion among investigators as to whether a condition should be considered a sarcoma or an inflammatory condition. Many consider *Mycosis fungoides* as an inflammatory condition, others regard it as a new growth.

An understanding of the etiology of such conditions usually serves to separate them from true tumors. On the other hand, bacteria-free and cell-free filtrates from chicken sarcoma have been found by Rous[8] to have the property of stimulating the tissues of normal chickens to grow in a manner characteristic of neoplasms. The filtrates of various types of chicken sarcoma produce on inoculation tumors identical with the original and chondroma, spindle cell and other varieties of sarcoma are propagated true to type in this way. Whether the etiological agent present in the filtrate is of the nature of a virus or of a chemical substance is probably not yet finally determined. These results are remarkable in that they appear to be dependent on some peculiarity in the reaction of the tissues of birds, for they do not apply to the etiology of the mammalian tumors thus far studied. The author,[9] in the course of the study of a transplantable sarcoma of the mouse which has been propagated in a large number of mice in the course of several years without failure in any instance, has filtered an emulsion of ground tumor through two layers of filter-paper and



employed the filtrate to inoculate normal animals. Although the filter was not sufficiently fine to hold back red blood corpuscles, in no instance has an animal inoculated with this filtrate produced a tumor. Certain lesions, such as those of Verruga peruviana,[10] which are demonstrably due to an infectious agent appear both grossly and microscopically like true tumors, in the above disease like capillary hemangiomata.

Age.—Senility is apparently a less important factor in the incidence of sarcoma than in the case of carcinoma and the former occurs frequently prior to middle life. Statistical data presented by Bashford,[11] tend to show however, a definite increase in the incidence of sarcoma with age, reaching its maximum between the fiftieth and sixtieth year. The age incidence of different types of sarcoma will be found to vary.

Heredity.—In given instances there is strong indication that the determining factor in the development of a tumor is furnished by inheritance, as when tumors develop almost simultaneously in identical sites in homologous twins. In general little is known of the relative importance of inherited and external or acquired factors in the development of tumors. It is possible that more accurate statistical enquiry or the experimental breeding of animals may throw light on this subject.

Diagnosis.—The recognition of various types of sarcoma may be based on the gross appearance, the

site of origin, the biological characteristics as manifested in clinical behavior, but more especially on histological appearance. Differential staining methods especially those devised by Mallory[12] have contributed materially in the recognition of various types of tumors. Aside from the well-recognized differentiated cells, characterized by fibrils, striations, and specific granules, too great a reliance should not be placed on cell characteristics in the diagnosis of tumors; for metaplasia, or change in the type of a tissue, and anaplasia or loss of type should be taken into consideration. Tumors are frequently met with which lack the differentiation requisite for adequate classification.

General Features.—Practically all tumors, in addition to the essential tissue of which they are composed, have a variable amount of supporting tissue consisting of connective tissue and blood-vessels, and known as the stroma. The blood-vessels found in tumors are for the most part thin walled and lack muscular coats. They amount practically to distended capillaries or sinusoids. In large rapidly growing tumors the pressure of newly formed tissue is sufficient to compress these thin-walled vessels with the result that the circulation of a certain portion of the mass is cut off and necrosis ensues, while in more slowly growing tumors there is a greater degree of adjustment between the vessels and the growing tissue. Rapidly growing tumors show necrosis more frequently than slowly growing tumors since the rate of necrosis in the former outstrips the rate of resorption of the dead tissue. The central portion of the tumor, being farthest from the normal tissues, is usually most affected. The necrotic tissue may liquefy with the result that cysts of softening are formed. The necrosis and especially the ulceration of tumors furnishes a favorable medium for bacterial growth, and apparent increase and decrease in their size may in reality be based on the appearance or subsidence of inflammatory swelling. In neglected cases ulcerated tumors are not infrequently invaded by maggots. The tumor tissue immediately around the blood-vessels is frequently the last to become necrotic, or it may grow more rapidly in this location; in either case it is said to have a *perithelial* arrangement. The tumor cells are frequently atypical both in form and arrangement. They may show in a single tumor extreme variation with respect to size or morphological characteristic. The cytoplasm may appear soft and loosely reticular. Granules and inclusions are often present. The nuclei commonly present an excessive amount of chromatin which may be distributed in one or more karyosomes. Irregular and multiple mitoses occur and frequently chromosomes fail to become incorporated in the more regular appearing karyokinetic spindles. Tumor nuclei frequently show irregularity of outline, and may appear nodular, fissured or lobulated in outline. Direct division is prevalent in some cases; multinucleated cells are evidently produced in this manner as well as by multipolar mitosis. A common inclusion commonly found in sarcoma as well as in certain epithelial tumors is a spherical or oval body often attaining large size which appears either within or invaginating the nucleus. This may show a central deeply stained point or granular material and appears to be of the nature of an abnormal attraction sphere. Whereas there is often with cancer a tissue reaction which is unfavorable to its growth as in the scirrhous varieties and possibly in the early growths on the lip and skin, sarcoma does not commonly excite such a reaction and appears to be in more harmonious relationship with the normal tissues. Apparently the most important influence retarding the growth of sarcoma is to be found in the differentiation of the tissue of which it is composed.

Natural History.—The great variation in tumors with respect to their clinical course will depend upon their biological character and their situation in the body. Interference of function through the destruction or immobilization of parts, obstruction of passages, and pressure upon important organs are in general the results to be expected from tumor growth. Cachexia frequently appears in the course of the development of malignant tumors. This appears not to be a condition specific to the growth of tumors and is usually present in a degree proportionate to the amount of necrotic material, ulceration, infection, and interference of function present. True malignancy is based on the biological character of the tumor tissue. Histological examination is of great assistance in the determination of the type of tumor in question but is by no means infalliable for it is not always possible to forecast the future behavior of a tissue from its present appearance. Rapidity of growth, together with tendencies to necrosis, to infiltrate adjacent tissues, to recur after operation, to metastasize, and to produce cachexia are all regarded as indications of malignancy. The active migration of tumor cells observed in tissue cultures outside the body suggests that an ability to infiltrate normal tissue in this manner may constitute an important factor in malignancy. Treatises dealing with tumors in their regional distribution should be consulted for more detailed information concerning their clinical course.[13] The more important features of each type of sarcoma will be discussed separately.

Sarcoma.—It seems necessary to retain this name without prefix for cellular non-epithelial tumors

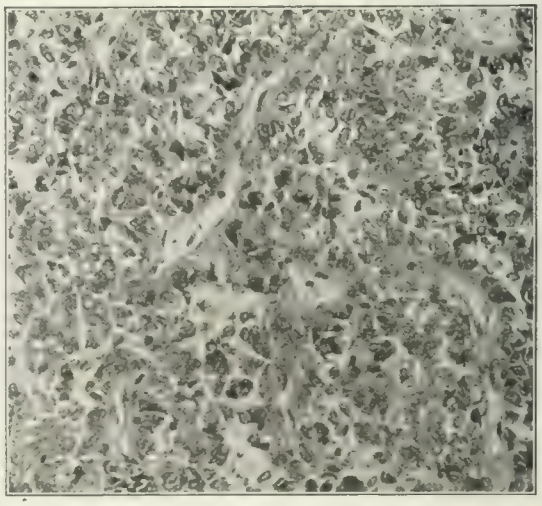


Fig. 4464.—Sarcoma (C. S. 14.104) Showing No Fibrils Apart from Those in the Stroma.

which produce no appreciable amount of intercellular material. Difficulty not infrequently arises in distinguishing between epithelial and non-epithelial tissue. This will seem less strange when it is considered that in some instances the recognition of epithelium must depend solely on the arrangement of the cells. Cells arranged in alveoli or *en masse* are thus frequently difficult to differentiate. *Round-cell* and *spindle-cell* varieties of sarcoma are distinguished. A careful analysis of the former type indicates an origin from lymphoid tissue in a considerable proportion of cases but it is quite certain that rapidly growing tumors of connective-tissue origin may be composed of rounded or polygonal cells without demonstrable fibrils. Sarcomata composed of elongated flattened cells will in most instances show intercellular fibrils and may then more properly be designated as fibrosarcoma.

Fibrosarcoma.—A malignant tumor composed of cells showing the differentiation of connective-tissue cells and associated with a variable amount of intercellular fibrillar material. The cells are commonly

elongated and somewhat flattened but may be rounded or polymorphic. The fibrosarcomata show considerable variation with respect to the size of the cells of which they are composed. The collagen fibrils are arranged in wavy bundles or, when more widely separated, in the form of a reticulum. This material is readily differentiated by Mallory's connective-tissue stain. The fibroglia fibrils are best demonstrated in tissue fixed immediately following excision and stained by Mallory's phosphotungstic hematoxylin method. This stains the fibroglia fibrils deeply and they are then apparently extending lengthwise of the cells in part in contact with the surface of the cell but extending for a considerable distance from one or both extremities. The presence of fibroglia fibrils in a tumor does not necessarily indicate its sarcomatous nature, for the connective-tissue stroma may be intimately intermingled with the tumor cells and in

Fig. 4465.—Fibrosarcoma of the Face. Patient, C. I. 12.2, 35 years of age. The exact point of origin was not determined. Removal of the tumor by operation was attempted twice in each case followed by prompt recurrence. Coley's toxin was administered for six or seven weeks and a third operation was performed only to be followed by recurrence. Coley's toxin was injected in the region of the tumor which rapidly enlarged and extended to all parts of the face. It at this time appeared to be attached to the lower jaw, the upper jaw, the malar and temporal bones. It protruded into the mouth, compressed the external auditory canal and pressed the eye upward and outward. Death occurred one year and nine months after the appearance of the growth. There were metastases in the lungs. Extending to the tumor were large distended veins. The greater portion of the mass was necrotic but the secondary nodules were whitish or pale pink in color and somewhat translucent.

many cases it is difficult to determine whether the fibrils are the product of tumor cells or of stroma. In order to differentiate between fibroma and fibrosarcoma, the relative proportion between the amount of cellular tissue and intercellular substance should be taken into account but more especially the presence of cells in mitotic division. While very cellular connective-tissue tumors are usually considered of a sarcomatous nature, certain ones showing considerable fibrous tissue show malignancy with respect to recurrence after operation. The lack of encapsulation or separation of a tumor from the surrounding tissue should be taken as an indication of malignancy.

The fibrosarcomata vary in their gross appearance but in general are of firm consistence and are composed of glistening pale pink or whitish tissue which on section presents a rather even surface. Metastasis may occur and secondary tumors are found most commonly in the lungs but also in other organs. Dissemination occurs more frequently by way of the blood stream and less frequently by way of the lymphatics than is the case with carcinoma. The growth of these tumors may be extremely rapid and although infiltration of adjacent tissues occurs the greater part of the primary mass is usually the result of expansile growth. Where the tumor comes in contact with bone the latter may be destroyed locally either by pressure or by infiltration as frequently is the case in sarcoma of the jaw. Infiltration of bone is usually regarded as evidence of greater malignancy than its destruction by pressure, although due allowance should be made with respect to the origin of the growth. In a case observed at the Huntington Hospital the spinous processes and the laminæ of a number of dorsal vertebræ had disappeared, although the adjacent bone appeared to be not involved, and the tumor partially enveloped the spinal cord. *Trichinella spiralis* was found in this case, but this should not be interpreted as invasion of the tumor. The parasites had come to be incorporated in the tumor through the infiltration and destruction of skeletal muscles harboring the encysted larvæ. Sarcomata of this type frequently attain large size without showing any great amount of necrosis or ulceration. This does not invariably hold true, however, and a broad crater-

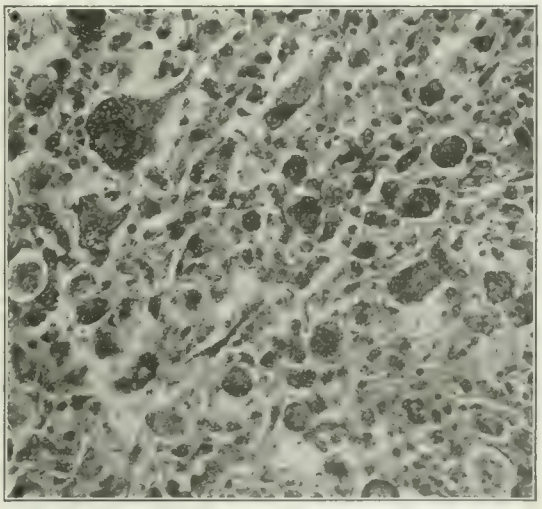


Fig. 4466.—Fibrosarcoma (C. S. 13.65) Showing a Large Number of Giant Cells Many of Which Have Arisen from the Tumor Cells.

like ulceration involving the concha has been observed which had a base of typical fibrosarcoma. Tissue sloughed from the region of the tonsil has also made possible a diagnosis of fibrosarcoma. Tumors of this type may occur almost anywhere in the body but are common in the regions of bones, tendons, muscles, fasciæ, skin, uterus, and ovaries.

Giant-cell sarcoma so called is a tumor of the nature of a fibrosarcoma in which foreign-body giant cells form a prominent feature. Although true tumor cells are not infrequently multinucleated, they are readily distinguished from foreign-body giant cells since the latter stain more intensely. This tumor occurs most frequently in the upper extremity of the tibia but may be situated in the jaw or in association with other bones. It is probably the least malignant of the sarcomata and is said to occasionally disappear spontaneously. In the course of its retrogression cysts of softening, "bone cysts," may be produced. Multinucleated sarcoma cells may be so numerous as to constitute a distinctive characteristic and there is no reason why tumors consisting of such cells should not be considered as a special variety of sarcoma.

Epulis is a topographical term for growths originating in the alveolar periosteum. Two types are recognized, the fibrous which has a pale smooth surface and may show foci of calcification, and the giant-cell

epulis which is softer, irregular, of a bright red color, and frequently contains spicules of bone. Although histologically resembling sarcoma they show slight tendency to infiltrate and rarely recur on excision. It is apparent that these growths should in general be considered as border-line conditions rather than true tumors although in rare instances they show malignant tendencies. With these growths a recurrence indicates a greater degree of malignancy than usual, as does also the lifting of the teeth from the sockets. Conservative measures with removal of only the affected portion of the alveolar portion of the jaw together with the adjacent teeth are generally recommended. It is important to differentiate such relatively benign conditions from carcinoma which also occur frequently in this locality.

Myxosarcoma.—Certain of the connective-tissue tumors contain in addition to fibrils a soft colloid material of the nature of mucin. Mucous connective tissue is found normally in the umbilical cord. The cells of such growths are usually irregular or stellate in form and are separated from one another by the intercellular material, although their processes may unite to form a syncytium. Tumors of this type are relatively rare. They are of soft consistence but tough from the presence of fibrillar material and are frequently of flattened rather than fully rounded in contour. There is considerable variation in color, but they commonly show marked translucence from the presence of mucin. On section the cut surface feels mucilaginous or slimy to the fingers. The presence of this constituent in the connective-tissue tumors of the jaw is regarded as an indication of activity of growth and as warranting more extensive operation in their removal. The presence of cells in mitotic division constitutes valuable evidence in the consideration of malignancy.

Chondrosarcoma.—A malignant tumor the cells of which are to some extent differentiated into cartilage

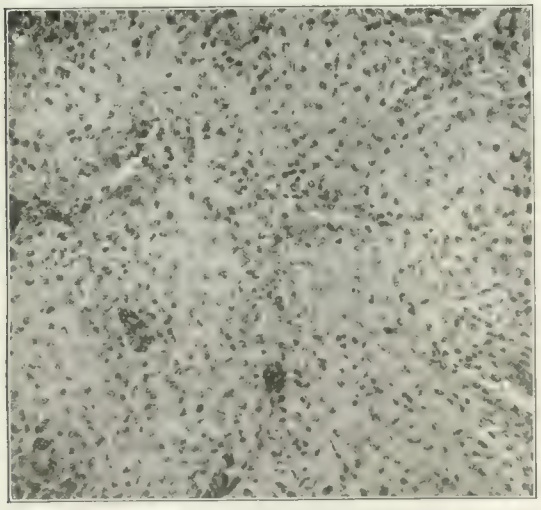


Fig. 4467.—Chondrosarcoma Showing the Production of Hyaline Material in Portions Farthest from the Blood Vessels. The tissue also contains a great number of fibrils.

cells. Like other types of sarcoma this has its benign counterpart, *i.e.* the chondroma, and all grades between slowly growing and rapidly growing tumors occur. Fibrils are found in association with the tumor cells but there is in addition a matrix formed of chondromucin in which both cells and fibrils are imbedded. The fibrous, elastic, and hyaline varieties of cartilage are recognized. There are various degrees of differentiation between the fibroblasts and the cartilage cell, the latter appearing rounded rather than elongated. There is, however, great variability in the form and appearance of the cartilage cells.

Fig. 4468.—Osteomyxosarcoma of the Orbit. Italian laborer (C. I. 14.13) 25 years of age. Pain was the first symptom noted. Eye removed and orbit cleaned out. Diagnosis, sarcoma. Recurrence during the course of post-operative treatment with radium, and the tumor forming a mass in the left orbit steadily increased in size. Death occurred six months after appearance of tumor. The growth presents a somewhat lobulated and nodular surface, portions of which are of a dirty brown color, others grayish, evidently necrotic in places. On section it is found to be composed of pale glistening tissue in which are numerous delicate spicules of bone. There is a large amount of glairy viscid material which flows from the cut surface. Some portions of the tumor have a yellowish tinge. No metastases. Extension to the anterior and middle fossæ of the cranium with extensive absorption of bone. (From a photograph by Dr. Ellis Kellert.)

Those tumors showing only a slight degree of differentiation are to be regarded as more malignant while

Fig. 4469.—Same Patient as Shown in Fig. 4468.

those composed of pure hyaline cartilage are considered benign. Although metastases have been

described, malignancy consists chiefly of the property of recurring after operation and extension to surrounding parts. Although infiltration occurs the growth is chiefly expansive so that huge masses are produced. They have the property of recurring long after operation, and the growth is generally faster when osteoid tissue is also present. The more differentiated, *i.e.* more cartilaginous portions of the tumor are situated farthest from the blood-vessels. Calcification may occur without the formation of bone. Cartilaginous tumors are usually hard and firm but if cellular in character may be of softer consistence. They are of an opalescent whitish color often with a bluish tinge. These tumors may originate almost anywhere in the body but most often in connection with bone. While they arise more frequently from the periosteum, they may also occur in the interior of bones. About the face they may be found arising from the alveolar process, the articulation, or practically any portion of the jaws, more frequently in the upper jaw, and also from the bony wall of the orbit and from the palate.

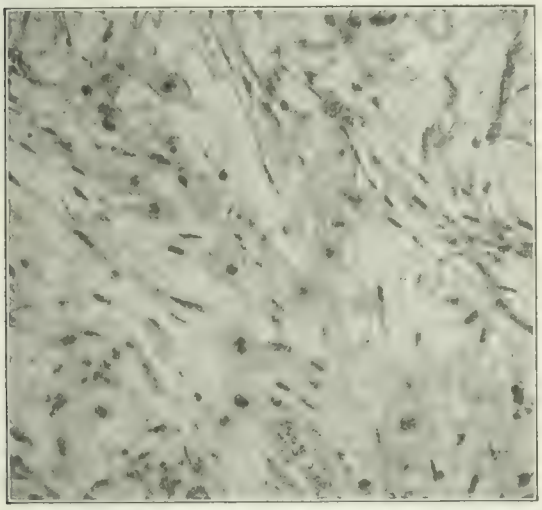


Fig. 4470.—Osteomyxosarcoma (C. I. 14.13.—see Figs. 4468 and 4469 for gross appearance). Portion of the growth showing elongated cells and fibrils separated by mucin and scattered cells around which osteoid tissue is being formed. Large numbers of foreign-body giant cells were present in certain portions of this tumor.

Osteosarcoma.—A tumor composed of tissue showing a tendency to differentiate into bone. The cells which are concerned in the production of bone are to be regarded as osteoblasts. These cells are derived both in development and to some extent following injuries in adult life from connective-tissue cells. All transitions between fibroblasts and osteoblasts are readily demonstrable. The so-called bone cells, that is the cells which are situated within a space or lacuna in bone are to be considered as an end product and usually manifest no activity of growth. Bony tumors may thus arise from the periosteum or endosteum and possibly from other portions of the body. In the production of bone within tumors as well as in normal development there is produced a homogeneous matrix of osteoid substance, the ossco-mucin, in which lime salts are subsequently deposited to form bone. There is no satisfactory evidence that cartilage may be transformed to bone or that cartilage cells may produce bone although bone replaces cartilage in the normal development. Bony tumors present all degrees of differentiation between apparently soft tumors with only a slight amount of bone production to hard ivory-like masses. The osteosarcoma or more malignant tumor is more cellular and continuous growth rather than differentiation is one of its most important features. The bone produced is atypical in character and just as in normal bone there are frequently giant cells present which are of the nature of osteoclasts or foreign-body giant cells. These tumors are of a pale gray or whitish color, of a fairly firm consistence and difficulty may be met with in cutting due to the presence of bone in the form of spicules. Such tumors like those of the preceding type grow chiefly by expansion but may metastasize in some cases.

Mixture of type frequently occurs with respect to the last four tumors. Thus we may have tumors showing various proportions of fibrillar material, mucin, cartilage, or bone. Such tumors are named according to the constituents which predominate; for example, osteochondrosarcoma or osteomyxosarcoma.

Melanoma (*Melanotic Sarcoma*).—Tumors which are characterized by the production of melanin, and by the rapidity with which metastasis takes place. There are diverse views as to the origin of these growths which were formerly considered to be a

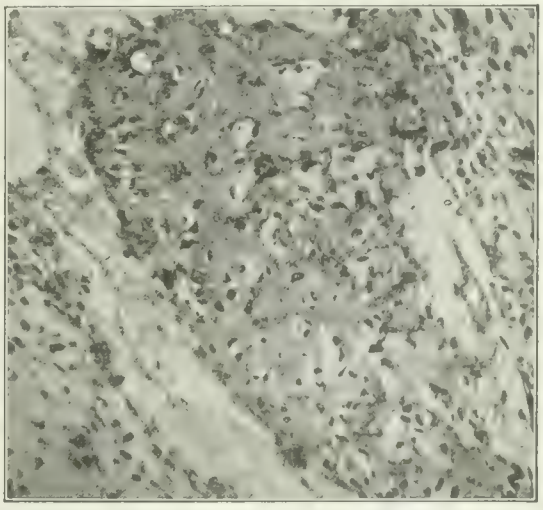


Fig. 4471.—A Portion of the Same Growth (Figs. 4468, 4469 and 4470), Showing Calcification of the Osteoid Tissue.

form of sarcoma. Unna,[14] by a study of the development of soft nevi from which pigmented tumors frequently arise, became convinced of their epithelial origin. Although this view had a large following, it was opposed by a great number of investigators who claimed that Unna's views were based on unsatisfactory evidence and that the nevus cells and likewise the melanoma cells are of endotheial origin. Ribbert,[15] disregarding these opposing views, found the origin of pigmented tumors in the pigmented cells or chromatophores. A further study both of soft nevi and of melanoma has been made by Johnstone,[16] who traces the nevus cells to lymphatic endothelium and finds this to be a common origin of pigmented tumors, but finds also certain pigmented epithelial tumors which are relatively less malignant. He recognizes I *Melanoendothelioma*, including (1) *Nevomelanoma*, (2) *Melanotic whitlow* or *Malignant lentigo*, and II *Melanoepithelioma*. Mallory[17] defines the pigmented tumor as one of mesenchymal origin of which the cells tend to differentiate into melanoblasts (chromatophores). He further states that this cell is characterized by production of pigment and by lack of any intercellular substance. Many pigmented tumors have, however, a distinctly fibrillar appearance (Fig. 4474) and, although no coarse fibrils such as commonly occur with fibroblasts have been observed,

there are numerous delicate lines which extend lengthwise of cells. The intimate relationship of the tumor cells to the collagen which forms a delicate meshwork permeating all parts is difficult to account for except on the basis of its production by the tumor.

The non-epithelial pigmented tumors, notwithstanding clinical differences with respect to origin, show great similarity in their histological structure, although the cells of which they are composed frequently show a high degree of pleomorphism. The cells are frequently polygonal or rounded in outline and arranged in alveoli. The nucleus in such cells is ovoidal or spheroidal in shape with a large karyosome. The cytoplasm is in relatively large amount and stained rather evenly bluish or purplish by the eosin and methylene-blue method. In many cells the nucleus is pressed to one side and may be indented or even crescentic in shape. A centrosome is usually

Fig. 4472.—Melanotic Sarcoma Originating in the Region of Thumb of a Seamstress (C. I. 12.21), 42 Years of Age. The nail had been tender and cracked for five years previously but definite evidence of growth appeared following injury with a piece of wire. The primary growth became ulcerated and bled easily. Removal first of the distal phalanx and later of the axillary and clavicular glands was followed by a reappearance of the growth at the elbow. Coley's toxins had no beneficial effect and the arm was amputated at the shoulder as a palliative measure. Nodules later appeared in the skin over various portions of the body. Death occurred not quite two years after the first appearance of the growth. The smaller nodules removed were of a light chocolate color. The growth shown at the elbow joint showed only slight pigmentation but appeared yellowish translucent, with portions of a dark red color. There was extensive necrosis with cysts of softening in the interior. (From a photograph by Dr. Thomas Ordway.)

demonstrable in the concavity and it is in this portion of the cell that golden-brown pigment may be apparent. In many cases the cells vary greatly in size, some having a diameter only a small fraction of that of others. The alveolar arrangement may be lost and the tumor distributed diffusely without special arrangement. Some cells attain huge proportions and have lobulated or multiple nuclei. In other cases all the tumor cells may be elongated so that there is close resemblance to a fibrosarcoma. There is here also a great variation in the size of the spindle cells which may be arranged in irregular bands and layers. Frequently the cells are arranged with their long axis nearly vertical to the surface of a contiguous band. Attention is frequently called to the perithelial arrangement and certain melanomata are described in which the long axis of the cell is parallel to that of the blood-vessel. There is, however, no regularity with respect to arrangement and the cell may be at an angle or nearly vertical to the vessels.

The pigment which is iron free and contains sulphur is found in part within the tumor cells and in part within irregular or rounded cells. There appears to be a lack of transitional forms between the latter and the tumor cells, so that certain authors are convinced that melanoblasts independent of the tumor

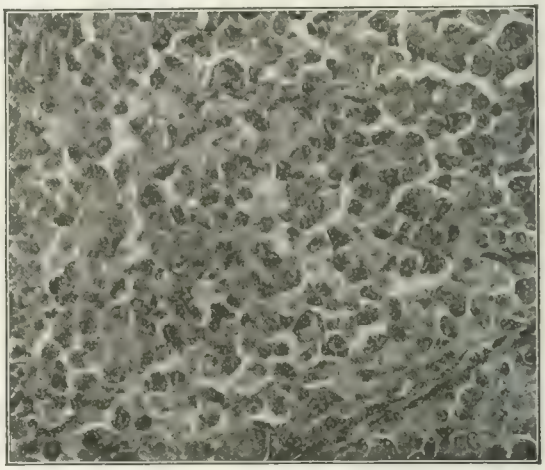


Fig. 4473.—Melanotic Sarcoma. A section from Case C. I. 12.21 illustrated in Fig. 4472. The cells from this portion of the growth are rounded or polyhedral and of large size.

supply the pigment to the latter. Such cells are found in places in the region of the tumor which have apparently not been invaded. They are usually scattered about the periphery of lobules of the tumor and at the border of degenerating areas. They possess a smaller and less atypical nucleus than the tumor cell and, although the pigment which they contain appears to be of the same character, it is usually

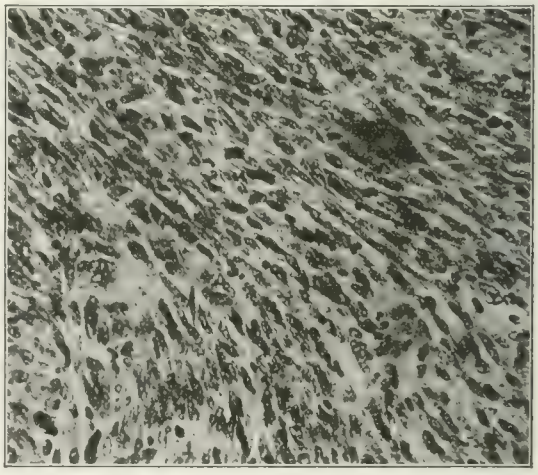


Fig. 4474.—A Section Taken from Another Portion of the Tumor of the Same Case (C. I. 12.21). Cells are greatly elongated and resemble those of fibrosarcoma in arrangement.

distributed in conglomerate masses. It thus seems probable that such cells represent phagocytes rather than true tumor cells. In many cases the greater portion of the tumor contains no microscopically visible pigment, in others it forms a prominent feature. It is often present in greater amount near degenerating areas or farthest from the vessels. Tumor cells, especially those having a reticulated cytoplasm, show

great numbers of deeply stained granules which appear to be closely related to the pigment. The presence of coarse cytoplasmic granules throughout a tumor having the general structure of a spindle-cell sarcoma should suggest the possibility of its being a melanoma.

Melanomata occur chiefly in adults and may appear at any time up to extreme old age. They arise chiefly in the skin, frequently from the soft nevi or pigmented moles, from mucous membranes representing invagination of the ectoderm and from the choroid. Certain such tumors have been first discovered in internal organs and the cortex of the adrenals has been regarded as the site of origin in certain cases. A pigmented tumor has been first recognized as the result of its causing an intussusception. Since the site of origin is readily overlooked or may have been previously surgically removed, it is frequently difficult of demonstration. About one-third arise from the choroid. Of those which develop on the skin not all arise in moles. Some first appear at the site of an injury, and the primary tumor may appear as ulceration or as a mass of exuberant tissue to which little significance is attached by the patient. The *melanotic whitlow* of Hutchinson[18] is such and appears commonly in a nail fold of a finger. These frequently show pigmented or "silver nitrate" streaks radiating into adjacent tissues. The *malignant lentigo* of the French usually arises from pigmented spots on the extremities. Melanomata vary in color from black, to brownish or slaty bluish gray. An increase in the extent of a mole or the appearance of blue-gray masses in the skin should receive immediate attention. The consistence of such tumors is moderately firm and they may attain large size without ulceration. They, however, show extensive necrosis in the interior and cysts of softening are frequently present. Secondary nodules may vary markedly from the original growth with regard both to the morphology of cells and to the amount of pigment. It is not uncommon to find metastases of pale whitish color devoid of pigment.

Metastasis occurs usually with great rapidity both through the lymphatics and blood stream so that the melanomata constitute an extremely malignant type of tumor. This should not, however, militate against an attempt to eradicate by operative procedure, for here as in other conditions the attention to early or border-line conditions should prove of value.

Malignant Leiomyoma.—Tumors showing smooth muscle differentiation are generally non-malignant in character and tend to become replaced by fibrous tissue as for example the so-called fibroma of the uterus. In rare instances tumors showing slighter tendency to differentiate into smooth muscle and more marked properties of continued growth appear chiefly in the uterus but also in other portions of the body. These tumors are distinguished by the characteristic fibrils found in association with their cells. The smooth muscle cells show a number of delicate fibrils extending longitudinally in the surface of the cell and coalescing toward its extremity to form a coarser fibril. In the malignant type the cells may be rounded or irregular as well as fusiform. It may be difficult to differentiate from fibrosarcoma but the cytoplasm of the smooth muscle is rather more abundant than that of the fibroblast and is more acidophilic in its staining reaction. Malignant leiomyomata are of softer consistence than the slowly growing ones of this type and may infiltrate the normal tissues.

Rhabdomyoma.—A tumor composed of cells which tend to differentiate into striated muscle. Rhabdomyomata are of two types according to whether their cells differentiate into cardiac or skeletal muscle fiber. The rhabdomyomata of the heart[19] are congenital tumors usually associated with anomalies of the central nervous system. They are of such rarity as to be of slight clinical importance. Tumors showing the differentiation of skeletal muscles, *i.e.* constituted of distinct rather than of anastomosing cells, occur in the genito-urinary tract, as for example the testis, prostate, uterus, bladder, kidney, and, apart from the occurrence of striations in the cytoplasm of their cells, resemble fibrosarcoma. Such tumors may grow rapidly and tend to infiltrate. Cells with striated cytoplasm are also found in certain of the mixed tumors of the genito-urinary tract.

Lymphosarcoma (Malignant Lymphoma).—This should be defined as a malignant neoplasm derived from the atypical proliferation of cells of the lymphoid type, presumably lymphoblasts or primitive lymphoid cells. Since such cells produce no intercellular substance and may appear quite atypical as compared with normal cells, it is difficult to determine the exact status of many tumors usually included in this group. Sarcoma arising from the reticulum of lymphoid tissue may be difficult to differentiate from true lymphosarcoma. The question is further complicated by the recognition of a distinct entity, Hodgkin's disease, which is considered by many to be a granuloma or inflammatory condition rather than a neoplasm. The recent isolation of a diphtheroid bacillus from this condition by certain investigators has been regarded by them of

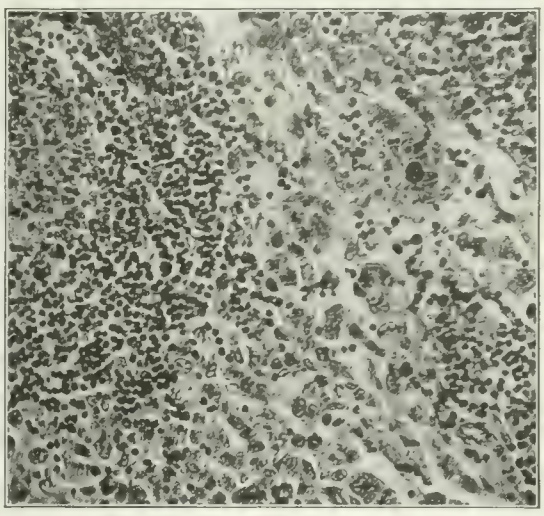


Fig. 4475.—Lymphosarcoma (C. I. 15.56). The larger cells are apparent replacing the lymphoid tissue. To the left a lymph follicle is evident.

etiological significance, but bacilli apparently identical in character have been isolated from other conditions such as tuberculous lymph nodes and other swellings. Mallory includes Hodgkin's disease with the lymphoblastoma, considering its essential cells to be of lymphoid character but associated with excessive reaction of other tissues. Ewing[20] has described under endotheliomata of lymph nodes a series of cases many of which furnish evidence of an inflammatory condition which preceded the appearance of a definite neoplasm. Tissue excised on different occasions revealed at first only inflammatory or hyperplastic conditions, later on definite neoplasms. In some cases the inflammatory condition appeared to be of the nature of tuberculosis although the specific bacilli were not demonstrated. This author believes that the tumor associated with or following such conditions should be distinguished from tumors of a lymphomatous character. Hodgkin's disease he regards as an inflammatory condition which may, however, be followed by a true neoplastic condition, "Hodgkin's endothelial sarcoma." From these observations it is apparent that the classification of the tumors and other related conditions of the

lymphoid organs is still far from satisfactory and subject to error of interpretation.

Hodgkin's Disease.—The clinical use of this term to indicate a peculiar symptom-complex is frequently lacking in accuracy since it may be applied to tuberculous adenitis and various new growths. From the pathological viewpoint, however, a fairly distinct condition may be distinguished, based on the observations of Reed,[21] Loncope,[22] and MacCallum.[23] It is characterized by the presence of large atypical cells regarded by some as endothelial, by others as lymphoid in origin and by marked inflammatory reaction characterized by the presence of eosinophile cells, giant cells and great increase in connective tissue. If the large atypical cells are neoplastic in character, they then frequently comprise an insignificant part of the tumor mass which is composed chiefly of fibrous tissue. Nodules have been excised in this disease, sections of which showed none of the atypical cells and for which the diagnosis of fibroma was suggested by the pathologist. A marked characteristic is found in the proliferative changes in blood-vessels and typical granulation tissue is produced in some instances. The proliferation of the endothelium is frequently

Fig. 4476.—Hodgkin's Disease (C. I. 15 334) Showing the Characteristic Large Hyperchromatic Cells and General Transformation of the Lymphoid Tissue.

sufficient to obliterate the lumen. The significance of this reaction may be differently interpreted since Ewing regards the inflammatory condition as anteceding and as a causative factor in the production of new growth, while Mallory regards it as a condition resulting from the presence of tumor cells. It does not appear that the origin of these cells has been established beyond question. If they are endothelial in character, Hodgkin's disease could not then possibly be included under sarcoma according to the classification here adopted. They are usually several times the diameter of the cells with which they are associated as lymphoid cells, leucocytes, etc., possess large vesicular nuclei with an excess of chromatin arranged in one or more large masses or karyosomes. The cytoplasm has a soft, fluffy appearance and tends to color with the blue rather than the eosin stain. It often gives the appearance of a wide-meshed reticulum and frequently shows numerous stained rounded or rod-shaped granules, evidently metabolic products of a deranged cell physiology. Atypical and multipolar mitotic figures are found and multinucleated cells of large size occur. These cells show no pronounced phagocytic activity. This condition may remain quiescent for years and then show a rapid increase, or it may be rapid from the first or show gradual increase throughout its course which is usually fatal notwithstanding attempts to eradicate by operation. It has not been transmitted to animals by inoculation although similar conditions occur spontaneously in the latter. An implant of a bit of the tissue of Hodgkin's disease into another part of the body of the patient from whom it was removed has failed to develop. The lymphoid tissue is primarily attacked in this disease and the cervical lymph nodes are frequently the first to be affected. It may eventually spread to other organs, and nodules may be found in the lungs, liver, and spleen. In these organs the nodules are identical in character with the involved lymphoid tissue and constitute a pathological entity as characteristic as the lesions in tuberculosis.

Neoplasms consisting of cells of unquestionable lymphoid character may vary one from another somewhat in type but differ in certain respects from Hodgkin's disease. Whereas the latter appears to consist of a *transformation* of the lymphoid structure and the character of its component cells, the conditions which are more definitely neoplastic show invasion and

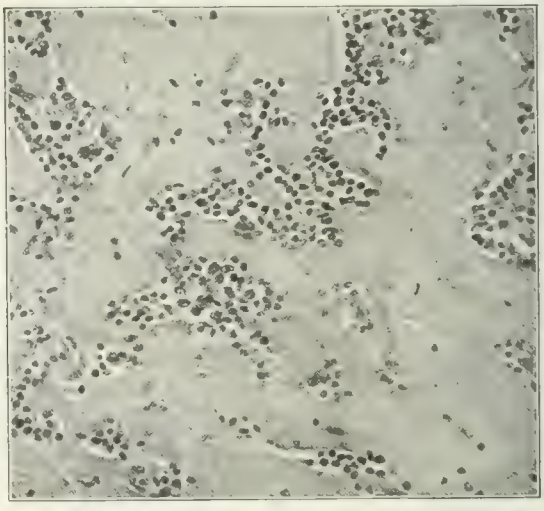


Fig. 4477.—Hodgkin's Disease (C. I. 13 18). A portion showing marked increase in the connective tissue of the reticulum.

replacement of the lymphoid tissue (Figs. 4475,4476). In the one the transformation of lymphoid tissue leaves no trace of its normal structure, in the other well-preserved lymphoid tissue is to be found associated with, but readily distinguished from the tumor with which it is being invaded. The cells of which such true lymphosarcomata are composed may be large or small and more or less atypical. The nuclei of the larger cells show an excess of chromatin, are in some cases rounded, in others somewhat irregular in outline. They possess a relatively small amount of cytoplasm and although they may occur in compact masses they tend to become disassociated one from another in places at least. If the cells are large and have an alveolar arrangement, it is then necessary to consider the possibility of the tumor being a carcinoma. Tumors in which the cells are adherent in a single layer to a connective-tissue reticulum may be difficult to interpret. This arrangement suggests an epithelial or endothelial growth but may also be produced by the disappearance of all cells of the alveoli except those which lie against the reticulum. Tumors of lymphoid origin are usually of great malignancy. They become disseminated very rapidly not only through lymphoid structure but also the lungs, liver, intestine, and other organs. Such

tumors probably bear a definite relationship to lymphatic leucemia. In fact many pathologists regard the latter as a neoplasm the cells of which occur in the circulating blood. Thus certain authorities differentiate leucemic and aleucemic lymphoma. Apart from the presence of the cells in the blood these forms are indistinguishable microscopically. Others to whom the clinical aspect of leucemia appeals, are inclined to regard the acute form of the latter with its febrile disturbances as a manifestation of an unrecognized infection. Lymphatic leucemia is frequently associated with tumor nodules in various parts of the body. Nodules have been found distributed as elevated or pedunculated masses for nearly the entire length in the mucosa of the small intestine and replacing the Peyer's patches with masses from the size of an almond to the size of a walnut, while the solitary follicles were replaced by pea-sized nodules. Lymphatic leucemia, however, generally lacks the destructive invasive properties of lymphosarcoma. The latter frequently infiltrates the intestinal wall diffusely causing great thickening and rigidity.

Myeloma.—A tumor originating in the bone marrow and composed of cells more or less closely resembling the plasma cell. The cells are rounded with deeply staining, non-granular cytoplasm and an eccentrically situated nucleus the chromatin of which is frequently arranged in several coarse masses at the nuclear membrane. Most cells have a single nucleus but some have two or even more. A clear area is frequently apparent near the nucleus in which a centrosome may be demonstrated. There is present a variable amount of connective-tissue stroma with thin-walled blood-vessels. In gross appearance this tumor is of a deep red color and of a soft and rather gelatinous consistence. They are frequently multiple but are confined to the bones and show no tendency to invade other organs. The ribs, sternum, and vertebræ are more commonly involved although the pelvis, the skull and the long bones may also be affected. They may produce pain, deformity of the bones, or spontaneous fracture may occur. Albumose, the so-called Bence Jones[24] body, is found in the urine in this condition, and its presence in considerable quantity has been regarded as pathognomonic of myeloma, but it has also been found in variable amounts with malignant tumors of other types and with various infectious diseases. The generic position of this tumor is not fully established. Its cells are believed by some to be of the nature of plasma cells. Although there is no question as to its origin from the bone marrow, its cells show none of the granules of the myelocyte series. Origin from the erythroblasts and from the megacaryocytes has been suggested but the plasma cell is the only one to which its cells show any marked resemblance.

Myelogenous Leucemia (Chloroma).—A condition regarded by many pathologists as a neoplasm the cells of which show the differentiation of the myelocyte series although atypical. It differs, however, from conditions of unquestionable neoplastic nature in that there appears to be a transformation of the entire myeloid tissue rather than its partial replacement by atypical tissue. The atypical myeloid tissue does, however, invade and replace lymph nodes and frequently tumors of considerable size are produced. These are in some cases of a greenish hue and were formerly regarded as a distinct neoplasm under the name *Chloroma.* A considerable proportion of those who have studied leucemia do not regard it as a true new growth. Since sarcoma is never applied to this condition, and since it will be discussed separately, no further comment is necessary.

Glioma (Gliosarcoma).—A tumor composed of cells of the nature of atypical neuroglia cells and like these producing intercellular substance in the form of neuroglia fibrils. Such tumors show a great variety of type, are frequently cellular and show evidence of active infiltrative growth. Such growths may resemble sarcoma of connective-tissue origin but the nature of the fibrils produced as well as their location in or intimately connection with the central nervous system is sufficient to differentiate them. They are malignant through the character of their growth which is commonly infiltrative and rarely metastasize to other organs.

Neuroblastoma.—Tumors the cells of which differentiate as neurons. The cells have a characteristic arrangement in group often in rosettes and associated with fibers which do not react to stains like neuroglia, fibroglia, myoglia, or collagen fibrils. They frequently show marked malignant qualities. Since this type of tumor will be considered elsewhere it is unnecessary to discuss it here in detail.

It is questionable whether *Chordoma* should be considered in the discussion of sarcoma since it is a tumor not commonly showing malignant qualities. It may also be preferable to regard it as of epithelial origin since the cells of the notochord from which it is derived have at first an epithelial arrangement, although they produce intercellular substance so that a distinct tissue having a certain resemblance to cartilage is produced. Such growths have been found for the most part about the upper extremity and less frequently at the lower extremity of the vertebral column and should be taken into consideration in the diagnosis of tumors occurring in these regions.

The neoplasms here designated as sarcoma constitute a number of genera some so closely related as to fuse one into another, *i.e.* fibrochondrosarcoma, others distinct and non-related. In some instances *sarcoma* is applicable as an ending to the generic name, as in fibrosarcoma, myxosarcoma, chondrosarcoma, and osteosarcoma. The term sarcoma should also apply to other malignant tumors of unquestionable mesenchymal origin which do not produce intercellular substance or show characteristic differentiation. Although the origin of the pigmented tumors may be open to question, there is sufficient evidence in favor of their non-epithelial character to justify its inclusion with the sarcomata. Leiomyoma and rhabdomyoma, although simulating sarcoma of connective-tissue origin when they appear in malignant form, may consistently be termed leiomyosarcoma and rhabdomyosarcoma but "malignant" leiomyoma and rhabdomyoma appear to have found more general acceptance. Tumors of lymphoid character have on the other hand been frequently designated as lymphosarcoma. There is apparently no precedent in other branches of science for applying a single ending to all generic names of a group and there is thus a justification for retaining terms like leucemia or Hodgkin's disease for specific pathological entities. Certain other tumors such as glioma and neuroma although not commonly designated as sarcomata may be included on the basis of their non-epithelial character and malignancy.

E. E. Tyzzer.

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Sarcophaga.—A genus of flesh-flies, *Sarcophagidæ*. The larvæ of these insects usually feed upon meat, but may be found in cheese, oleomargarine, fish, dead or living insects, and feces. They may also occur in the human body in the alimentary canal, vagina, sores, tumors, etc. A. S. P.

Sarcophila.—A genus of flesh-flies, *Sarcophagidæ*. Larvæ of these insects have been found in ulcers. A. S. P.

Sarcopsylla.—A generic name synonomous with *Dermatophilus*. *D. penetrans* is the chigoe, a flea which often attacks man and in which the female burrows in the skin where she causes a little ulcer. A. S. P.

Sarcopsyllidæ.—A family of fleas in which ctenidia are absent, with long labial palps and well-developed mouth parts. Important genera are *Echidnophaga*, *Hectopsylla*, and *Dermatophilus*. A. S. P.

Sarcoptes.—A genus of mites. Those included are minute, semi-globular, have a delicately striated cuticula, lack eyes and tracheæ. *S. scabiei* is the itch mite which is hard to eradicate because it burrows in the skin. Several other species attack man.

Sarcoptes scabei crustosæ, which is a distinct variety of the human itch mite, is the cause of so-called Norwegian itch. This disease is very contagious, and is much more resistant than ordinary scabies. Unlike the latter, it may occur on the face and scalp. A. S. P.

Sarcoptoidea.—A group of astigmatous mites, in which the three-pointed palpi adhere for some distance to the hypostome; usually with ventral suckers. Only two families are important in medicine: *Tyroglyphidæ*, found in flour, sugar, cheese, etc., and often attacking man; *Sarcoptidæ*, the itch mites which not only attack the skin but sometimes live as endoparasites. See *Arachnida*. A. S. P.

Sarcosine, methyl glycocoll—$CH_2\begin{matrix}NH.CH_3\\COOH\end{matrix}$—Sarcosine is a product of the decomposition of creatine which is found in meat, and of caffeine which is a constituent of coffee and tea. It may be obtained from creatine and creatinine by suitable treatment with alkalies F. P. U.

Sarcosporida.—An order of Sporozoans which includes the genus *Sarcocystis*. These animals are usually muscle parasites in the higher vertebrates, where they seldom cause trouble. They are, as a rule, large enough to be seen with the naked eye as elongated white bodies in the flesh. See *Protozoa*. A. S. P.

Sarsaparilla, U. S.—The root of *Smilax medica* Chamisso et Schlechtendal (Mexican, Vera Cruz, or Tampico sarsaparilla), *Smilax ornata* Hooker f. (Jamaica, Central American, Costa Rica, or Lima sarsaparilla), *Smilax papyracea* Duhamel (Brazilian, Para, or Rio Negro sarsaparilla), or a species known commercially as *Honduras* sarsaparilla (fam. *Liliaceæ*). Various other species than those here named have been recorded as yielding sarsaparilla, but it is doubtful if any appreciable amount of the present article of commerce so originates. The genus *Smilax* L. is large, being credited with some 200 species. Its habits and characters are well illustrated by our ordinary cat-briars, green-briars, or bread-and-butter vines, the green, tough, spiny, tendril-bearing stems of which constitute the principal element in dense thickets of the eastern United States. Apparently, the northern species do not possess the medicinal properties of those of the tropics. The aërial stems of the latter grow from excessively long slender rhizomes, which run just underneath the loose forest mould, and send down from each joint a fascicle of from few to many tough, elongated roots, which, dried, constitute the drug sarsaparilla. They are collected at about the close of the rainy season, probably chiefly with the idea of saving labor, since the ground is then soft and the roots are more easily torn out. After being collected and dried, they are packed in various ways, as explained below, these different forms of packing being characteristic, and aiding in identification, although the practice of packing a cheaper article to imitate a more expensive one is not unknown. Other forms of sophistication are not common, though other roots, sticks, and even stones are occasionally found in the interior of the packages.

Description.—Mostly more than a meter (more than a yard) in length, and four to six millimeters (one-sixth to one-fourth inch) thick, with few or many fine roots adhering; externally varying from light gray brown and smooth, with few deep and sharp wrinkles, to dark or orange brown and less smooth, and with more and smaller wrinkles; internally whitish, with a thick, mealy, or sometimes horny cortex, a circular wood zone and a thick pith; fracture tough; nearly inodorous; taste mucilaginous, somewhat sweetish and bitter, slightly acrid.

The thick, woody, knotty rhizome, if present, should be rejected.

As a rule, Honduras and Brazilian sarsaparillas have the cells of the parenchyma more densely crowded with starch grains, so that they are termed "mealy

sarsaparillas," the other two being denominated "nonmealy." It is probably due to this excess of starchy contents that the mealy sarsaparillas wrinkle less deeply in their drying, their wrinkles, however, being usually much more numerous than those of the nonmealy varieties.

Honduras sarsaparilla consists of the roots separated from the rhizomes, folded back and forth to a length of about two feet, and very closely and tightly wound from end to end with one or more of its own roots, the folded ends not cut off, but projecting slightly beyond the winding at either end. These rolls have usually a diameter of about two and a half or three inches. This variety is generally of a rather light brown color. It varies greatly in its tendency to bear rootlets, though as a rule these are not numerous. A transverse section made near to the rhizome shows the diameter almost equally divided between the cortex, wood, and pith. The cells of the endodermis are rather thin walled, the thickness of the outer and inner walls nearly equal, and the form of the cells nearly square.

Brazilian sarsaparilla also consists of roots freed from the rhizomes, but it is differently packed. The rolls are very large, a yard or more in length and a foot in diameter. They are rolled with extreme tightness, and closely wrapped with a thin tough vine. The folded ends are cut squarely off and the trimmings enclosed in the center of the roll next packed, the rolls thus possessing a swollen middle portion. This root is of a very dark brown color and bears a large number of branching rootlets. It is finely wrinkled. The transverse section shows the woody zone much narrower than the cortical and the pith large. The cells of the endoderm are radially elongated, with an oblong aperture, and the inner portion of the wall is thicker.

Mexican sarsaparilla has the roots of each node still attached to a short portion of the hard woody rhizome. They are loosely folded into somewhat flattened bundles, much thicker at one end and loosely tied with a root which passes several times around in an irregularly spiral manner. The root is of a pale drab brown, often a little shining, almost free from rootlets and bearing but a few wrinkles, which are exceedingly deep and sharp. The transverse section shows very small pith and wood zones, with a very broad cortical layer. The endodermal cells quite closely resemble those of the Brazilian.

Jamaica sarsaparilla presents two distinct forms. The plant named above is native of Central America, whence the most of our supplies are received. This root is of a dark gray-brown color, rather thin, sharply wrinkled, and very abundantly supplied with branching rootlets. It is always separated from the rhizome and may come either pressed into square bales or tied into rolls with folded ends, like those of the Honduras, but usually thicker, looser, and with a much scantier and looser winding. The other form is known as "native Jamaica" (species of Smilax undetermined), and is the product of plants which have been introduced into the island named. This root is usually much thicker and cleaner looking, and is almost invariably of a bright orange-yellow or orange-red color. It is packed either in bales or in short, thick, lightly tied bundles. The endodermal cells are radially elongated and their walls heavily thickened.

The widest differences of opinion exist as to the relative values of the different varieties of sarsaparilla, and the predominant opinion is not constant, one variety maintaining its position as a favorite for a time, and being then displaced by another. On the whole, Honduras sarsaparilla probably enjoys a wider preference than any other, though the native Jamaican is mostly preferred in Great Britain.

Constituents.—Most earnest attempts have been made to find a tangible and useful active principle in sarsaparilla, but with only partial success. From three to fifteen per cent. of starch, according to the variety, a trace of volatile oil, a small amount of resin, pectin, etc., are unimportant. The activity appears to reside in a mixture of three saponin-like bodies, amounting in the specimens examined by Otten to nearly three per cent. Some confusion of ideas has arisen regarding the relations of these substances to one another, on account of the variety of names assigned them by different investigators. Both *parillin* ($C_{26}H_{44}O_{10}$) and *smilasaponin* ($C_{22}H_{32}O_{10}$) have been called "smilacin," and on account of this indefiniteness the last name has been dropped from scientific literature. The third body, *sarsasaponin* ($C_{22}H_{36}O_{10}$), is about three or four times as active as either of the preceding. Like parillin, it is crystallizable, while smilasaponin is not. These constituents are all more or less soluble in water or alcohol, more so upon the application of heat. Either the decoction or a preparation with a warm mixture of alcohol and water well represents the drug. The constituents are fatal to animals, with the general symptoms of poisoning by the sapotoxins.

Action and Use.—Sarsaparilla was first carried to Europe about 1536–45, and first or early employed as a cure for the same disease with which it has been since most generally associated, and for which another smilax, "China," had previously been used. The use in numerous other slow diseases, especially in eruptions and as a "blood purifier" in general, followed, and has continued extensive until the present time. Although now it has been nearly discarded as a serious medicine by physicians, it is still a much-prized popular remedy, and is extensively used, the world over, for syphilitic and scrofulous diseases. Its reputation is doubtless greatly and unduly enhanced by the enormous popular advertising of numerous proprietary articles bearing its name, but in reality quite different substances. On the other hand, there can be no doubt that the judicious use of sarsaparilla by physicians should be extended. The valuable depurative effects of the saponins, not only by promoting excretion by the intestines, but through most other channels, requires no argument, and the timely use of a laxative dose of sarsaparilla, perhaps at the soda fountain—if only a genuine article could be there expected—may well prevent the necessity for more violent treatment later on. The dose of any preparation should represent from ʒi. to ij. (4.0–8.0). The Pharmacopœia provides a fluid extract; a compound fluid extract of seventy-five-per-cent. strength, with twelve per cent. of liquorice root, ten per cent. each of sassafras and three per cent. of mezereum and a compound syrup, containing twenty per cent. of the fluid extract, fifteen per cent. each of the fluid extracts of licorice and Alexandria senna and traces of the oils of sassafras, anise, and birch.

Allied Product.—China root, from *Smilax china* L., in large, hard, jalap-like tubers, is used in the East for the same purposes as sarsaparilla.

Henry H. Rusby.

Sassafras, U. S. P.—*Sassafras bark.* The dried bark of the root of *Sassafras sassafras* (L.) Karsten. (*S. variifolius* [Salisb.] Kuntze—fam. *Lauraceæ*). Although all parts of the sassafras tree are aromatic, the bark of the root is selected for official purposes because its aromatic properties differ in kind from those of the leaves and branches, and are far stronger than the similar properties of the bark of the trunk and the wood of the root and trunk. The British Pharmacopœia makes the root, the German Pharmacopœia the wood of the root, official, while certain others include, or even specify, the wood of the trunk or at least of its lower portion. There can be no question that the official article of the United States Pharma-

copœia is very superior to any other part of the plant. The sassafras tree grows very abundantly in light soil and exposed or partly exposed situations from eastern Canada southward, being collected chiefly in the coast region. It occasionally reaches a height of seventy feet or more and a trunk diameter of upward of three feet, though usually its height is from twenty-five to forty feet and its trunk diameter little more than a foot. The root is much and irregularly branched. When it is freshly dug, its outer color is whitish and its wood yellowish or brownish white, but the former soon turns gray and the latter of a rusty red or brown after collection. Annual rings are apparent in cross-section, though less conspicuous than in most trees of the same region. The bark of the trunk is ashy gray and deeply fissured externally, whitish within, soon turning rusty brown, though not so deeply as does that of the root. The wood of the trunk is similar to that of the root, though less deeply colored. The young twigs are at first deep green and smooth, gradually becoming brownish warty, then brown and fissured with age. The large pith of the branches is described below. The form of the leaf is displayed in the accompanying cut, though often not lobed or with a lobe on only one side. The leaves are thin and downy when very young, soon becoming thickish and smooth. The diecious, small, yellowish flowers are borne in umbels or corymbs, and appear somewhat before the leaves. All parts of the tree are aromatic, bitter, and strongly mucilaginous.

The drug is thus described:

In irregular, warped, chip-like fragments, five millimeters (one-fifth inch) or less in thickness, the thicker pieces deprived of most of the gray corky layer; bright rust brown, or with more or less of the gray-brown cork adhering and exhibiting its outer surface softly and rather finely scaly, from numerous short, intersecting, shallow fissures; inner surface obscurely short striate; light, soft, and fragile, with a short, weak fracture which exhibits a broad, irregular, whitish layer between two rust-brown ones; strongly and peculiarly fragrant; taste sweetish and bitterish, aromatic, mucilaginous, and slightly astringent.

The stem bark is in strips or elongated pieces, with a lighter gray, more deeply and longer fissured outer surface, and is less aromatic, more mucilaginous and bitter.

The most important constituent of sassafras is its volatile oil, of which there is sometimes nearly ten per cent. When fresh, the bark contains a large amount of a peculiar tannin, which, after collecting, gradually becomes converted into the peculiar granular yellowish-brown substance, *sassafrid*, which is readily dissolved in alcohol. A large amount of starch, much gum, and an unstudied bitter principle also exist. The properties of sassafras are almost wholly referable to its volatile oil. No preparation of it is official, but it is largely used in the household, and to some extent by physicians, as a stimulating diaphoretic and as a deobstruent or alterative ("blood purifier"), stimulating the excretions of the kidney and skin. For these purposes, the infusion is commonly employed. It should have a strength of five per cent., and may be taken in wineglassful doses.

Oil of sassafras (*Oleum Sassafras*, U. S. P.) is defined as a volatile oil distilled from sassafras, and it is directed to be kept in well-stoppered bottles, protected from light. Although thus defined as obtained from official sassafras, it is really obtained from the entire root, the wood of which yields from one and one-half to two per cent. It is thus described:

A yellowish or reddish-yellow liquid, having the characteristic odor of sassafras without the odor of camphor, and a warm, aromatic taste. It becomes darker and thicker by age and exposure to the air.

Specific gravity: 1.070 to 1.090 at 15° C. (59° F.).

Soluble, in all proportions, in alcohol, the solution being neutral to litmus paper; also soluble, in all proportions, in glacial acetic acid, and in carbon disulphide.

If to five drops of the oil five drops of nitric acid be added, a violent reaction will take place, producing at first a red color, and finally converting the oil into a red resin.

If to a few drops of the oil a drop of sulphuric acid be added, a deep red color will be produced at first, which soon becomes blackish.

The oil consists chiefly of *safrol* ($C_{10}H_{10}O_2$), with a small amount of *safrene* ($C_{10}H_{16}$) and a very small amount of eugenol. Safrol fully represents the properties of the oil.

Oil of sassafras differs but little in its action and uses from ordinary stimulating volatile oils, for example, oil of peppermint. Although an active carminative, it is scarcely so efficient as oil of peppermint or oil of anise in that direction. On the other hand, it appears to be rather more freely excreted through the skin and a more efficient diaphoretic. It is also distinctly laxative and its reputation for stimulating the excretory functions appears to be justified. The dose of this oil is one to five minims. There is no official preparation.

Sassafras pith (*Sassafras medulla*) is the dried pith of the sassafras and is thus described:

In cylindrical, straight, curved, or coiled pieces, one to several inches in length and three to eight millimeters (one-eighth to one-third inch) in diameter, or in split portions of the same; white, very light, and spongy; inodorous or with a slight odor, as well as taste, of sassafras; very mucilaginous.

Macerated in water, it forms a mucilaginous liquid, which is not precipitated on the addition of alcohol.

Its aromatic content is entirely insignificant and it is valued wholly for its gum, which readily forms a mucilage upon maceration with water. This mucilage possesses the important property of mixing with alcohol without precipitation, and it becomes a useful vehicle for the administration or application, especially to the eye, of active substances. Its properties in general are merely those of mucilages. Its mucilage is directed to be made freshly, when wanted, by macerating two grams of the pith in 100 c.c. of water for three hours and straining.

Several other vegetable products are called sassafras in other countries, but none of them is of interest in our Materia Medica. Henry H. Rusby.

Sassy Bark.—*Mancona Bark.* The bark of *Erythrophleum guineense* Don. (Fam. *Leguminosæ*), a good-sized, acacia-like tree, growing in tropical Africa, and employed by the tribes of the west side like Calabar beans, as an ordeal. It was made known in Europe and America about forty years ago, and was revived as a medicine about ten years since. It is a ponderous bark, heavier than water, of a dull red color, a fissured external surface, and a short fracture. Odor slight, taste astringent. The active principle of sassy bark is *erythrophleine*, a crystalline alkaloid, first obtained by Gallois and Hardy. It is an active heart-poison of the digitalis kind, producing slowing of the pulse, increase of blood pressure, and in experiments upon animals death, with the heart in systolic contraction. The powdered drug is a powerful sternutatory. But little use has been found for this potent medicine. It is sometimes used like digitalis, in doses of one to three grains, of the bark, in the form of a tincture, but is far less certain and regular than that drug and even more inclined to upset the stomach. It is said to be employed at home in dysentery, etc., with benefit, as well as in intermittent and other fevers. In full doses it is nauseating and emetic, as well as somewhat narcotic.

H. H. Rusby.

Satterlee, Richard Sherwood.—Born in Fairfield, Herkimer County, New York, Dec. 6, 1798. He studied medicine, and, after graduating, began the practice of his profession in 1818, in Seneca County, New York; but soon afterward he removed to Detroit, in the Territory of Michigan. In February, 1822, he obtained the appointment of Assistant Surgeon in the United States Army. In 1837 he accompanied the troops to the Florida War, and was assigned to duty as Medical Director on the staff of Col. (afterward General) Taylor, of the First Infantry. During the following sixteen years he saw active service in a number of places: with General Scott in the Cherokee campaign (1838); on the Canada frontier (1839 and 1840); in Mexico (1846 and 1847); and in various shorter military expeditions. In February, 1853, he was assigned to duty as Medical Purveyor of the Army, a position which he held till the close of the Civil War. In 1866 he was made Brevet Brigadier-General, "for diligent care and attention in procuring proper army supplies as medical purveyor, and for economy and fidelity in disbursing large sums of money"—amounting to a total of nearly twenty millions of dollars. Stone says of him: "The active duties of Gen. Satterlee in a peaceful branch of the military profession prevented his giving that exclusive attention to any special department of the medical profession. The noted care of the troops under his charge and their efficient organization speak for him as a surgeon and a physician as well as an organizer." He died in New York City Nov. 10, 1880. A. H. B.

Satyriasis.—See *Neuroses, Sexual.*

Saw Palmetto.—See *Sabal.*

Sayre, Lewis Albert.—Born at Bottle Hill (now Madison), New Jersey, Feb. 29, 1820. He studied medicine at the College of Physicians and Surgeons, New York City, and received his doctor's degree from that institution in 1842. In 1853 he was appointed an Attending Surgeon at Bellevue Hospital, and in 1859 Surgeon to the Charity Hospital on Blackwell's Island. He was one of the prime movers in the organization of the Bellevue Hospital Medical College, in 1861, and, upon the formation of its Faculty, was made Professor of Orthopedic Surgery and Fractures and Luxations. Dr. Sayre was the first American surgeon who performed an operation for the relief of hip-joint disease, with a successful result. This was done in 1854, and the case was reported in the *New York Journal of Medicine* for January, 1855. A few years later Dr. Sayre gave much attention to the treatment of Pott's disease of the spine and its resulting deformity—lateral curvature of the spine; his method being by suspension of the body and the application of a plaster-of-Paris jacket. He died September 21, 1900.

Of his numerous contributions to medical literature the following deserve to receive special mention: "Exsection of the Head of the Femur and Removal of the Upper Rim of the Acetabulum for Morbus Coxarius;" "Mechanical Treatment of Chronic Inflammation of the Joints of the Lower Extremities;" "Report on Pott's Disease, or Caries of the Spine Treated by Extension and Plaster-of-Paris Bandage;" and "Results in Cases of Hip-joint Disease Treated by the Portable Traction Splint. Dr. Sayre has also published two larger treatises, viz., "A Practical Manual of the Treatment of Club-foot," and "Lectures on Orthopedic Surgery and Diseases of the Joints." A. H. B.

Scabies (Latin, *scabies*, an itching eruption, from *scabo*, I scratch).—Synonyms: The Itch; German, *Krätze;* French, *Gale.* Scabies is a contagious disease of the skin, wholly local in character, due to the presence of an animal parasite—the *Acarus* or *Sarcoptes scabiei* (see *Arachnida*, in vol. i.) in, and upon, the skin. The eruption present may vary from the smallest amount imaginable, a few papules, up to the most severe development of inflammatory lesions, even such as to render the patient helpless; the subjective sensations may vary from a slight pruritus, which is described as not unpleasant when relieved by scratching, up to an itching which is almost unendurable, causing restless nights and distressing days.

The most common sites for the lesions of scabies are the hands, especially about the wrists, in the soft skin between the fingers, and on the sides of the hands. But in many cases the eruption is entirely absent from this locality and is well marked elsewhere. In males the penis seldom escapes, and in females the region of the nipples is very apt to be affected; the anterior fold of the axilla is a very common seat of the lesions, and the elbows and extensor surface of the forearms are sometimes most severely affected. In those who sit a great deal the buttocks often present an abundant eruption. In infants and children the softer parts of the feet and ankles generally exhibit lesions. It may be said that the head is never affected by scabies.

The eruption of scabies exhibits the greatest variety of lesions, from the smallest papules and vesicles to large pustules, often ecthymatous in character, and in weakly children pustular bullæ may form on the hands. The bulk of the lesions is papular, although small vesicles can generally be seen on tender portions of the skin during some period of the disease. Mingled with these primary lesions there are generally found the results of scratching, viz., abraded surfaces and those covered with crusts.

The only single pathognomonic sign of scabies is the *cuniculus*, furrow, or burrow (German, *Milbengang;* French, *sillon*), which is caused by the penetration of the female beneath the epidermal layer of the skin in the search of a place where she may lay her eggs; the male seldom, if ever, goes beneath the skin. This cuniculus consists of a minute, dark-colored line, generally somewhat beaded in appearance and curved, appearing much as if a bit of dark sewing-silk had been run beneath the surface; rarely, it is as long as a fourth of an inch, more often half that length; and generally it may be seen to terminate at one end in an inflamed papule or vesicle, or sometimes to run over a pustule. The female insect will be found at that end of the furrow, and the dark line is her track, which is found to be filled with eggs in various stages of development, and, among them, black particles of feces. If the skin is washed these dark lines, instead of being removed, become more apparent; but in recent cases, or in individuals who are very cleanly or have undergone treatment, it is often impossible to discover any of these cuniculi, although the disease may still exist, and, if left alone, it will increase and may be communicated to others.

Scabies is not a very frequent disease in this country, forming only about 1.5 per cent. of a large number of skin cases analyzed. In other countries it is more common, and in Glasgow it formed twenty-five per cent. of 10,000 cases analyzed by McCall Anderson.

Diagnosis.—Considerable care is often required to diagnose a mild or unusual case of scabies, and cases sometimes go unrecognized for a long time. The disease most commonly confounded with it is eczema, which may present almost identical appearances, except that there are no cuniculi; when these latter are positively found the diagnosis is certain. The location and distribution of the eruption, the history of contagion, and the multiform character of the lesions are generally sufficient to establish the diagnosis. Scabies may also be confounded with lichen, pityriasis, prurigo, pruritus, and urticaria papulosa.

Etiology.—There is but one cause of scabies, the presence of the parasite (acarus or sarcoptes scabiei),

whose removal or destruction is followed by the cessation of the disease. It often occurs, however, that the treatment employed may occasion an amount of artificial eruption or dermatitis which may mask the true affection, and may even remain after the real cause of the disease has been destroyed; this second eruption may require a very different treatment, of a soothing character.

Pathology.—The only pathological lesions, aside from the presence of the cuniculus, are those connected with inflammation of the skin. The lesions are simply inflammatory areas of greater or less size, caused either by the direct irritation of the burrowing insect, or by the scratching or other measures employed for the relief of the itching, or by both. When the local irritation is removed the eruption ceases; if the acari could all be removed mechanically, picked out, there would be no eruption. In patients who are paralyzed on one side, or who have been unable to scratch, there is very little eruption on the portions of the skin which are out of reach.

Treatment.—The treatment of scabies is purely local and consists in such measures as destroy the life of the parasitic insects and their eggs. The patient first takes a warm bath, using plenty of strong soap rather alkaline in character, such as the sapo viridis or the common laundry soap, and rubbing the affected parts so as to break the furrows as much as possible. After drying, the affected parts, or even much of the body, should be well rubbed with an ointment of which sulphur is a chief ingredient. The ordinary sulphur ointment diluted once, with the addition of a dram of liquid storax to the ounce, answers as well as anything. A very cleanly treatment, though sometime as little irritating, is with beta-naphthol, well pulverized, half a dram to the ounce of rose ointment. After thorough friction with this for at least half an hour, the patient puts on underclothes which are to remain on night and day until the end of treatment. The ointment should be freshly rubbed in twice daily for several days, and a bath is to be taken on the third day, the ointment being again rubbed in and a fresh suit of underclothes put on. After three days more of treatment another bath may be taken, and it is then to be expected that the cure is complete. But frequently some of the cuniculi will be found to have escaped being broken, or new infection may come from the clothing or elsewhere, and in such case the treatment must be repeated. Sometimes an artificial eruption is excited by the treatment, when soothing remedies are required. The clothing should always be treated; the underclothes should be boiled a long time and very thoroughly ironed; the outer garments may be baked or very thoroughly ironed on the wrong side. Patients should be more or less isolated, although when they are under treatment the chances of communicating the disease are very small.

Prognosis.—The prognosis is, of course, favorable; there can never be the slightest harm in curing even the most inveterate or severe cases of scabies. In the hospitals abroad it is claimed that a cure is effected in a few hours, but it is questionable if, in the large majority of cases, the relief is more than temporary, a portion only of the parasites being killed. Practically, cases require treatment for a number of days, or even weeks, to make the cure certain; when the skin is delicate the active parasitic treatment may have to be interrupted, owing to the dermatitis excited, and occasionally it will be found difficult to use remedies strong enough to effect a cure.

L. Duncan Bulkley.

Scammonii Radix.—Scammony Root, U. S. P., B. P.) The dried root of *Convolvulus scammonia* L. (fam. *Convolvulaceæ*), yielding not less than eight per cent. of the total resins of Scammony Root. This is a perennial herb of the Levant, having a long, thick, cylindrical, several-headed, but otherwise usually simple, milky-juiced root, and numerous twining stems, resembling those of an ordinary morning-glory vine. The root is up to a meter in length, and a decimeter in diameter, at the crown, light brownish yellow without, white within, fleshy, and resinous. In drying, it shrinks to about half of its former diameter and is more or less twisted. Its only use is for the extraction of the resin.

Resina Scammonii or *Resin of Scammony*, U. S., is extracted from the roots defined above. Heretofore, it has been required that it be collected from the living root. This was done by cutting off the living root at the crown and either scraping off the exudation as it appears or placing some receptacle, commonly a mussel shell, at the lower side to receive it as it runs down. It may dry at once, a very high grade of the drug thus resulting; or, as is more usual, the separate collections are laid aside until enough is accumulated to make a "cake," when it is all moistened and kneaded together. In this way the bubbles and sour odor of what is known as "virgin scammony," are produced.

It is now extracted from the official root by the following process: Moisten scammony root, in No. 30 powder with sufficient alcohol, pack it in a cylindrical percolator, then add enough alcohol to saturate the powder and leave a stratum above it. When the liquid begins to drop from the percolator, close the lower orifice, and, having closely covered the percolator, macerate for forty-eight hours. Then allow the percolation to proceed, gradually adding alcohol, until the percolate ceases to produce more than a slight turbidity when dropped into water. Distil off the alcohol until the percolate is reduced to the consistence of thin syrup, and pour it slowly, with constant stirring, into 1,000 millilters of hot water. When the precipitate has subsided, decant the supernatant liquid, wash the precipitated resin twice by decantation with fresh portions of 1,000 milliliters each of hot water and dry the resin on a water bath. It should then consist of brownish, translucent masses or fragments, breaking with a glossy, resinous fracture; odor characteristic and fragrant.

It is soluble in alcohol in all proportions, and not less than ninety-five per cent. is soluble in ether (distinction from *resin of jalap and resin of false scammony*). When triturated with water, it does not alone form an emulsion. Ammonia water and solutions of the alkali hydroxides dissolve it with the aid of gentle heat, and from these solutions the resin is not reprecipitated by dilute acids. Its solution in alcohol does not give a blue color with ferric chloride T.S. or with solution of hydrogen dioxide (*guaiac*).

Sulphuric acid does not gradually turn red when stirred in a porcelain dish with an equal weight of resin of scammony (*rosin*).

Resin of scammony yields not more than one per cent. of ash.

Composition.—The peculiar resin of scammony, unfortunately called *jalapin*, and now known as *scammonin*, first obtained in a state of purity by Johnston, in 1840, differs from the *convolvulin* of jalap by its solubility in ether.

When purified, it is a colorless, translucent, brittle non-crystalline resin, tasteless and odorless, of nearly neutral reaction, and freely soluble in ether. It is a glucoside, and resolvable into *scammonic acid*, a crystalline substance, and sugar. Good scammony (the exudation from the lining root) contains eighty or ninety per cent. of this resin.

Action and Use.—Scammony and its resin are to be counted among the very active drastics, excelled only by croton oil and elaterium. Their action is similar to that of jalap, but considerably more intense. They are used as derivatives and hydragogue cathartics in

cases of cardiac and renal troubles associated with dropsy. Aromatics and carminatives are appropriate adjuvants. Dose, of good scammony, gr. viii. (0.5) or so; of the resin, gr. v. 0.3). The compound extract of colocynth contains fourteen per cent. of resin of scammony. Of late, large quantities of spurious scammony resin have been manufactured from *Ipomœa orizabensis*, of Mexico, which has thus come to be called Mexican scammony root. Many attempts have been made to import this root into the United States, for this fraudulent purpose, but have been opposed by the U. S. Department of Agriculture.

H. S. Rusby.

Scanzoni, Friedrich Wilhelm von Lichtenfels.—Born at Prague, Bohemia, Dec. 21, 1821. He studied medicine at the university of his native city, and received his doctor's degree in 1844. Then, after he had made the usual tour of visits to the hospitals and clinics of other European cities, he was given the position of surgeon in charge of the gynecological section of the Prague Allgemeines Krankenhaus. In 1850 he accepted a call to fill the Chair of Obstetrics in the University of Würzburg, and he continued to hold this position up to the year 1887, when he retired from the professorship, but still continued to be the Director of the Gynecological Clinic, the Lying-In Hospital, and the School for Midwifery Nurses. The title of Geheimer Medizinalrat was conferred upon him during this same year. He died at Schloss Zinneberg, Upper Bavaria, June 11, 1891.

Of Scanzoni's published writings the following deserve to receive special mention: "Lehrbuch der Geburtshilfe," 3 vols., Vienna, 1849–52 (fourth edition in 1867); "Die Geburtshilfliche Operationen," Vienna, 1852; "Die Krankheiten der weiblichen Brüste und Harnwerkzeuge, sowie die dem Weibe eigenthümlichen Nerven- und Geisteskrankheiten," Prague, 1855 (a continuation and completion of Kiwisch's Clinical Lectures on the Special Pathology and Therapeutics of the Diseases of the Female Sexual Organs); "Lehrbuch der Krankheiten der weiblichen Sexualorgane," Vienna, 1857 (fifth edition in 1875); "Die chronische Metritis," Vienna, 1867; and "Beiträge zur Geburtskunde und Gynäkologie, 7 vols., Würzburg, 1854–78.

A. H. B.

Scapula, Diseases and Injuries of the.—Diseases of the Scapula.—Acute periostitis and osteomyelitis of the scapula are rare. When present they are usually the result of traumatism followed by infection, and affect most commonly prominent portions of the bone, such as the spine.

Tuberculous osteomyelitis of the scapula is much more common and may give rise to extensive caries and necrosis. Cold abscesses may form and reach the surface at some distance from the focus in the bone. In rare cases the shoulder-joint may become involved.

The treatment of tuberculous disease will depend upon the extent of the local process. Small foci may be scraped out with the Volkmann spoon and treated later by iodoform injections. Larger foci may require resection of a part of the bone, such as a portion of the body or the spine. Complete excision of the scapula is seldom indicated.

Tumors of the scapula may be either benign or malignant, the latter being the most common. A collection of 64 cases made by Langenhagen showed the following relative frequency: Exostosis, 8; chondroma, 14; fibroma, 5; carcinoma, 23; sarcoma, 12; uncertain tumors, 2.

The tumor may reach an enormous size, and in case of the malignant varieties the surrounding parts may become invaded. Some tumors grow into the axilla, others spread to the adjacent muscles, and may eventually ulcerate through the skin. Metastases may occur in the pleura, lungs, vertebræ, or some other internal organ.

The treatment of malignant neoplasms consists in excision of the scapula provided that the tumor has not involved the arm. In the latter case removal of this as well may be indicated (interscapulo-thoracic amputation).

Benign tumors, when circumscribed, may be removed by partial resection of the portion of bone involved. The usual incision for excision of the scapula begins over the acromion, runs along the spine to its inner border and there descends to the angle. Through this incision the muscular attachments are divided close to the bone, and the whole bone is removed. If possible that part of the acromion should be preserved which receives the insertions of the trapezius and deltoid muscles. Otherwise the function of these muscles will be lost.

Fractures of the Scapula.—These are comparatively rare injuries (according to various authors from one to four per cent. of all fractures), and occur chiefly in adult males.

The following varieties of fractures occur

1. Fracture of the body of the scapula (including one of the angles).
2. Fracture of the glenoid cavity.
3. Fracture of the neck.
4. Fracture of the acromion and spine.
5. Fracture of the coracoid process.

1. *Fractures of the body* are the most common. They occur usually in the infraspinous fossa, and the line of fracture is most commonly transverse. The cause is blunt violence, such as a blow or fall, and there may be considerable contusion of the overlying soft parts. In case of multiple fractures, there may be several fissures radiating from a central point. Fractures of the lower angle form a comparatively common group of fractures of the body, and may be accompanied by considerable displacement of the small lower fragment. Fractures of the upper angle are far less frequent.

The objective symptoms of fractures of the body are, as in other fractures: crepitus, false motion, and localized tenderness. These signs are not always easy to make out, especially in muscular subjects or in case of marked swelling. The scapula can be brought into prominence and thus be easier to palpate if the elbow is drawn inward in front of the chest or the arm carried backward and inward. Dislocation of the fragments is most marked in fractures of the lower angle, and is then due to the combined action of the teres major and serratus magnus muscles upon the lower fragment.

The prognosis of these fractures is good. Bony union usually takes place promptly under proper immobilization, and the function of the arm is not impaired. In the rare cases of compound fracture suppuration may occur, and the pus may burrow downward between the scapula and the muscles of the back.

The treatment consists in immobilization of the shoulder and scapula in that position which overcomes the deformity. The arm can be kept in this position by means of a Velpeau bandage to which may be added some turns of a plaster-of-Paris bandage. In about four weeks the fracture should be solid and movements of the arm may be begun. Suture of the fragments has been recommended in certain cases.

2. *Fractures of the Glenoid Cavity.*—These are rare fractures which may involve chipping off of some portion or of the whole of the articular surface (fractures of the anatomical neck). They are sometimes associated with dislocation of the humerus. The symptoms are very obscure, and it is doubtful if a diagnosis can be made. As a dislocation of the humerus is often present, the treatment would be that of the dislocation.

3. *Fractures of the neck of the scapula* are of considerable practical importance. The line of fracture runs downward from the incisura scapulæ. The causes are usually some form of direct violence applied to the shoulder region, such as a blow or fall.

The symptoms resemble somewhat those of dislocation of the head of the humerus. There are a flattening of the shoulder and abduction of the arm; the acromion is prominent, and the axis of the arm is not directed toward the shoulder-joint. The chief point of difference is that the fractured piece can be felt in the axilla as an irregular object not resembling the smooth head of the humerus. By grasping the coracoid process with the middle finger and the posterior aspect of the shoulder with the thumb, crepitus can be felt on rotation of the arm. Crepitus can also be felt by palpation in the axilla. The deformity of the shoulder can be readily overcome by upward pressure on the fragments within the axilla, but recurs again as soon as pressure is stopped. In dislocation of the shoulder, on the other hand, the deformity is made to disappear only by special movements for reposition of the head of the bone.

The treatment consists in replacing the fragment by upward pressure and maintaining it in place by a pad in the axilla. The arm is secured to the body by means of a Velpeau bandage. Plaster bandages may be applied as an outside dressing. The fracture sometimes requires as long as from ten to twelve weeks for consolidation.

4. *Fractures of the acromion and spine* are produced by direct violence upon these prominent portions of the bone. The line of fracture is usually transverse. The most important symptoms are the irregularity in the outline of the bone, localized tenderness, and occasionally crepitus. In case of the acromion, the fracture lies either in front of the acromioclavicular joint or near the base of the acromion. The outer fragment may be displaced downward from the weight of the arm. The treatment of fractures of the spine consists in immobilization of the arm in a flexed position. In fractures of the acromion the outer fragment is elevated by pressing the humerus upward. It is retained in position by means of a bandage bound around the shoulder and body or by an adhesive plaster strip supporting the elbow and crossing itself over the point of fracture.

5. *Fractures of the Coracoid Process.*—These are very rare and are usually combined with some other fracture or dislocation in the vicinity. The fracture is usually near the base of the process, and results most commonly from direct violence, although muscular contraction has been known to produce it.

The chief symptoms are local swelling, ecchymosis, abnormal mobility, and crepitus. Pain can be elicited by flexion of the forearm in a supinated position, as this brings the short head of the biceps muscle into action.

The treatment consists in immobilization of the arm in a flexed position by means of a Velpeau bandage.

BENJAMIN T. TILTON.

Scarlatina.—*Synonyms:* Scarlet fever; *Scharlach* (German); *la scarlatine* (French); *scarlattina* (Italian); *escarlatina* (Spanish); *febris rubra* (Latin).

DEFINITION.—Scarlet fever is an acute, highly contagious disease characterized by a sudden onset with high fever, vomiting, headache, and sore throat, followed in from twelve to thirty-six hours by a generalized punctiform eruption, which in turn is followed by desquamation. One attack usually renders the individual immune to this disease for life. The most common complications are otitis media, adenitis, and nephritis.

HISTORY.—This disease has probably existed for many centuries, but it was not recognized as a disease *sui generis* by ancient writers, including Hippocrates, who confused it with measles, smallpox, and diphtheria. The first authentic description of scarlet fever as a disease entity is attributed to Ingrassias, of Palermo, whose work is dated 1560. Sydenham was the first to give this disease its present name; and on the basis of his study of the London epidemics from 1661 to 1675, to present a clear delineation of the clinical features of this disease. During the eighteenth century epidemics of scarlet fever prevailed throughout Europe. The disease first appeared in the American colonies in 1735.

GEOGRAPHICAL DISTRIBUTION.—Scarlet fever occurs in all parts of the world, but is said to be rare in Asia and Africa. According to Minor, there is a zone of comparative immunity in the Eastern Hemisphere extending from 10° south latitude to 20° north latitude, which zone includes Sumatra, Borneo, India, and most of Africa. In the Western Hemisphere there is a zone of comparative immunity extending from the equator to 10° north latitude, and one extending from 30° to 35° north latitude. In the latter zone are included South Carolina, Georgia, Alabama, Mississippi, Louisiana, Texas, and the northern part of Florida. As regards the influence of climate, a very high temperature, combined with a humid atmosphere, is said to be unfavorable to the development of scarlatina.

EPIDEMIOLOGY.—Scarlet fever is endemic in most large cities and also occurs in epidemic waves.

Seasonal Incidence.—In England and on the continent of Europe scarlet fever is most prevalent in the autumn, but in the United States it is prevalent mostly in the late winter and early spring months.

Age Incidence.—Scarlet fever occurs mostly during the early period of childhood. It is most apt to be contracted at a later period of life than is measles or whooping-cough. Infants under one year are relatively immune. The disease occurs with increasing frequency from the second to the sixth year of life, but the second five years of life show the greatest number of cases. Adults are far less susceptible to the disease than are children and after the age of fifty the disease is rare.

Sex Incidence.—Females are attacked slightly more frequently than males.

Susceptibility.—The susceptibility to this disease is far less than in the case of measles. A classical illustration of this fact is furnished in the case of the Faroe Islands in which from 1873 to 1875 there occurred an epidemic of scarlet fever after a period of sixty years in which not a single case had been observed. During the epidemic only thirty-eight per cent. of the inhabitants of the chief city contracted the disease, whereas during an epidemic of measles in 1875 ninety-nine per cent. of the population were affected. The white races in the United States are six times more susceptible to scarlatina than are the negroes. Throat conditions increase the susceptibility to scarlet fever. Predisposition to this disease is also favored during convalescence from diphtheria.

ETIOLOGY.—The cause of scarlet fever is probably a microorganism the identity of which has as yet eluded discovery. Various observers have described cocci, bacilli, and protozoa as the exciting agent, but without sufficient proof. Various strains of streptococci have been isolated in pure culture from the throat, tonsils, blood, desquamated epithelium, and from the internal organs in cases of scarlet fever. As arguing against the etiological rôle of these microörganisms the following considerations are offered by F. Rolly: (1) The inoculation of healthy individuals with these streptococci has not evoked the disease. (2) Streptococcus infection does not confer an immunity to further infection with the same germ, whereas one attack of scarlet fever usually renders an

individual immune to this disease. (3) In cases of scarlet fever in which death has occurred on the second or third day the blood and the internal organs are found to be sterile. This would seem to indicate that the streptococcus is a secondarily invading microorganism. (4) The streptococci cultivated from the blood in cases of scarlet fever are identical with streptococci obtained from other sources. (5) The so-called scarlatinal streptococci have a much lower degree of infectivity and a considerably lower degree of viability than the virus of scarlet fever.

The pathogenic agent in scarlet fever is transmitted from individual to individual by direct contact, or indirectly by human or animal carriers, by fomites, or by foods. During the period of incubation the individual in all probability does not infect others, in this respect contrasting with measles. With the beginning of and possibly slightly before the period of invasion the virus is given off from the tonsils, the buccal and nasal secretions, and the skin, and in the urine. The duration of this infectivity has been regarded until recently as extending to the completion of desquamation; the cessation of all discharges from the throat, nose, and ear; and the healing of all wounds in the scarlet fever patient. The infectivity is greatest during the febrile period; diminishes gradually during the stage of convalescence; and is practically nil at the end of five weeks from the beginning of the period of invasion, provided there are no pathological discharges from or lesions in the body. The duration of this period of infectivity varies from patient to patient. The virus may persist for a long time on articles of clothing, books, toys, etc. It may be carried through the medium of milk or other foods. The morbid agent usually enters the body through the tonsils, but may gain access through wounds of the body surfaces. Although one attack of scarlet fever, as a rule, confers lasting immunity, second and even third and fourth attacks may occur. These repeated attacks must be distinguished from the relapses that sometimes occur three or more weeks after the onset of the original attack.

Symptoms.—*Period of Incubation.*—This comprises the latent period from the moment the virus gains a foothold in the body until the beginning of the period of invasion. It may last from two to seven days but usually lasts from two to four days. There are no characteristic clinical manifestations during this period. In the large majority of patients during this stage there are neither subjective nor objective symptoms. A few patients complain of malaise, lassitude, and headache, and there may even be a slight rise of temperature.

Prodromal Period or Period of Invasion.—This begins suddenly, in contrast with the gradual onset of measles, with chills, headache, vomiting, diarrhea, and sore throat. The four cardinal symptoms of this stage are fever, headache, vomiting, and sore throat. One or more of these symptoms may be absent in mild cases. Vomiting is more apt to occur in children than in adults. The temperature rises rapidly and in a short time reaches 104° F. The patient feels quite sick and in addition to the headache and sore throat, complains of pains in his limbs and back, and of dryness and burning in his mouth. Sleep is disturbed and delirium may occur. The objective symptoms are an acceleration of the pulse out of all proportion to the temperature (a sign of considerable importance in the diagnosis), a reddening and swelling of the mucous membrane of the throat and soft palate, an inflammation of the tonsils, and a tenderness in the glands at the angle of the jaw. The tongue is thickly coated and sometimes the enlarged papillæ may be perceived along its margins. The face is flushed and the region about the mouth may appear uncommonly pale. The prodromal period lasts from twelve to thirty-six hours. In exceptionally mild cases none of the symptoms of this period may be pronounced and the appearance of the eruption may be the first manifestation to attract attention.

Period of Eruption or Efflorescence.—This is also known as the stage of advance and the *stadium exanthematicum.* It lasts from one to four days or from the moment the rash appears until it begins to fade. The temperature remains at the level which it has reached during the preceding stage, between 101° and 104°, and subsides with the fading of the rash. The pulse regains its normal ratio to the temperature after the first twenty-four to thirty-six hours of the eruption. The face is highly flushed and the circumoral pallor is intensified. The eyes are clear and the conjunctiva is injected only in severe cases.

The eruption is admirably described by Ker, of Edinburgh, as follows: "The rash is usually obvious within twenty-four hours of the onset of symptoms. It appears first on the sides of the neck and on the upper part of the chest, spreading downward over the trunk and extremities. The whole body may be covered in a few hours. As it appears so it fades, the last traces of it being often to be found on the legs. The *distribution,* then, is general, except in so far that the face does not participate in the general punctation. The most that is usually to be seen in this situation is some punctate spotting in the neighborhood of the angle of the jaw. The palms and soles, moreover, though flushed, seldom show definite punctation, except perhaps on the thenar and hypothenar eminences of the former. The back of both hands and feet, however, is invaded by the rash. As to the *character* of the eruption, it consists of closely set minute points, usually of a brilliant red color upon a paler but often flushed background. In mild cases the spots are pink and the background is pale. The individual punctate spots almost touch each other. They may vary somewhat in size, but on an average will hardly exceed half the diameter of the head of an ordinary pin. Their margin is not always too clearly defined, but in intense rashes tends to blend almost imperceptibly into the subjacent erythema. The spots are not appreciably raised above the surface, and are obliterated by light pressure. The pattern of the hand, firmly pressed on the skin, is left for a few seconds standing out dead white on a brilliantly red background. It may be mentioned that the skin often feels pungently hot to the touch. In most cases the rash is uniform, but it is often better marked in some situations than others. Thus it is usually very well developed on the back, although its punctation may not be very distinct there. The abdomen and inner side of the thighs will often show a brighter and more definitely punctate eruption than some other parts. On the extremities the rash in some cases tends to be blotchy, the lesions showing a certain tendency to irregular distribution and grouping. Again, in rough-skinned persons particularly, the spots appear to be slightly raised above the skin on the arms and legs. This gives a suggestion of fine papulation to the rash. The raised skin papillæ may retain their hyperemic appearance after the rest of the rash has faded, and this point is often of importance in diagnosis. The rash varies in its *intensity* according to the severity of the case. When it is extremely marked it may become miliary, the individual puncta becoming crowned with tiny vesicles containing a yellowish fluid, and the whole surface of the body, and often of the extremities, is, as it were, peppered with minute yellow spots on a dark red background. The rupture of these miliary vesicles gives an explanation of the mechanism of desquamation. It leaves a little pinhole breach in the cuticle and we can well believe that what occurs macroscopically in a miliary eruption also takes place microscopically in the hyperemic skin papillæ of the typical rash. In other patients the intensity of the eruption is evidenced by the occurrence of slight

hemorrhage into the punctate spots, which become darker and purple in color, and no longer disappear on pressure. Such spots may remain visible for some time after the subjacent erythema has faded. Even in moderate cases, however, some degree of *staining* survives the rash. In the flexures of the joints, particularly in the fold of the elbow, a dark red line is often left transversely across the limb, not fading on pressure but well stained into the skin. This line may be of great assistance in the diagnosis of a doubtful case. The *duration* of the rash as apart from staining seldom exceeds four days. In very mild cases it may last for only a few hours."

During the stage of eruption the appetite is completely lost, the tongue is heavily coated, and the sore throat is intensified. The tonsils are red and swollen and covered with yellow or dirty-white patches of exudate or false membrane and the surrounding mucosa of the throat, soft palate, and uvula is also greatly swollen and reddened. The coating on the tongue is gradually cast off revealing on the fifth or sixth day the greatly swollen and reddened papillæ of the tongue, which account for the designation "strawberry tongue." Accompanying the scarlatinal angina there is a swelling of the glands at the angles of the jaw and of the remaining cervical and occipital lymph nodes. The urine is highly colored and may present a slight febrile albuminuria. There is no diazo-reaction in the average case, in contrast with measles, but there is frequently an early acetonuria. The blood shows a pronounced leucocytosis which depends upon an absolute and relative increase in the number of polymorphonuclear cells. The onset of the fever is accompanied by an eosinophilia which may continue to the end of the first week. A slight bronchitis is occasionally present. The spleen is, as a rule, swollen, soft, and palpable. The symptoms subside in their intensity with the fall of the temperature at the same time that the rash fades.

Period of Desquamation and Convalescence.—The temperature falls by a rapid lysis within three to five days and in rare instances by a crisis. At the same time the rash recedes and the throat resumes its normal appearance. Desquamation is first noted on the lobes of the ear and sides of the neck, although it sometimes begins as a fine powdering on the cheeks. From the head the desquamation spreads over the trunk and limbs. In its characteristic type this process consists in the separation of large or small flakes of skin. Sometimes the cuticle separates as an almost imperceptible powder. The flakes are best seen on the neck and chest and on the outer surfaces of the arms, forearms, and thighs. The peeling on the palms, soles, fingers, and toes is almost constant. The last skin to be exfoliated is that of the heel.

Types of Scarlet Fever.—These may be classified as follows: (1) *Scarlatina simplex* is the average type of the disease as described above. (2) *Mild types* may occur in which the fever and other symptoms may be slight and evanescent. A bright rash and the "strawberry tongue" may occur unaccompanied by any fever. In some epidemics there may be a preponderance of these mild cases. This group includes the cases of so-called *scarlatina sine* (without) *angina*, *scarlatina sine febre*, and *scarlatina sine exanthemate*, all of which are extremely uncommon, but the possibility of which must be borne in mind. The diagnosis of scarlet fever without an eruption would depend upon the presence of the throat and tongue signs and the occurrence of the characteristic late complications. (3) *Severe types.* These include the toxic and the septic cases. They may occur in any epidemic, may preponderate in some epidemics more than in others, and are responsible for the majority of the fatalities. *Toxic scarlatina* is synonymous with the older conception of *scarlatina maligna*, and is characterized by severe general symptoms associated with moderate throat lesions and a fatal termination. Some of these cases may be *fulminant* in which death occurs within twenty-four hours after, perhaps, continuous vomiting and diarrhea. Generally the patient survives from two to five days; the rash is scanty and delayed; the temperature is high and the pulse rapid; obstinate vomiting and diarrhea may be present; nervous symptoms, such as delirium, insomnia, and subsultus tendinum may occur; the heart may fail, as the result of which the face becomes pale and the rash scanty and cyanotic; and petechiæ may occur. *Septic scarlatina* represents a type in which the severe symptoms are the result of a supervening infection with pyogenic bacteria. This type is responsible for most of the deaths in scarlet fever. The rash is well marked, the temperature is high, the pulse is rapid, and the angina is severe. There is considerable swelling with ulceration in the throat and nasopharynx, there is a profuse purulent discharge from the nostrils, and the lips become excoriated. The glands of the neck become greatly enlarged. A purulent otitis media almost always occurs and mastoiditis may develop rapidly. The general condition is one of septicemia. Recovery may occur after three or four weeks, but death usually occurs in the third week. A *typhoid* type of scarlet fever is described as one belonging to the septic group but unaccompanied by severe throat lesions. In this type the disease runs a course similar to that of typhoid fever; a remittent temperature persists after the disappearance of the rash. *Surgical* and *traumatic* forms of scarlatina include cases in which the infection is acquired as the result of an injury such as a burn or finger-prick.

Complications.—These occur during the period of desquamation, mostly during the third and fourth weeks of the disease. The most common complications are nephritis, adenitis, and otitis media. There also occur endocarditis, arthritis, rhinitis, vaginitis, bronchopneumonia, and postscarlatinal diphtheria.

Nephritis.—Most of the cases of scarlatinal nephritis occur between the sixteenth and the twenty-sixth days of the disease. Nephritis may complicate mild as well as severe types of scarlet fever. A mild and even an unrecognized case of scarlet fever may be followed by a severe attack of nephritis. This complication is the result of the action of the toxins of the specific microorganism of scarlet fever upon the kidneys, or of the invasion of these organs by secondary invaders, usually streptococci. Exposure to damp and cold may predispose to the condition. The most frequent age incidence of scarlatinal nephritis is five to seven years. The earliest symptom is vomiting. Other symptoms are edema of the face and limbs, irregular fever, headache, drowsiness, and convulsions. The urine is scanty and contains considerable albumin, blood, and a large variety of casts. Suppression of urine may occur. Recovery results in the vast majority of cases, usually at the end of six weeks. Death may result from uremia, convulsions, or edema of the lungs. Scarlatinal nephritis may be followed by a subacute or a chronic nephritis.

Adenitis.—The "late" adenitis of convalescence must be distinguished from the adenitis present in septic cases. The condition involves the glands of the neck which are enlarged and tender and which sometimes undergo suppuration, and is usually accompanied by a high remittent temperature.

Otitis Media.—This is said to occur in about 12 per cent. of all cases. The symptoms are earache, rise of temperature, and sometimes enlargement of the lymph nodes below the ear. Suppuration may occur even without pain. The ear-drum may perforate spontaneously but early paracentesis is necessary in the majority of cases. Mastoiditis is a frequent sequence of scarlatinal otitis.

Endocarditis.—This may occur alone or as an accompaniment of arthritis. The discovery of this

complication may explain a persistent rise of temperature.

Pericarditis occurs more rarely than endocarditis and then usually as a complication of a septic case.

Arthritis.—This occurs in 4 per cent. of the cases, more frequently in older children and adolescents, and usually from the sixth to the twelfth day of an attack of scarlet fever. The condition which is generally attributed to the action of toxins involves most frequently the wrists and the joints of the fingers.

Rhinitis.—This is a common complication, particularly in young children and is responsible for many "return" cases of scarlet fever.

Diagnosis.—In the pre-eruptive stage the most suggestive symptoms are the sudden onset, the sore throat, and the unduly accelerated pulse. The punctate eruption on the soft palate is an important sign. The diagnosis during the eruptive period as a rule presents no difficulty. The characteristic rash in conjunction with the sore throat, the red strawberry tongue, and the other symptoms, enable one to make a prompt diagnosis in the vast majority of the cases. During the stage of convalescence the diagnosis is based upon the history, "the presence of desquamation, and the manner in which it corresponds with the history of the case."

Differential Diagnosis.—Sometimes a case of scarlet fever presents itself after the disappearance of the rash, when on account of the presence of a membranous angina it is necessary to distinguish the condition from diphtheria. (See article *Diphtheria.*) It is frequently of importance to differentiate a case of suspected scarlatina from one of the other exanthemata and to differentiate a true scarlatina rash from one produced by food, drugs, serum, or an enema, or from one occurring in septic conditions or in various skin diseases. This subject is discussed fully in the articles *Exanthemata* and *Erythema Infectiosum.*

Prognosis.—The mortality varies from two to five per cent. and is almost entirely to be attributed to the septic and toxic cases occurring during epidemics. According to Ker "the younger the patient the greater the risk, and infants in particular show a high fatality rate. The death rate decreases as age advances till fifteen years are reached, after which it rises again very gradually, especially after the age of thirty-five. Toxic cases are practically invariably fatal, and bad signs are a poorly developed or dusky eruption, a very rapid soft pulse, and hyperpyretic levels of temperature. Persistent vomiting or severe diarrhea in the early stages of the fever should cause great anxiety." The gravity of the illness in a septic case is "in proportion to the amount of glandular enlargement, to the persistence and extent of the throat lesions, and to the level maintained by the temperature. Bronchopneumonia adds much to the risk and restlessness, insomnia, or the refusal of food are all grave signs." The prognosis also depends upon the presence or absence of complications. If nephritis is recognized early and treated properly the prognosis is not impaired to any appreciable extent. Uremic symptoms such as convulsions and persistent vomiting are signs of serious omen. A scarlatinal arthritis tends to get well in one or two weeks. An endocarditis if properly managed is no more serious than that occurring in articular rheumatism, but a pericarditis is usually fatal.

Treatment.—The patient may be kept at home if there are facilities for suitable isolation but if these are lacking it may be best to recommend his removal to an isolation hospital, if such is available. The sick-room should preferably be one with ample space, light, and ventilation and provision should be made for the isolation of the nurse. The patient should be isolated for from five to six weeks. The rule has prevailed that the scarlet fever patient should not be released from isolation until there is no longer any evidence of desquamation and until all pathological discharges from the body have ceased. At the present time there is a tendency to discount the danger of infection from desquamated skin, and in some isolation hospitals the patient is released at the end of five weeks even though desquamation has not been completed, provided, however, that there are no pathological discharges from the body and also that there are no complications demanding further confinement of the patient to the sick-room or ward. In the average case the patient should be kept in bed for three weeks. During the first few days of the febrile period the diet should consist of milk, or of milk diluted with a thin cereal decoction. Plenty of water should be given at regular intervals. At the end of three or four days there may be added fruit juices, whey, buttermilk, or artificially soured milk. According to modern tenets governing the dietetic treatment of the febrile diseases milk alone does not provide sufficient calories unless an excessive amount of fluid be administered. Meara recommends that to every seven ounces of milk there should be added one ounce of 16 per cent. cream and one-half ounce of milk sugar. At the end of the febrile period cereal gruels, milk-soups, toasted bread, milk-toast, crackers, and apple sauce may be added to the dietary. After the third week vegetables and eggs may be given unless contraindicated by the presence of fever or some complication. The skin should be kept clean by means of a daily sponge bath, and should be anointed with boric acid ointment or liquid petrolatum. Itching may be relieved by the use of a calamine and zinc oxide lotion or by the cautious use of a one per cent. phenol ointment. If the patient's temperature rises to 103°F. or over he should be sponged every three hours with water at a temperature of 85° to 90°F. If there is prolonged hyperpyrexia or if there is considerable restlessness and delirium cold packs may be necessary and an ice-bag may be applied to the head. During the febrile period a mixture containing nitrous ether and acetate of ammonium may be administered. In the treatment of the nasopharynx the patient if old enough may gargle a mild alkaline antiseptic or physiological salt solution, or these may be used in a spray or medicine dropper. The bowels should be kept open by the administration of an effervescent saline laxative. If there is any evidence of heart weakness there may be given strychnine, caffeine, strophanthus, or camphor; or any of these in combination or alternately. The urine should be examined every second day and upon the slightest evidence of nephritis the diet should be confined to milk or milk substitutes and all other measures that are necessary in the management of a case of nephritis should be resorted to. (See article *Nephritis.*) For the treatment of a complicating otitis, mastoiditis, adenitis, arthritis, endocarditis, or diphtheria the reader is referred to the special articles on these subjects.

In the treatment of toxic cases of scarlet fever one may resort to free stimulation with alcohol and the use of hot packs to induce perspiration. If vomiting is present salines may be administered by the rectum or by hypodermoclysis. Recently good results have been reported from the Willard Parker Hospital of New York in the treatment of toxic cases of scarlet fever by the subcutaneous injection of blood serum obtained from patients convalescing from this disease. In the treatment of septic cases of scarlet fever in which secondary infection by the streptococcus plays the important rôle, the polyvalent streptococcus serum of Moser has been employed in Vienna since 1902 with a definite reduction in the mortality from this type of the disease. Alexander Spingarn.

Scarpa, Antonio.—Born at Motto, near Treviso, Italy, June 13, 1747. He began the study of medi-

cine, at the University of Padua, while he was still quite young. He manifested a decided preference for experimental physics and for anatomy, and he made such rapid progress in the latter branch of knowledge that, already during the second year of his course, he was able to assist, and occasionally to take the place of, the prosector. Morgagni, his illustrious teacher, very quickly learned to appreciate his rare talents, and from that time forward he befriended him in every possible way. From Padua he went to Bologna, for the purpose of obtaining further instruction in surgery, under Riviera. Upon his return to Padua he received the degree of Doctor of Medicine. In 1771 he was appointed Professor of Anatomy and Surgery at Modena. In 1783 he was appointed to the Chair of Anatomy in the University of Pavia. In 1796, when the Cisalpine Republic was established, Scarpa refused to take the oath which was required of all public functionaries; and on this account he was obliged to give up his professorship. Napoleon, after being crowned King of Italy at Milan in 1805, made a visit to Pavia and asked to have the professors of the University presented to him. Not seeing Scarpa among those who came to the reception, he asked where he was. Then, upon being told why he was absent, he remarked: "What have political opinions and a refusal to take the oath to do with the position of a professor of anatomy? Scarpa reflects honor upon the University and upon the country which is under my rule, and I desire that he should resume his position." Accordingly, Scarpa was invited to return to the University, and up to the year 1812 he continued to teach anatomy and to conduct the surgical clinic. He died Oct. 31, 1832. During the last five years of his life he suffered a great deal from calculous nephritis and chronic inflammation of the bladder.

Of his published writings, not a few of which are beautifully illustrated, the following deserve to receive special mention: "De structura fenestræ rotundæ auris et de tympano secundario anatomicæ observationes," Modena, 1772; "Anatomicæ 'disquisitiones de auditu et olfactu," Pavia, 1789; "Tabulæ neurologicæ ad illustrandam historiam cardiacorum nervorum, noni nervorum cerebri, glossopharyngei et pharyngei ex octavo cerebri," Pavia, 1794; "Saggio di osservazioni et di esperienze sulle principali malattie degli occhi," Pavia, 1881; "Memoria sulla ligatura delle principale arterie degli arti, con un appendice all' opera sull' aneurisma," Pavia, 1817; "Sull' ernia del perineo," Pavia, 1821; and "Memoria sull' idrocele del cordone spermatico," Pavia, 1823. A. H. B.

Schick Reaction.—Unlike the majority of the skin reactions, the Schick toxin reaction for immunity in diphtheria is not an allergic phenomenon. One-fiftieth of the minimum lethal dose of diphtheria toxin is diluted in such a manner that it is contained in 0.05 c.c. and is injected intracutaneously. If the patient has one-thirtieth of a unit or more antitoxin in his blood, the toxin is neutralized and no reaction develops. If his blood contains less than this amount of antitoxin, the toxin is not neutralized but acts as an irritant in the skin and produces a characteristic lesion. An area of erythema develops about the site of inoculation and reaches its maximum in from eighteen to thirty-six hours when it may measure six or eight centimeters in diameter After three or four days the color gradually fades leaving behind a brownish stain and the skin often shows a fine desquamation. A negative reaction shows that the individual is more or less immune to diphtheria and, if exposed to diphtheria, probably does not need an immunizing dose of antitoxin. A positive reaction, on the other hand shows that the patient is not protected and needs to be immunized. There is much clinical evidence in favor of Schick's contention and the test has been much used. Kolmer and Moshage have shown that forty per cent. to fifty per cent. of children between one and fifteen years give positive reactions. The use of this test results not only in a great saving of antitoxin but also avoids the possibility of sensitizing to horse serum a large number of those exposed to diphtheria. Kolmer and Moshage have also shown that a certain number of children, notably those suffering with measles and scarlet fever, exhibit a hypersensitiveness of the skin which results in pseudoreactions which appear in twenty-four hours but fade rapidly leaving no stain. They advise that, if possible, readings be made at the end of forty-eight hours to avoid the confusion caused by such a false response. The toxin should be as concentrated and the dose as small as possible.

Ralph G. Stillman.

Schistosomidæ.—A family of trematode worms. The sexes are separate and the male is wrapped about the female. These parasites are found in the veins. There is only one genus, *Schistosomum.* See *Trematoda.* A. S. P.

Schistosomum.—*Bilharzia, Gynæcoporus.* A genus of flukes which occur in the veins. Ciliated larvæ enter the skin when persons are wading or bathing; the young worms are found in the portal vein where they mature and mate; the adults rest in the veins of the rectum or bladder and discharge eggs. *S. hæmatobium* is found in the wall of the bladder and the eggs have a terminal spine. *S. mansoni* comes to rest in the blood-vessels of the rectum and the eggs have a lateral spine near one end. *S. japonicum* also attacks the rectum; the eggs are spineless. See *Trematoda.* A. S. P.

Schizogregarinida.—A suborder of Sporozoa. Reproduction is by schizogony and sporogony. These parasites are found in insects. See *Protozoa.* A. S. P.

Schizophora.—The group of dipterous insects which includes the true flies. Important families are the *Oestridæ, Sarcophagidæ, Muscidae,* and *Anthomyidae.* A. S. P.

Schneider, Conrad Victor.—Born at Bitterfeld, Germany, about the year 1610. He was the physician of the Elector of Saxony, and a professor in the University of Wittemberg. He died Aug. 10, 1680.

According to Sprengel, Schneider began in 1660 the publication of seven large volumes devoted to the description of the nasal fossæ. His researches proved conclusively that the ancient belief in the existence of one or more passages of communication between the ventricles of the brain and the nasal fossæ was incorrect; and he maintained that the nasal mucus which escapes from the nose of a healthy individual, is secreted by the arteries belonging to the membrane which, as he was the first person to describe its texture and precise relations, is named after him (Schneiderian membrane). The treatises referred to above bear the following titles: "De catarrhis libri VI," Wittemberg, 1660–62; and "De catarrhis liber specialissimus, quo juxta Hippocratem libro de glandulis et de locis in homine, septem catarrhi, ut catarrhus oculorum, aurium, narium, pulmonis, stomachi, medullæ spinalis, sanguinis, etc.," Wittemberg, 1664.

A. H. B.

Schoenlein, Johann Lucas.—Born at Bamberg, Germany, Nov. 30, 1793. He studied medicine

partly at Landshut and partly at Würzburg, and received his doctor's degree in 1816. After graduating he visited the hospitals and clinics of Goettingen and Jena, practised his profession for a short time in his native town, and then (in 1817) passed the preliminary examinations required of all applicants for the privilege of teaching pathological anatomy at the University of Würzburg. In 1819 he took N. Friedreich's place (during his illness) in the management of the Clinic in the Julius Hospital. In 1820 he was chosen Professor Extraordinary, and in 1824 regular Professor, of Special Pathology and Therapeutics, and Director of the Clinic. Schoenlein, disregarding the custom which prevailed at that time, conducted his lectures in German, and in still other ways rendered them extremely popular; and, as a result, students of medicine flocked to Würzburg during the term of his professorship in unusually large numbers. Although Schoenlein's participation in the political disorders of 1830 was very slight, he was nevertheless compelled to leave Würzburg. He was sent first to Passau, close to the Austrian frontier, and then, fearing that he might at any moment be arrested, he sought refuge in Zürich, Switzerland. In 1833, the newly founded High School of that city chose him Professor of Medicine, and during the following six years his success as a teacher was as great in this new position as it had been in Würzburg. In 1839 he accepted a call to be Professor of the Medical Clinic at Berlin and to be the King's private physician. For nearly twenty years his career at Berlin, both as a clinical teacher and as a private practitioner (largely as a consultant), was eminently successful. The death, in 1856, of his highly accomplished son while engaged in botanical researches in Africa, and several other very depressing occurrences, so disturbed Schoenlein's peace of mind that he gave up his professorship and his private practice and retired in 1859 to his native town. He died there Jan. 23, 1864.

Schoenlein contributed very little to medical literature. His discovery of the favus fungus which bears his name (*Achorion schoenleinii*) is reported in Mueller's *Archiv für Anatomie*, 1839; the title of this article being "Zur Pathologie der Impetigines."

A. H. B.

School Hygiene and Medical Inspection.—Extent of Physical Defects in Children of School Age.—There are approximately twenty million children in the public schools of the United States at the present time. It has been estimated by Wood[1] that from one and a half to two per cent.—three hundred thousand to four hundred thousand—of these have organic heart disease; probably five per cent.— one million—at least have now or have had tuberculous disease of the lungs; about five per cent.—one million—have spinal curvature, flat-foot, or some other moderate deformity serious enough to interfere in some degree with health; over five per cent.—one million—have defective hearing; about twenty-five per cent.—five million—have defective vision; about twenty-five per cent.—five million—are suffering from malnutrition, in many cases due in part at least to one or more of the other defects enumerated; over thirty per cent.—six million—have enlarged tonsils, adenoids, or enlarged cervical glands which need attention; over fifty per cent.—ten million—(in some schools as high as ninety-eight per cent.) have defective teeth which are potentially, if not actually, detrimental to health. Several millions of the children possess, each, two or more of the handicapping defects. About seventy-five per cent.—fifteen million—of the school children in this country need attention to-day for physical defects which are partially or completely remediable.

The above estimate was made as the result of a statistical study of the cities, towns, and rural communities which now have a system of school medical inspection. Allowing for the inaccuracy found in statistics of this kind, and considering the percentage of error arrived at by checking up the statistics from those communities possessing well organized and supervised systems, the tables as presented by Wood probably underestimate rather than overestimate the existing conditions.

Prevalence of Physical Defects in Urban and Rural Communities.—The distribution of the relative occurrence of physical defects in children of school age is fairly constant in (*a*) cities, and (*b*) rural communities, but between the two groups a sharp contrast is noted. This contrast demonstrates with peculiar significance that the general environment of the child, *i.e.* whether urban or rural, is of relatively minor importance, and that the predisposing causes which produce the physical abnormalities studied must be sought rather in the immediate environment: the school and the home.

A study made in eight States[2] shows that, in general, the country school child is from fifteen to twenty per cent. more defective than the city child. That such conditions existed a decade ago is doubtful, but at present the cities have progressed rapidly in sanitation and hygiene, particularly in reference to schools and dwellings, and the easy accessibility of free dispensaries for medical, surgical, and dental treatment have all contributed largely to the welfare of the city child. Even in consideration of the present extension of the public health movement the present status of the child in many parts of the country has received scant recognition. How long such conditions have persisted we do not know but, certainly, from our knowledge of biological law we may safely assume that, as Terman[3] expresses it, "the ultimate survival of an organism is threatened whenever it is subjected to conditions of environment widely different from those which directed its evolution. We have taken the child out of its natural habitat of open air, freedom and sunshine, and for nearly half his waking hours we are subjecting him to an unnatural regimen, one which disturbs all the vital functions of secretion, excretion, digestion, circulation, respiration and nutrition," to which we may add the statement by Gulick, "So extensive a readjustment of the young of a species has never before been attempted."

Responsibility of the State.—It may be considered axiomatic, therefore, that the State having made education of children compulsory, the State is equally responsible in making provision for such sanitation and hygiene of school buildings and their hygienic maintenance that the process of education may not react harmfully upon the physical status of the child.

Here the duty of the State is clearly defined, but in equal measure it is responsible for the home environment of the child. In a broad sense, the minor child is a ward of the State and in practically all of the states this fact is recognized in the enactment of laws making it obligatory for parents to provide proper shelter, maintenance, food, clothing, medical attendance and care for their minor children, the penalty therefor being the removal of the child from the custody of the parents and the assumption of this control by the State directly. Such laws have as a basis, *a priori*, the responsibility of the state to make essential provision for sanitation, hygiene, and those measures of health protection for children in the home which must be provided by community action, for from the very complexity of organized community life, they are otherwise unattainable by the individual. Such State functions include those measures of public health education, whether by indirect measures, such as public lectures, publicity in print and enactment of health and sanitary legislation, or the direct method of individual instruction of parents in regard to child care. Such action should emphasize rather than detract from the doctrine of individual responsibility

and has as its object the attainment of proper care for the child by the parent as a result of educational methods directed toward that end rather than any attempt at corrective legislation designed to relieve the parents of the responsibility for the immediate welfare of their children.

History of School Medical Inspection.—The assumption by the State of the responsibility for the welfare of the child of school age has been recognized by practically all governments, though tardily in the United States. Such control has taken the name of "school medical inspection." This title, acquired during the early days of the movement, is unfortunate because misleading. The evolution of the work, with its emphasis on the child rather than on the school, would indicate that "the health supervision of children" would be a more accurate and desirable description. The same unfortunate nomenclature has given us "medical inspector" as the designation of the doctor employed to care for the children. Here the term "health director" would be more exact and more directly indicative of the nature of the position. Time and usage, however, have made the terms practically universal, and their earlier restricted meaning has become inclusive. The employment of trained nurses in this work has occurred within recent years, and the term "nurse" has been and continues to be desirable and applicable.

The early history of school medical inspection belongs to Europe. By the Law of 1833 and a Royal Ordinance of 1837, France charged the school authorities with the duty of providing for the sanitary condition of school premises and supervising the health of the school children. Not until 1842, however, when a governmental decree was promulgated in Paris requiring that all public schools in that city be inspected by physicians, was school medical inspection actually begun. Even this effort was of little significance or value until 1897. It is of interest to note that one doctor was appointed to supervise each 1,000 children. Germany instituted tests of vision of school children in Dresden in 1867, and began a regular system of school medical inspection in Frankfort-on-Main in 1889.

Chronology of School Medical Inspection.—The dates of installation of this system in the indicated countries and in three cities of the United States are as follows:

France	1833	Argentine Republic and Chile	1888
Germany	1867	England (London)	1891
Sweden	1868	Mexico	1896
Russia	1871	Japan	1898
Austria	1873	Bulgaria	1904
Belgium	1874	Australia	1906
Egypt (Cairo)	1882	Tasmania	1906
Norway	1885	Canada (Montreal)	1906
		Boston	1894
		Philadelphia, Penn.	1895
		New York, N. Y	1897

Existing state laws in the United States on school medical inspection are as follows:

Mandatory:		Permissive:	
Massachusetts	1906	Connecticut	1907
District of Columbia	1907	California	1909
New Jersey	1909	Washington	1909
Colorado	1909	Ohio	1910
Maine	1909	Vermont	1910
Minnesota	1910	Virginia	1910
Louisiana	1911	Indiana	1911
New York	1913	North Dakota	1911
Pennsylvania	1911		
Rhode Island	1911		
Utah	1911		
West Virginia	1911		

In addition to the above, a considerable number of cities and towns carry on a system of school medical inspection by virtue of local ordinances or without any legislation.

In this country at least, the first attempt made to supervise the health of school children was the result of an epidemic of contagious disease (diphtheria in Boston, 1897) and for many years various cities took up this phase of the work as part of the regular program of health departments in their efforts to limit the spread of infectious diseases. Not until 1905, when New York City began systematically to examine each school child for evidence of non-contagious physical defects did the need for such care receive the attention of health authorities. The emphasis placed on the danger of the segregation of children in schools as a focus for the dissemination of infection naturally led to the inauguration of the earlier systems of school medical inspection under health control.

With the recognition of the need of safeguarding the general health of children and the relation of school hygiene, including the curriculum, to child health, educational authorities assumed the function in many places and, during the past ten years, probably three-quarters of the cities and towns inaugurating such systems have placed them under the authority of the department of education. A great difference of opinion exists to-day as to the relative merits of health and educational control of this work. Where health departments are well organized and have a definite program, the tendency has been for them to inaugurate such systems of care for the health of the school child as part of their general responsibility for the health of the community. Thus, of the ten largest cities in the United States, only two—Cleveland and St. Louis—have school medical inspection under the department of education. In smaller cities and towns, departments of education are as a rule better organized and frequently more progressive and so have taken the initiative in this important work.

The main difference of opinion between the two groups seems to be that educational authorities consider the health of the school child in its relation to education, and emphasize the responsibility of the school in conserving the health of the child, holding this to be their legitimate function, while health authorities view the question of child health as part of any coordinate program for the conservation of the health of all persons in the community. The latter view regards the child as "a child of school age" rather than as "a school child" and calls attention to the fact that the child is in school only five hours out of the twenty-four hours of the day, and that for only about 190 days a year, and that the factors which influence its health outside of the school are matters which in any event cannot come under the jurisdiction of school authorities. It is a debatable question as to how far health authorities are justified in relegating the health control of approximately one-fifth of the population to other authorities who have no legislative right to control a great proportion of the factors which influence the health of this part of the population.

Many other arguments pro and con have been advanced on this mooted point. From the point of view of community function, it would seem as though health departments should assume full jurisdiction; from the point of view of expediency and the urgent need of such supervision, with the present unorganized condition of public health boards throughout a large part of the country, it is justifiable and necessary that educational departments must assume this work for the present. In either event, the need of the children is best met by efficiency of organization and management and other considerations may well take a subordinate position.

School Medical Inspection Organization.—The health director or chief school medical inspector should devote his entire time to the service. The field inspector or school doctor may preferably give part

time to the service, and an average of three hours each school day should be required. While, theoretically, the school doctor may be assumed to offer better service if he has no other occupation, it has been found that with the small salaries paid for this position, it is not possible to secure the type of service desired. Another, and even more weighty objection, is that exclusive work of this kind, without the inspiration afforded by general outside medical work, tends toward a narrowing of interests and routine work. The full time health director should be paid a salary of from $3,000 to $5,000 a year, according to the population of the community. The school inspectors' salaries show a wide variation in different localities, but from $80 to $100 per month should be considered a minimum standard.

Nurses' salaries are at present at too low an average, seventy-five dollars or less a month being the accepted rate. The work of the school nurses has broadened immeasurably since they were first employed, and while the present rate may be adequate for small towns or rural districts, a salary of $100 a month should be established for cities.

The ideal system would provide one physician for each three to four thousand children, and one nurse to each twenty-five hundred to three thousand children. Such ideal conditions, however, can be found in few places at the present time, and the ratio of from five to nine thousand children to each physician and from three to five thousand children to each nurse is more commonly encountered.

The systems which may be used are (*a*) those using both physicians and nurses, and (*b*) those using nurses alone. The employment of a school physician without a nurse is of doubtful value, as the results of such a procedure have proved to be of statistical value rather than definite benefit to the children.

In any assignment of forces, the teacher must be considered as a valuable adjunct. Her close relation with the children makes her the first line of defense in the discovery of abnormal conditions of children and their environment and she may readily be instructed in the methods of detecting abnormalities of sight and hearing, defects of the teeth or nasopharynx, as well as nervous, orthopedic or nutritional disorders. She must be relied upon in all instances to detect the earliest symptoms of illness which may prove to be of infectious origin and, in rural communities, where the visits of the school doctor or nurse occur at infrequent intervals, she will prove of great assistance in making periodic health surveys both of the school and its surroundings and of the pupils.

The general routine of the school inspection system must vary in accordance with the number of chilrdren to be supervised, the distances between schools and the size of the medical and nursing staff. The following outline is recommended and should be followed as closely as possible:

1. Sanitary survey of school building, surroundings and equipment at the beginning of each term.

2. Yearly testing of vision and hearing of all pupils (by nurse or teacher).

3. Daily inspection of all pupils in each classroom by class teacher, this inspection to take place at the opening of the morning session, the teacher to refer at once to the doctor's room in the school all children who show any signs or symptoms of any illness or physical abnormality.

4. Periodic lectures to teachers (at least once each month) to be given by the school doctor or nurse on the topic of school or child hygiene and the early detection of symptoms of illness.

5. Daily visit to each school by the doctor or nurse At this visit the following children should be examined and appropriate action taken:

(*a*) All children referred by teachers as showing symptoms of illness or physical defects.

(*b*) All children who have been previously excluded from school attendance.

(*c*) All children who have been absent from school for any unassigned cause.

6. Routine inspection of all pupils in the school, at the begnning of each term by the school doctor and once each month thereafter by the school nurse.

7. Physical examination of each child in the following order:

(*a*) Children entering school for the first time.

(*b*) Children referred by the nurse or teacher.

(*c*) All other children in the school, proceeding grade by grade.

8. Regular visits by the school nurse to

(*a*) Treat cases of mild forms of contagious eye and skin diseases, allowing the children to remain in attendance at school.

(*b*) Treating minor injuires by means of "first aid," such cases to be thereafter referred to their parents to provide the necessary care.

(*c*) Conference with teachers regarding health conditions of the children and the readjustment of school surroundings.

9. Visits by the nurse to the homes of children suffering from physical defects whose parents have neglected to provide proper care, at these visits the nurse to instruct and advise parents regarding the need of treatment and the hygiene of the home and of the child.

Contagious Diseases.—Children showing any symptoms indicative of a contagious disease should be excluded from school attendance at once. Cultures should be taken in every case of sore throat and the child excluded until the bacteriological diagnosis is made. All excluded children should be visited at their homes within twenty-four hours by an officer of the Department of Health, for the purpose of confirming the diagnosis and enforcing continued exclusion and isolation. No child should be readmitted to school after exclusion without a certificate from the Department of Health.

The real test of efficiency in the control of the general contagious diseases in school children lies in early exclusion, therefore it is essential to send children home "on suspicion." The time in school that is lost by children excluded on mistaken diagnosis is of no importance when compared with the protection afforded by this method.

Contagious Eye and Skin Diseases.—It has been amply demonstrated that the majority of children affected with contagious eye and skin diseases can be kept in school without danger to the other children as long as they continue under regular treatment.[4] Simple protective applications afford early control of the infection. In New York City this method has reduced the exclusions for this cause from 57,000 in 1903 to less than 5,000 in 1914, and no instance of spread of infection in the schools has occurred during this time.

Physical Defects.—Statistics regarding the prevalence of physical defects among school children are open to criticism because of the lack of methods of standardization of the manner in which the examination is made and the records kept. The following standard used in the New York City schools is offered as a guide:[5]

"Each child must be carefully examined to determine the presence of any of the following defects:

1. Defective vision (Snellen test card to be used, with separate examination and recording of visual acuity of each eye. A paper or card must be used to cover the eye not tested).

2. Defective hearing (either an acumeter, or the watch or whispered voice test at a standard distance may be used).

3. Defective nasal breathing (the nasal passages must be cleared and the passage of air through each nostril tested by pressure occlusion of the opposite

nostril. Evidence of mouth breathing must be differentiated between (*a*) habit, and (*b*) obstruction of the nasal passages).

4. Hypertrophied tonsils (visual examination with use of a separate tongue depressor for each child).

5. Defective teeth (visual examination with reference to whether the primary or permanent teeth are affected and the extent of the defects).

6. Defective nutrition (it must be determined whether the condition is found alone or dependent upon other physical defects).

7. Cardiac disease (in the case of boys, the examination for this condition should be made with a stethoscope over the bare skin. In girls the stethoscope must be used over the clothing unless the parent is present and consents to its removal or the written consent of the parent has been obtained for the removal of any part of the clothing. General objective symptoms should be noted).

8. Pulmonary disease (the lungs must be examined with a stethoscope. In boys the examination should be made over the bare skin. In girls the stethoscope must be used over the clothing unless the parent is present and consents to its removal or the written consent of the parent has been obtained for the removal of any part of the clothing. General objective symptoms should be noted and if any doubt exists as to the diagnosis the case should be referred for more extended diagnosis as hereinbefore described).

9. Orthopedic defects (the character of the defect should be noted).

10. Nervous diseases (the type of nervous affection should be noted).

11. Defective mentality (no particular test need be given but when, in the opinion of the inspector, the mentality of the child is considered defective a special note to that effect should be made to the teacher with the recommendation that the child be referred to the inspector of ungraded classes of the Board of Education).

Frequency of Physical Examinations.—In Europe the general method of procedure includes three physical examinations of each child during its school life. Usually these examinations are made (*a*) on entering school for the first time, (*b*) in the fifth or sixth school grade, (*c*) before graduation from the elementary grades. In the United States, several States require a physical examination each year. Unless funds for the latter procedure are obtained in sufficient amount to allow for thorough examinations it would seem advisable to reduce the number of examinations, have the latter made in a competent manner and depend upon inspections of each child at least twice each year to ascertain those children who are obviously in need of medical attention.

Follow-up Visits by Nurses.—Each child who is found to have a definite physical defect or to be physically subnormal should be referred to the school nurse. The nurse should visit the family of the child and instruct the family in (*a*) adjustment of home conditions relative to sanitation and hygiene, and (*b*) the desirability of obtaining proper treatment for the child. Repeated home visits should be made until satisfactory results have been obtained. If absolute refusal to obtain treatment is met or if neglect to remedy unhealthful home conditions is encountered, recourse should be had to such local laws relating to health or parents' responsibility toward minor children as may be in force.

Records.—A health record of each child should be kept in the school. This record should be part of the regular school record of the child and should follow it from grade to grade. The forms used by the Philadelphia and New York City Departments of Health are recommended.

The medical inspectors and nurses should render reports at regular intervals to their superior officers, giving in detail an account of all work performed. The daily report forms used in New York City and the form for weekly reports used in Philadelphia offer standard guides for this purpose.

Aids in School Medical Inspection.—Group conferences with teachers in regard to health topics should be held at regular intervals by the medical inspector and nurse. These may include (*a*) the sanitation and hygiene of school buildings and classrooms, (*b*) the hygiene of the child, (*c*) the early detection of symptoms of illness, and (*d*) the teacher's cooperation in readjustment of home conditions.

Conferences should be held with teachers relative to (*a*) adjustment of classroom conditions in the prevention of physical defects among the children and (*b*) school care needed as a factor of treatment for children who have been found to have physical defects.

Extension of self-government among the school children should be encouraged by the formation of "Health Leagues" which may include the appointment of one or more children in each class as health officers whose duties shall consist of active cooperation in maintaining the health of all children in the indicated class.[6]

School Hygiene.—The sanitation and hygiene of school buildings have an important bearing upon the health of school children. This is particularly true of the classrooms where the child spends at least four-fifths of its time while in school.

Location of School Building.—In general, the location of school buildings in cities is determined by certain fixed causes, leaving little latitude as to the exact location selected. Certain fundamental principles, however, should determine, so far as possible, the location and construction of the building as it relates to proper exposure, adequate light and ventilation of the classrooms.

In country districts, much greater freedom can be obtained in selecting a site for the schoolhouse. Such a site should always be on high ground, with proper and sufficient drainage. The water supply for the country schoolhouse should be piped from a distance wherever possible, but when it is essential that it be obtained from nearby wells, precautions should be taken to avoid contamination of the water supply.

School buildings should preferably be so situated that the classroom windows face directly either to the east or to the west. The eastern exposure is preferable for classrooms, because it allows the morning sun to enter the room before the day's session begins. In a western exposure, the sun will enter the classroom after the day's session is closed. Either of these afford the best light as far as the child is concerned. The schoolroom thus may be thoroughly aired and flushed with the sunlight either at the beginning or end of the day, yet there will be no cross-light or dazzling light during the school hours.

A southern exposure gives the most difficult light to control. Here the sun shines into the room during the greater part of the school hours and, even with dark shades, it is hardly possible to subdue it. Northern exposure, on the other hand, gives no sunlight at all. Rooms with such exposure should not be used for school purposes other than those where a northern light is distinctly favorable, such as painting or art work in general.

Standard Size of Classrooms.—The classroom may be considered the unit of schoolhouse construction. The size of a classroom depends upon several factors, and what may be considered an ideal classroom has been planned as the result of an analysis of these factors.

Length.—(*a*) This is determined by the distance the ordinary speaking voice of the teacher will carry clearly and distinctly. The pupil in the last row must be able to hear her well; (*b*) in addition, the teacher should be able to hear all of the children in the room, distinctly and without their raising their

voices; (*c*) length is also determined by the distance at which maps, charts and the blackboard may be easily seen by the children.

It is stated by Dresslar[7] that a series of investigations showed that the distance at which these requirements are met is twenty-nine feet. Allowing three feet behind the last row of desks for the necessary aisle, we have a distance of thirty-two feet as the proper length for the standard classroom.

Width.—This is determined by several factors, in which the whole problem of lighting of the classroom has to be considered. The points to be considered are (*a*) abundant light and (*b*) unilateral lighting.

In general, classrooms will be adequately lighted when the window space is at least one-quarter of the floor space. If the windows are placed properly, that is, beginning not less than four feet above the floor and reaching to within six to twelve inches of the ceiling, we find that the rays of light will carry into the room a distance equal to double the height from the top of the window to the floor. Such a height may be for the present arbitrarily estimated at twelve feet. This question of height will be considered in the next section. It has been found that if these requirements are met our standard classroom will be twenty-four feet wide.

Height.—It has been determined that a height greater than thirteen feet in a classroom of the dimensions given above increases the cost of heating. At thirteen feet there is no upper dead chamber for air and the problems of ventilation are thereby greatly lessened.

Lighting.—Mention has been made before of the necessity for unilateral lighting. The windows should not only be upon one side, but should be placed close together toward the rear of the room, and the desks so arranged that the light always falls over the left shoulder of the pupil. The lower edge of the window should always be above the line of vision of the children.

If the windows face east or west as advised, tan window shades may be used; if the exposure is southern, dark green shades are preferable.

Walls.—The walls in a classroom should be painted a neutral color, such as tan, preferably with a band of a dark shade of brown reaching to a height of at least six feet above the floor.

Blackboards.—Blackboards should always be of clear black slate or black or clear dark green composition material. They must be placed directly in the line of vision of the child and not subject to the cross light. The main point regarding blackboards is their cleanly maintenance. They should be thoroughly washed each day. Only white crayon should be used in the general routine of school work. Colored crayons should be reserved for special map work or for drawing of a similar nature. Dusty blackboards and colored crayons have a distinct effect upon the production of eyestrain or defective vision in children.

Blackboard erasers should be cleaned thoroughly each day, preferably by the use of a vacuum cleaner. Where this is not possible, they should be taken out of doors and thoroughly beaten and brushed.

Desks and Seats.—The most important principles of correct seating arrangements in classrooms are (*a*) that the seats should be of proper height and size for the individual pupil, (*b*) that the desks should be placed at such a slant that the child will not have to strain either his body or his eyesight in assuming a posture for easy desk work, and (*c*) the chairs should be so constructed that the back affords natural support for the back of the child in any position required in writing, reading or ordinary class work.

In order to fulfill the above requirements there are many varieties of desks and chairs upon the market. Some have the advantage of having the desks attached directly to the chairs, and are not only adjustable, but are also freely movable about the room. Such chairs have great advantage in open-air classes or, indeed, in any classroom where it is desirable to have physical exercises, for the desks and chairs may be readily pushed toward one side of the room during the progress of the physical training.

If the desks must remain fixed, however, the chair should be adjusted carefully to the height of the child and should be changed at least once each term either to allow for the child's growth or for readjustment to another occupant.

A practical rule for the height of the desk and chair consists in having the seat of the chair at such height that the child's feet rest evenly and firmly upon the floor. The back of the chair should fit the child's back so that there can be no slouching of the shoulders or incorrect posture. The desk should extend at least four inches over the knees of the child and be of a height sufficient to allow the child's forearms to rest easily upon the lid without stooping of the shoulders.

Adjustable desk tops which may be slanted so that the books may be held upon them for easy reading have advantages in conserving the eyesight as well as maintaining correct bodily posture.

Ventilation.—The amount of cubic air space required by each child in a classroom depends entirely upon the number of times that the air may be changed within one hour. In the standard classroom mentioned above there are 9,600 cubic feet. Allowing 300 cubic feet of air space for each child, such a classroom would accommodate thirty-two children. Allowing 3,000 cubic feet of air per hour for each child, this would require complete change of air in the classroom once every six minutes. Such change may be effected without the use of drafts by the utilization of both natural and artificial methods of ventilation. Three thousand cubic feet of air per hour is given as an ideal for the school child, irrespective of its age. It may be accepted that the child of primary grade on account of its rapid growth requires as large a provision of fresh air as the child of elementary or high-school grade.

Until within recent date, the recognized standard in regard to atmospheric purity required that the CO_2 should not exceed twelve parts per ten thousand of the atmosphere. However, Benedict and Miller,[8] in a study of metabolism of matter and energy in the human body established that a subject in a respiration carorimeter can read, sleep and eat meals with the usual regularity and show no deviation from his usual physical and mental condition in an atmosphere containing 226 parts of CO_2 per 10,000.

Recent investigations, particularly those made by the New York State Commission on Ventilation[9] have established the fact that the degree of temperature, of moisture and of movement of the air are the main requisites of efficient ventilation. In order to obtain these factors certain standards as to temperature and humidity must be maintained. In temperate climates sixty-eight degrees should be considered a standard for classrooms. In such rooms forty per cent. humidity should be allowed in very cold weather and fifty per cent. of humidity in ordinary winter weather.

The humidity and temperature have direct bearing upon the condition of the nasal and throat passages of the child. If a child remains for any length of time in an overheated, dry room and then goes out into cold, moist air, it is thereby rendered susceptible to infection from the germs of influenza, pneumonia, diphtheria, and similar infectious diseases. In many instances the bacteria are already in the mucous membrane and the irritation of the mucous membrane due to the rapid change of temperature and moisture offer the best opportunity for their development.

Artificial systems of ventilation are all dependent in greater or lesser degree upon forcing the fresh air,

through ducts, into the room and extracting the foul air through other ducts placed in advantageous places. In general, inlet ducts are placed at a height of about eight feet above the floor. The outlet ducts should be situated on the same side of the room, with the openings near the floor.

Fresh air is forced in, usually through the so-called fan or propulsion system, and the air of the classroom is drawn out by means of a fan located above the outlet, its action causing a vacuum. Through such systems the air may be forced into the room either at the temperature and degree of humidity of the outside air, or it may be filtered, moistened or heated by means of a special ventilating apparatus before it reaches the classroom.

While the installation of adequate ventilating systems would seem to be a simple engineering problem, their efficacy depends entirely upon the intelligence of their maintenance. In city schools at least, they are usually managed under the supervision of the school janitor, and it is possible that their failure, in the majority of instances, depends upon this inexpert supervision.

In the absence of systems of artificial ventilation, or where the latter have been found to be inadequate, much may be done by simple dependence upon the open window.

All schools should have the windows thrown widely open at least one hour before the school session begins, and for one to two hours after the school session closes. In addition, the windows should be opened for a period of three minutes at the end of every forty minute session. During this time the children should do "setting up exercises" and keep their bodies in active motion. In country schools, where open-window ventilation in cold weather seems impossible because of the immediate drafts that are created, the simplest and best procedure is to have the upper sashes of the windows removed and the openings covered with a strong grade of unbleached muslin, tacked securely over the window frame. This covering allows the air to circulate freely through the room, without creating any strong current and has the added advantages of filtering the air and of subduing the direct light from the upper part of the windows.

For practical purposes the open-window system of ventilation, both in the city and country schools, has given excellent results in relation to the health of the child. Children in open-window classrooms show an increase in hemoglobin as well as a gain in weight almost equal to that found in children placed in classrooms directly in the open air. When it is considered that these healthful conditions may be obtained at no cost and without any added equipment or difficulty of maintenance, it would seem that the open-air type of classroom should be developed as rapidly as possible in our public school buildings.

If the open-window method cannot be kept up, owing to unusually severe weather, the regular window board should be used so that a constant current of fresh outdoor air may be circulated through the classroom at all times.

Cloakrooms.—The two main requisites of cloakrooms in the schools are (*a*) ventilation and (*b*) sufficient separation of the children's outer garments. Cloakrooms should, therefore, always be placed where a direct current of air can be obtained. The individual locker system, consisting of lockers with solid partitions, but with open wire fronts, is the best known. Where this is found to be too expensive practically an equal degree of protection may be assured with an even better access of ventilation by simply placing the hooks upon which the children's clothing is hung at a sufficient distance from each other, so that the hats and coats cannot come in contact.

Toilets.—In cities, toilet facilities are usually subject to local sanitary regulations. Within the school building, however, at least one toilet should be provided for every fifty children, and the bowl and seat of each should be thoroughly cleansed daily. In order to prevent the spread of infection the seat used should be of the horseshoe or "U" shaped type, leaving the opening at the front.

In rural schools where a water supply is not available, the common outdoor privy should be allowed only when it is so placed in relation to the water supply that the latter may entirely escape contamination. Open privy vaults should in no case be allowed. The minimum requirement should be the provision of cans placed directly under the seats, the contents of which are daily sprinkled with a mixture of ashes and chloride of lime. Such cans should be removed at least once each week and clean empty ones left in their places. There are now on the market several types of "chemical closets." These closets have the ordinary seat and bowl of the indoor water-flushed toilet. They are connected with a drainage tank which rests at or below the level of the earth. The excreta are deposited through the bowl into this tank and are kept constantly in a fluid state by means of the action of certain chemicals. At intervals this fluid must be withdrawn. It is, however, not offensive, no odor can be shown, and the fluid may readily be disposed of. Such closets may be placed in rural schoolhouses, with a door directly connected with the schoolhouse, thus avoiding not only the insanitary factors of the outdoor privy but the exposure incident to using it.

Drinking Facilities.—The common drinking cup is one of the most frequent methods whereby specific germ infection may be carried from one child to another. Studies made by Park and Wilcox of the research laboratories of the Department of Health of New York City show that dpihtheria bacilli can remain alive on infected drinking glasses at least eighteen hours and that streptococci have been demonstrated at an even greater length of time after the glass was first infected.

In place of the common drinking cup can be substituted either the drinking fountain or individual drinking cups. For obvious reasons the various types of drinking fountains on the market cannot be mentioned. It may be said, however, that before installing any of these fountains care should be taken to see that the objectionable features common to some of them do not appear. First, the nozzle from which the water runs should be so protected that the child cannot put his mouth directly over it before turning on the water. Second, the rim surrounding the nozzle should be at such a level that the child cannot rest his face upon it when drinking. The best types of fountains are those which force the stream of water so high in the air, or from such a source, that in no instance may the child's lips touch the nozzle itself.

Makeshift fountains may be provided at small cost by simply turning ordinary faucets upside down or by extension pipes from the faucets to which nozzles may be attached.

In country schools somewhat the same effect may be obtained by placing large hogsheads of water at a high level on a shelf and having pipes reach down, ending in a "U" shaped turn, with a nozzle at the end. Convenient stopcocks can regulate the flow of water.

Hygienic Maintenance of the School Building.—The classrooms and toilets should be cleaned thoroughly after school hours each day. Dry sweeping and dusting should not be permitted. Oil dressings for the floors make it possible to have them simply wiped up with a damp cloth and, during school hours prevent the dust from rising. Walls and desks should be wiped off at least once a week with damp

cloths. In addition, as has been suggested, each classroom should receive a thorough airing before and after the school session.

It has not been shown that disinfectants have any value, either peventive or corrective, as an adjunct in school maintenance. Soap and water, with sunlight and fresh air, furnish the best means of disinfection known at the present time.

Hygiene of the Home.—The Federal Children's Bureau, as a result of a study made in Johnstown, Pa., has demonstrated in an urban community in the United States the relation between social maladjustment and infant mortality. There can be no doubt that the unhygienic, insanitary condition of homes reacts in equal degree upon the health of the older children and is a factor of great importance in the etiology of physical defects, as well as in engendering the lowered vitality which leads to the occurrence of contagious diseases.

In the home, adjustment must be made to require enforcement of such sanitary laws as relate to building, construction, lighting, ventilation and proper sanitary facilities. .

The minimum allowable living space for a family, in accordance with the requirements of health, should be placed at 300 cubic feet for an infant and 600 cubic feet for an adult. The hygienic maintenance of the home must receive attention, particularly in regard to the disposal of refuse and the prevention of the breeding and presence of flies. Cleanliness, regular hours, provision of adequate ventilation and proper food are the most important points in connection with environment as it relates to the health of the child. The effect of pure air in the home can be particularly shown in increased vitality and bodily resistance, decreased liability to contract contagious diseases, increased mental capacity and efficiency and the prevention of physical defects.

Hygiene of the Child.—The hygiene of the child properly divides itself into three periods—those of sleep, study, and play. These must necessarily vary at different ages. The following table is suggested as a standard:

Age.	School, Hour.	Home Study, Hour	Meals and Play, Hour.	Sleep, Hour.	Bedtime
5– 7	3	none	10	11	7 30
7–10	5	1	8	10½	8 00
10–12	5	1½	8	9½	9.00
12–14	5	2	8	9	10.00

In home study, it must be remembered that the child's work should preferably be done in the late afternoon or early evening, leaving the daylight hours for outdoor play. The light used must always be hung low and so placed that its rays will come over the left shoulder of the child. Such simple methods will often prevent eyestrain and obviate headache.

The instinct for play in a child is natural and the only control usually needed is to see that the child's play is not malicious mischief. It is also necessary to provide a place where the child may play in safety and in normal surroundings. In cities these needs may be met by the playgrounds; in country districts the problem is not a serious one.

The value of fresh air and the muscular exercise of unrestricted play bears a definite relation to the hygiene of the child, and practically all its waking hours, except those spent in school, can be spent by the child below adolescence out of doors, engaged in healthful play.

Auxiliary Aids in School Hygiene.—These may be definitely grouped as a series of special classes for the proper control of the school child who is affected with special kinds of non-contagious physical defects. The special classes which have given promise of most brilliant results are those known as "fresh-air classes." Here the children live entirely out of doors in very cold weather protected by special woolen bags which cover the lower part of the body to above the waist line. Heavy sweaters, gloves and hoods complete the costume. The general routine of the day consists of a study period from nine to eleven, lunch of milk or cocoa and bread and butter at eleven, study from eleven-fifteen to twelve-thirty. A regular hot lunch is served at twelve-thirty, including soup and cocoa with sandwiches or a hot meat and vegetables. There is a rest hour from one-thirty to two-thirty, class instruction from two-thirty to four, and lunch at four, consisting of milk or cocoa and crackers or bread and butter.

Children in such classes, therefore, have the advantage not only of continued fresh air but of special attention to their diet. The universal results are increase in weight and hemoglobin, arrest of any incipient tuberculous process and markedly increased resistance to infection.

Ungraded classes of another kind are those devoted to diseases where little improvement, if any, may be expected but where the children are handicapped by some marked physical or mental defect so that they are unable to keep up in their school progress with the other children of equal age. Such classes are those known as "classes for the mentally defective" where simple manual training is taught to children of various ages who are committed to such classes after physical and mental examinations have been made to prove their mental retardation.

Special classes are also maintained for the deaf, the blind and the crippled, and should be established for children with cardiac disease. In such instances special attention might be paid to the conditions which promote health without regard to rapid advancement in school work.

Effect of Physical Health on School Progress.—While there is no reliable evidence at the present time that physical ill-health has a widespread and definite relation to retardation, still, experience has shown that the retarded children are more frequently affected with physical defects than are children who progress normally in their grades.[10] If, therefore, systems of school medical inspection must be limited in extent, or systems of school hygiene economically planned, special attention should be given in all instances, as a primary consideration, to those children who have been shown to be retarded in their school progress.

S. Josephine Baker.

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Schwalbach is a spa situated in the province of Hesse-Nassau, Prussia. It lies in the valley of the Münzenbach, about twelve miles from Wiesbaden, and five miles from the health resort Schlangenbad.

Its elevation is 972 feet above sea-level, and as it is well protected against all but the southerly winds, its climate is mild and well suited for invalids. There are eight mineral springs at Schwalbach, known as the Wein-, Stahl-, Rosen-, Paulinen-, Ehe-, Neu-, Linden-, and Adelhaid-Brunnen. There is but little difference in the composition of the waters of these springs. The following is the analysis of two of the springs, as made by Fresenius. In 1,000 parts there are, of:

	Wein-Brunnen.	Linden-Brunnen
Ferrous bicarbonate	0.057801	0.009902
Manganous bicarbonate	0.009085	0.004680
Sodium bicarbonate	0.245345	0.042317
Calcium bicarbonate	0.572129	0.429277
Magnesium bicarbonate	0.605120	0.395267
Ammonium bicarbonate		0.002205
Lithium bicarbonate		0.002033
Strontium bicarbonate		0.001048
Sodium chloride	0.008630	0.017622
Sodium sulphate	0.006193	0.016156
Potassium sulphate	0.007469	0.006414
Sodium nitrate		0.005541
Sodium phosphate	Trace.	0.000438
Aluminum phosphate		0.000197
Silicic acid	0.046500	0.042821
Organic matter, etc	0.000046	0.000003
Total solids	1.558318	0.965291

The gases are carbonic acid and a very small proportion of sulphureted hydrogen.

Schwalbach is a favorite health resort, and is visited by several thousand guests every year. The diseases for the relief of which a course of treatment at this spa is recommended are anemia and chlorosis, epilepsy, chorea, progressive muscular atrophy, neuralgia, neurasthenia, hysteria, and other functional and organic nervous disorders, Bright's disease, diabetes mellitus, chronic vesical catarrh, and various affections of the female sexual organs.

The waters are employed externally and internally, according to the individual indications, and facilities are afforded for pine-needle, mud, vapor, and other baths. The season lasts from May to October. There are excellent accommodations for visitors.

EDWARD O. OTIS.

Schwann, Theodor.—Born at Neuss, Germany, Dec. 7, 1810. He studied medicine at Bonn, Würzburg, and Berlin, and received the degree of Doctor of Medicine from the University of the latter city in 1834. For several years he was an assistant at the Anatomical Museum of Berlin, and then (in 1839 he accepted a call to fill the Chair of Anatomy at the free University of Louvain. In 1848 he went to Lüttich to be Professor of Physiology and Comparative Anatomy, and he held this chair for over thirty years. He died at his brother's residence, in Cologne, Jan. 11, 1882, from a stroke of cerebral apoplexy.

In the minds of most medical readers the name of Schwann suggests the latter's discovery of one of the important parts of a nerve fiber—viz., the so-called "sheath of Schwann." (Beiträge zur Anatomie der Nervenfaser," in *Mueller's Archiv*, 1836.) According to Pagel, however, Schwann made other more important contributions to the science of biology. He founded, for example, the doctrine of animal cells and proved that these are, morphologically and physiologically, the equivalents of the cells of plants. The whole subject is fully set forth by Schwann in his treatise entitled: "Mikroskopische Untersuchungen ueber die Uebereinstimmung in der Structur und dem Wachsthum der Thiere und Pflanzen," Berlin, 1839. It is perhaps not so well known that Schwann was also the discoverer of the active stomach-ferment to which he also gave the name of "pepsin." (Cf. *J. Mueller's Archiv*, 1846.) A. H. B.

Schwartze, Hermann H. R.—The leading aural surgeon of Germany during the second half of the nineteenth century. He was born at Neuhof, Sept. 7, 1837, and studied medicine at the universities of Berlin and Würzburg. The following is a list of the various official positions which he held in the course of his professional career: Assistant to August Foerster in the Pathologico-Anatomical Institute at Würzburg; Instructor in Otology at the University of Halle (on the Saale) in 1863; Professor Extraordinary in 1868; Director of the University Clinic for Diseases of the Ear in 1884; Geheimer Medizinal Rat in 1887; and Honorary Professor-in-Ordinary of Otology in 1896. He died in 1910.

To Schwartze is due the credit of having been the first to lift aural therapeutics, in the presence of an acute or chronic infective process involving the middle ear and adjacent parts, from the timid, non-effective state that existed previous to 1869 or 1870, to the dignity and life-saving efficiency which characterizes this department of surgery to-day. From 1873 to the time of his death he edited the *Archiv für Ohrenheilkunde*, a periodical that was established originally by von Troeltsch, Politzer, and himself in 1864. His most important published work is that entitled: "Handbuch der Ohrenheilkunde," 2 vols., 1892 and 1893. A. H. B.

Sciatica.—See *Neuralgia*.

Scilla.—SQUILL, U. S. P. The bulb of the white variety of *Urginea maritima* (L.) Baker (fam. *Liliaceæ*), deprived of its dry, membranaceous outer scales, and cut into thin slices and dried.

Squill is derived from a perennial herb of the Mediterranean coast region, especially in Spain. The bulb is large, four or five inches long, globular ovoid, covered with two or three dry, reddish or gray, papery scales, and made up within of numerous thick fleshy ones. There are two varieties, the white and the red, distinguished by the color of the outer tunics of the bulbs. For medicinal use, the bulbs are collected in the latter part of summer, sliced transversely, dried in the sun, and the papery scales winnowed out. To produce the best article, only the outer scales should be preserved. The presence in the drug of the less valuable central portion is indicated by the relative shortness and thinness of the strips, and their higher degree of curvature. Squill occurs in irregular, more or less curved segments several centimeters (about one to two inches) long and four to eight millimeters (one-sixth to one-third inch) broad, thinner in one direction, with two to four sharp edges; yellowish white or somewhat reddish, slightly translucent, brittle, and pulverizable when dry, tough and flexible when damp; inodorous and of a mucilaginous, bitter, and acrid taste.

Structurally, it consists of a simple parenchymatous tissue, loaded with mucilage and containing numerous oxalate-of-lime crystals, and traversed by occasional vascular bundles.

CONSTITUENTS.—Besides a large amount of gum, some sugar, the unimportant dextrin-like substance sinistrin, etc., squill contains as its active constituents several glucosides, the constitution and relations of which are not yet well known.

Scillitoxin is amorphous, light brown, soluble in alcohol, not in ether or water, a cardiac poison resembling digitalis; *scillipicrin*, a yellowish-white, amorphous, hygroscopic powder, similar to the above but less active; and finally *scillin*, of no medicinal qualities.

Action and Use.—Few medicines outrank squill in antiquity, it being mentioned by nearly all medical writers from the earliest down. It possesses in a measure the heart-slowing and diuretic action of digitalis, for which it is occasionally substituted and with which it is more frequently given as an adjuvant. As a slightly depressing expectorant it is a common ingredient of cough preparations. Large doses (from six to twelve grains) occasion vomiting and purging.

It is stimulant, or in overdoses irritant, to mucous membranes; hence it acts as a direct diuretic in its passage through the kidney, in addition to its indirect diuretic effect through increased blood pressure. Hence, also, the frequent production of bloody or suppressed urine, and bloody stools and other indications of intestinal inflammation, in cases of poisoning.

Administration.—Squill is difficult to powder, apt to cake up when powdered, and seldom given in substance.

The following preparations are official: Fluid extract (*Fluidextractum Scillæ*, strength $\frac{1}{2}$), dose, ♏ i.–ij. (0.06–0.12); vinegar (*Acetum Scillæ*, strength, $\frac{1}{10}$), dose, ♏ xv.–lx. (1.0–4.0); syrup of squills (*Syrupus Scillæ*), dose, ʒi.–ʒij. (4.0–8.0). The compound syrup (*Syrupus Scillæ Compositus*) is rather a preparation of antimony than of squill. Henry H. Rusby.

Sclera, Anatomy of the.—See *Eye*.

Sclera, Diseases of the.—Owing to the dense fibrous structure of the sclera, this part of the eyeball is slow to take on inflammation; hence affections of this tunic are comparatively infrequent. Once inaugurated, however, inflammations of the sclera tend to be protracted and discouragingly resistant to treatment.

Episcleritis is an inflammation of the subconjunctival connective tissue. Beginning as a localized hyperemia, usually near the sclerocorneal margin, on the temporal side, it goes on to produce an exudate which presents itself as a slight protuberance, rounded or somewhat flattened, smooth, and reddish yellow in color. Though pustular in appearance at times, it shows no tendency to ulcerate. The nodule is attached to the sclera, but the conjunctiva is freely movable over it. Two varieties of injection are visible; a superficial, circumscribed, pinkish hyperemia of the overlying conjunctiva (which can be made to disappear temporarily by the instillation of a drop of dilute adrenalin solution) and a deeper violet or purplish injection from the episcleral vessels, also circumscribed. The nodule is tender to the touch if it involves a ciliary nerve. The process persists for several weeks, gradually subsiding and often leaving a more or less permanent slate-colored patch. Two lesions may coexist in the same eye or both eyes may be affected. The disease tends to recur; a succession of nodules may form until the entire circumcorneal zone is involved. In intense types the adjacent corneal tissue may become infiltrated at the height of the attack, but iritis is a rare complication. No clearly defined line of demarcation exists between episcleritis and scleritis; transition forms are seen. The disease lasts from a few weeks to a few months, but recurrences may lengthen the process to a year or more.

The subjective symptoms vary from a slight feeling of irritation or weight in the eye to marked photophobia, lacrymation, and dull, heavy pain. Women are more frequently affected than men; in children it is rarely seen. Episcleritis is frequently attributable to rheumatism or gout. Menstrual derangements, exposure to cold, syphilis and tuberculosis are supposed predisposing causes. The prognosis, doubtful as to duration, is otherwise favorable. Rarely a marginal opacity of the cornea remains after an infiltration.

Treatment.—Careful attention to any underlying cause is essential. Locally the treatment should be sedative. The eyes should be shielded from strong light, and sudden changes of temperature avoided. In the early stages hot, bland, moist compresses or dry heat may be used if well borne. An occasional drop of one per cent. holocain in adrenalin solution 1 : 10,000 is soothing. If the irritation is marked, or the cornea involved, atropine may cautiously be employed. Two per cent. yellow oxide of mercury in a bland base, as eucerin, hastens absorption of the exudate when combined with gentle rotary massage through the closed lid. In obstinate cases subconjunctival injections of normal saline solution or of bichloride of mercury solution (1 : 3,000) are sometimes beneficial. Caustics and organic astringents are contraindicated. In rebellious cases excision, curettage or scarification have been recommended. Internally, colchicin, aspirin, sodium salicylate and potassium iodide are often of definite value. Pilocarpine may also be employed, hypodermatically or by the mouth. Errors of refraction should be corrected.

Fugacious Episcleritis ("Hot Eye") is a sudden transient hyperemia of the episcleral and adjacent conjunctival tissues lasting a few days, accompanied by pain, photophobia, and lacrymation, and reappearing at intervals varying from a few weeks to several months. It is apparently a vasomotor disturbance. The treatment is similar to that of ordinary episclerits.

Scleritis.—*Synonyms:* Deep scleritis, Complicated scleritis, Sclerokeratitis. This is fortunately less frequent than episcleritis. It may be acute or chronic, diffuse or circumscribed, anterior or posterior. The acute type is seen in orbital cellulitis and panophthalmitis; rarely as a separate entity. Deep scleritis runs a subacute or chronic course, commencing as a bluish-red or violaceous injection, usually in the ciliary region. As the process advances, it tends to circumscribe the cornea, by continuity or by the coalescence of several foci. The thinning sclera takes on a bluish tint from the underlying choroid or ciliary body. As a rule both eyes are affected. The frequency with which adjacent structures become involved makes scleritis a formidable affair. The cornea becomes infiltrated for a varying distance, from the limbus toward the center, the sclera appearing to invade the cornea as a dense opacity, much of which remains permanently. With this sclerokeratitis the iris is at times implicated; posterior synechiæ and occlusion of the pupil may occur. The process may go on to cyclitis and even hyalitis, with hemorrhages in the vitreous, and a resultant partial or total blindness. Deep scleritis and its complications may recur, each succeeding attack further weakening the scleral wall and causing more and more permanent impairment of vision. The thinning of the tunic eventually results in ectasiæ, or bulging of the sclera, either in the form of irregular nodules at the limbus (intercalary staphyloma) or as a marked distortion of a portion of, or of the entire, anterior segment of the sclera. The disease is marked by remissions, but may subside at any stage. The scleral injection fades to a dusky, dull gray, with patchy infiltration of the adjacent cornea, with or without ectasiæ. Depending upon the extent of their involvement, the deeper structures also will retain evidences of their participation in the inflammatory process.

Scleritis occurs chiefly in adults, in women more often than in men. Gout, rheumatism, syphilis, tuberculosis, exposure to cold, and menstrual disorders are often underlying causes, though severe cases are seen in persons otherwise robust and healthy. Leprosy often presents a nodular anterior scleritis.

The *treatment* of deep scleritis is on the whole rather unsatisfactory, owing to its resistance to therapeutics and its tendency to remissions. The discouraged patient usually wanders from specialist to specialist;

rarely is one able to retain a case from its incipiency until the eye is again quiet. My best results in uncomplicated cases have been obtained by rest in bed, milk diet, and dark glasses, with or without colchicine internally. Particular attention should be given to any underlying dyscrasia. Internally, colchisine, antirheumatics, potassium iodide, and alkaline waters may be indicated. With a positive Wassermann, neosalvarsan intravenously repeated as indicated, and followed by mercury salicylate injections intramuscularly is advisable. As an alterative, repeated doses of the cacodilate of sodium, hypodermatically given, are useful. During the acuter stages the eye is intolerant of local treatment, even warm compresses may be unbearable. The occasional use of one per cent. holocain or dionin is sometimes useful. Atropine serves a double purpose in abolishing accommodative effort and lessening the danger of iritic involvement. Increased tension would require miotics instead. During recession, massage with two per cent. yellow oxide of mercury ointment and mild miotics are indicated. Iridectomy may be necessary to relieve tension or bulging, and in extreme cases the removal of a sightless and unsightly eye may be advisable.

Staphyloma (ectasiæ) of the sclera may involve the whole or any part of this tunic, resulting from a wide variety of causes. Anterior and equatorial ectasiæ occur as grayish or bluish-black protrusions, the color being that of the underlying choroid or ciliary body visible through the thinned sclera. Anterior forms are usually limited in front by the limbus, except those complicating staphyloma of the cornea. When occurring as complications of iridoscleritis, uveitis, and cyclitis they appear either as nodular protrusions between the ciliary body and the cornea (intercalary), as a more diffuse bulging in the ciliary region (ciliary) or as a general staphyloma of the anterior portion of the globe. Continued hypertension from glaucoma or a dislocated lens commonly produces staphyloma, often beneath or between the insertions of the recti muscles. Intraocular tumors, by direct involvement of the sclera or by increasing intraocular tension, may cause bulging. Equatorial staphylomata, from choroidoscleritis, do not tend to encircle the globe, and to be seen, the eye should be sharply rotated toward the opposite side. Posterior bulging occurs rarely as a congenital defect (incomplete closure of the fetal eye-cleft) often associated with colobomata of the choroid and iris (posterior staphyloma of Von Ammon). Axial myopia presents a posterior staphyloma involving also the choroid and visible through the ophthalmoscope as a crescentic area of choroidal atrophy, situated usually on the temporal side of the disc, occasionally surrounding and including the papilla. Total ectasia of the sclera is seen in the rare cases of buphthalmos, congenital or acquired.

Cyril Barnert.

Sclerema Neonatorum.—This rare disease of early infancy, to which a number of other names have been given at various times, such as *algidité progressive, induratio tela cellulosæ, l'endurcissement athrepsique*, was first described by Underwood as a hidebound condition of the skin occurring in new-born infants. At birth, or shortly after, a peculiar induration of the skin appears, usually first upon the lower extremities, whence it spreads rapidly to other parts of the integument, involving the entire surface of the body in a few days. When the disease is fully developed he infant appears as if frozen; the surface of the body is cold; the skin is hard and wax-like at first, but later usually becomes somewhat livid; the limbs are fixed and rigid, and, owing to the stiffness of the cheeks and lips, suckling is impossible. The respirations are weak and shallow, and the circulation is feeble. Death commonly occurs within eight or ten days. The disease may be congenital, in which case the infant is either stillborn or dies within a day or two.

The affection is most probably due to malnutrition arising from improper or insufficient food, poor hygienic surroundings, or previous exhausting disease. It may follow cardiac disease, gastrointestinal affections, disease of the lungs, or any other malady which greatly lowers the vitality of the infant. The congenital cases or those which occur a day or two after birth are of unknown origin.

According to Langer, the induration of the skin arises from solidification of the fat, brought about by the abnormally low bodily temperature, the fat of infants, owing to differences in composition, solidifying at a much higher temperature than that of adults. This explanation, however, is not entirely adequate. Parrot, who first distinguished the affection from edema neonatorum, with which it was for a long time confounded, believes it to be a drying out of the tissues brought about by the draining off of the fluids of the body by previous debilitating disease. This author finds the skin thinner than normal, the fat diminished, and the vessels, especially of the papillary layer, greatly contracted. Ballantyne agrees in the main with Parrot's conclusions.

The only affections with which sclerema neonatorum is likely to be confounded are scleroderma and edema neonatorum. From the former it may be distinguished by the early age at which it occurs, no case of scleroderma having yet been observed in the first few months of life. From edema it differs in the waxy appearance of the skin, the absence of pitting on pressure, the rigidity of the limbs, and the more general distribution of the cutaneous changes, edema being most marked in the dependent parts of the body.

The *prognosis* is extremely unfavorable, death occurring in almost all cases. In the exceptional cases in which the entire surface is not involved, recovery may take place.

Treatment consists in the employment of measures to increase the temperature of the body, which is always much below the normal, and the administration of easily digested food and stimulants. As the infant is unable to nurse, it is necessary to administer the nourishment with a flexible tube through the nose, or by enema.

Milton B. Hartzell.

Scleroderma.—Scleroderma (σκληρός, hard; δέρμα, skin)—also known as *sclerodermia, sclerema, scleroma adultorum, scleriasis*—is a rare, chronic disease, characterized by a peculiar hard, leather-like condition of the skin occurring in diffuse areas or in sharply circumscribed patches. The circumscribed form, sometimes called *morphœa* and regarded by some authors as a distinct affection, has been fully described elsewhere and will not be considered here. Diffuse scleroderma begins either acutely or insidiously with slight stiffness of the skin, which usually presents a certain amount of swelling and hardness. Vague pains in the joints and muscles may precede the alterations in the skin, but marked or characteristic prodromal symptoms are usually wanting. The induration and stiffness of the skin spread slowly or rapidly, more commonly the former), over considerable areas, and in rare cases the entire integument becomes involved.

When the disease is fully developed the skin is remarkably firm and inelastic, smooth or slightly scaly, no longer susceptible of being picked up between the fingers, and more or less adherent to the underlying tissues. While the color of the skin is usually white or yellowish white, a considerable amount of pigmentation is often present in the shape of streaks and macules of various shades of brown.

Subjective symptoms are, as a rule, slight. There are a feeling of tension and occasionally more or less itching. Tactile sensibility is as a rule unaltered, but in excep-

tional cases there may be slight hyperesthesia or anesthesia.

The functional activity of the glands of the skin in mild cases is usually unaltered, but in advanced or severe ones the excretion of sweat and sebum is diminished to a greater or less degree.

When the skin about the joints is affected movement is more or less interfered with, and in atrophic cases ankylosis with consequent complete immobility may result. When the face is attacked, the features are motionless, as if covered with a mask; the nose is pinched; the mouth contracted so that it is opened with difficulty; the eyes are only half-open or staring, owing to the immobility of the lids. If the skin of the thorax is involved extensively, the movements of respiration may be considerably impeded.

The parts most commonly affected are the face, the neck, the upper portion of the trunk, and the upper extremities, but no part of the integument is exempt, although the palms and soles are rarely affected.

In some cases the morbid process is not confined to the skin, but attacks the mucous membranes of the mouth, pharynx, larynx, and vagina.

In the great majority of cases constitutional symptoms are absent, but in those exceptional ones in which the affection begins acutely with marked edema of skin, spreading rapidly over a considerable surface, constitutional disturbance, such as chills and fever, may precede or accompany the alterations in the skin.

The course of the disease varies within considerable limits. When it has reached its acme, it may remain unchanged for months or years, and then the induration may slowly disappear, the skin resuming its normal suppleness and softness; or, after the disease has progressed toward recovery for a time, relapses may occur and new areas be invaded. On the other hand, the skin may become more tense, thinner, and parchment-like; the subcutaneous cellular tissues and fat may disappear, and the underlying muscles atrophy. When this atrophic process affects the extremities they are greatly reduced in size, distorted, and the joints ankylosed. When the hands are affected great distortion of the fingers with marked wasting occurs, a condition which has been described as *sclerodactylia*.

Owing to the extreme tension of the skin ulceration readily occurs, especially over bony prominences. The general health is, as a rule, but little if at all affected; but in very extensive cases with atrophy, especially if accompanied by ulceration, death may take place from exhaustion.

But little is known concerning the immediate causes of scleroderma. It occurs much more frequently in the female sex than in the male. In the cases collected by Lewin and Heller (435 in number), 292, or sixty-seven per cent., were women. Age seems to have but little influence upon the frequency with which the malady occurs, although it is most frequent between twenty and forty years of age. Exposure to cold and damp appears to exert a predisposing influence. In a certain proportion of cases the affection has followed some disease of the nervous system, and in a number of instances (sufficiently numerous to indicate more than an accidental association) traumatism of some kind has immediately preceded it. In a case of diffuse scleroderma studied by Hektoen the thyroid gland was found to have undergone fibrous atrophy with destruction of its glandular structure; and in a series of thirty-one cases observed by Roques quite recently more than seventy per cent. showed changes in the size of the gland.

Whitehouse and others have noted a positive Wassermann reaction in a small proportion of cases, but the number of such observations is as yet too limited to warrant any definite conclusion. In many cases, however, if not in most, the patient has been in good general health at the time of the beginning of the morbid changes in the skin.

Although the pathology of scleroderma is quite obscure, there is much in favor of the view that it is primarily an affection of the nervous system, a trophoneurosis; this, however, yet remains to be demonstrated. According to Crocker the various symptoms are produced by obstruction to the arterial and venous blood supply, and by interference with the flow of lymph, these being responsible for the alteration in the nutrition of the skin which characterizes the malady. Unna finds the chief pathological alterations in an hypertrophy of the collagenous tissues affecting all parts of the cutis, and consequent atrophy of the blood-vessels and the epidermis. The changes in the epidermis are slight, consisting of occasional deposits of pigment and mechanical alterations due to pressure. A considerable exudation of small round cells surrounds the narrowed blood-vessels, the sweat and sebaceous glands, and the hair follicles. The lymph spaces are narrowed, and, in the cases in which atrophy occurs, an obliterating endarteritis is present.

The symptoms of a typical, well-developed case of scleroderma are usually so characteristic that the *diagnosis* is readily made. The peculiar induration of the skin characteristic of the malady is found in no other disease except sclerema neonatorum; but this latter affection is met with only in the new-born and the induration of the skin is accompanied by marked coldness of the surface.

The *prognosis* is decidedly unfavorable. While it is true that a certain small proportion of cases end in recovery, the disease usually lasts for years even when recovery does take place. When atrophy occurs, a return of the skin to its normal condition is not to be expected. In cases in which a considerable part of the integument is involved, interfering greatly with movements of the limbs, death may eventually take place with symptoms of marasmus; or, owing to his debilitated condition, the patient may fall an easy prey to some intercurrent affection.

Treatment.—Patients with scleroderma should be given an abundance of easily digested, assimilable food, such as milk, eggs, and butter. The clothing should be warm and abundant, so that there may be no danger of chill. Such tonic remedies as iron, quinine, arsenic, cod-liver oil, may be given with the view of improving the patient's general health. Massage and frictions with bland oils and fats should be systematically and persistently employed for the purpose of improving the nutrition of the skin. Mild galvanic currents may be applied to the indurated skin to improve the circulation and nutrition. Drugs have little, if any, direct influence over the course of the disease. Thyroid extract has been given with good effect in a limited number of cases and should always be tried when there is any demonstrable change in the thyroid gland. Hans Hebra has reported marked benefit from hypodermatic injections of thiosinamin, one-half a Pravaz syringeful of a fifteen-per-cent. alcoholic solution being given every second day; and more recently Neisser has recommended the same treatment. Liebreich found considerable improvement follow the internal use of cantharidin in doses of 0.0002 grams.

Milton B. Hartzell.

Sclerosis, Lateral Spinal.—Primary Lateral Sclerosis.—*Synonyms:* Spastic spinal paralysis; Spasmodic tabes dorsalis.

Definition.—The disease is characterized by a gradually progressing paralysis, which begins in the lower extremities, is accompanied by greatly exaggerated tendon reflexes, muscular rigidity, and contractures, and is not attended by sensory, trophic, or visceral symptoms. The anatomical basis is supposed to be a primary sclerosis of the anterolateral columns.

Etiology.—We know very little of the causes of the

disease. It occurs chiefly in adults, more frequently in men than in women. Exposure, excessive venery, syphilis, trauma, infection, lead poisoning, etc., have been assigned as causes in individual cases. Some cases occurring near Rome, several of which were in one family, seemed to be due to the effects of a leguminous article of diet, *Lathyrus cicera*. In quite a number of instances heredity was the chief factor in causation; the disease occurring distinctly as a family disease, having been found in a number of generations, with often a number of cases in the same generation. For instance, in one of Strümpell's cases the grandfather, father, two uncles, and a brother were supposed to have been similarly affected; in one of Spiller's cases fourteen, in five generations, were believed to have had the disease. In some of Strümpell's cases the disease appears to have begun in early, in others in late adult life. In Spiller's and a number of other reported cases it began in early childhood. In most of these cases the disease appears to have been very slow in its progress.

Symptoms.—The disease begins with some increase in the tendon reflexes and weakness in one or both lower extremities. There is an undue sense of fatigue on exertion, and an objective examination shows a slight paresis. There is at the same time some difficulty in walking, this being at first most noticeable on rising in the morning. As the paresis increases, motor irritation symptoms are soon manifested. These are at first slight clonic or tonic spasms of the affected muscles. They are most likely to occur when the patient is fatigued, are easily evoked by active or passive movements of the limbs, but often come on in the middle of the night. The tendency to muscular spasm—brought on by either a voluntary or a passive movement, or in a reflex way—increases to such an extent that complete muscular rigidity and contractures of the limbs occur. This condition antagonizes every action of the patient, makes his voluntary efforts altogether futile, and, therefore, causes the paralysis to appear more complete than it really is. The rigidity can usually be overcome, in early stages of the disease, by slow persistent pressure, but when it becomes excessive it resists powerful efforts. The usual position of the rigidly contracted limbs is that of extension at the knees, the feet in the equinovarus position, and the thighs firmly pressing against one another. Their immobility is often interrupted by clonic spasms. Occasionally the limb is drawn for a short time into another position.

A striking and usually an early symptom is the exaggeration of the deep reflexes. The patellar tendon reflex is greatly exaggerated; muscular contractions can be elicited by striking any of the tendons—for instance, the inner or outer hamstrings, where tendon reflexes cannot be elicited, as a rule, in health—and even tapping over the periosteum will produce like manifestations. But the most striking of these phenomena is the ankle clonus, rapid and rhythmical clonic contractions taking place when the foot is sharply flexed, and continuing as long as the foot is held in a flexed position. When the reflexes are much exaggerated the clonic contractions, on evoking the ankle clonus, may not be limited to the ankle, but may extend to all the muscles of the extremity. The ankle clonus also becomes a disturbing element in walking, as every time the body rests on the toes in progressing forward there is a tendency to its production. The most notable change in the superficial reflexes is the presence of the Babinsky toe phenomenon.

The gait is very characteristic. As the legs are weak and stiff the feet cannot be freely lifted, and, when moving forward, they sweep the floor, making an almost characteristic scraping sound. At the same time, in order that the foot can be brought forward, it makes a wide outward sweep. The gait is sometimes further impaired by clonic spasms of the muscles —those representing the foot clonus, as just described —and these spasms may cause a temporary halt in walking, or may make that act altogether impossible. Walking is more difficult on an up or down grade, and on an uneven surface, than on the level and on an even surface. It usually becomes easier after the patient has walked for a while. The gait just described is that observed when the spastic symptoms are already well marked. At a later period, when there is complete rigidity of the legs, walking is impossible.

The disease slowly extends upward, involving the muscles of the abdomen, back, and upper extremities. The latter are usually affected to a less degree than the lower extremities, though exaggerated reflexes and muscular tension are associated with the paresis. The upper extremities may even be rigidly contracted, in which case the position is usually one of slight flexion and pronation of the forearm, and strong flexion of the wrists and fingers, the arm being pressed firmly against the body.

In typical cases there are no further symptoms on the part of the nervous system. The sensibility is intact, the functions of the bladder and rectum are normal, there are no trophic changes in muscles or skin, and no special changes in the electrical reactions.

Cases have been reported in which the disease appeared to be confined to one pyramidal tract, and in at least one case pathological changes were found *post-mortem* only on one side.

The progress of the disease is usually very slow. Though the patient be altogether bedridden and without power of motion, the general health need not suffer. Unless there be some complication he may live to old age.

The symptoms of spastic spinal paralysis are found in Little's disease, a congenital paralysis usually due to disease which has developed during fetal life, or which is the result of injury to the brain in parturition. The brain disease, in these cases, is usually shown by such conditions as strabismus, speech, disturbances, idiocy or imbecility, epilepsy, and the like. But in some instances there are no cerebral symptoms; the disease appears to be purely spinal and, therefore, belongs to this category. The pathological state, however, is likely to be due to a developmental defect. A definite determination of this question must await future pathological findings, though a few cases have been reported in which focal disease in the cervical cord occurred during fetal life, with secondary degeneration of the pyramidal tracts. Improvement in such cases is not uncommon.

The following case, at present under the writer's observation, illustrates this class of cases: I. J——, a boy eleven years of age, did not learn to walk as other children. Prior to that time nothing abnormal was detected. The spastic condition is now very marked. As he stands he rests altogether on his toes—the heels cannot be brought to the ground—and the thighs are pressed firmly together. When he tries to walk, which he can do only if well supported, the thighs rub each other and the legs cross. When the patient sits the feet and lower legs sway in the air. The rigidity of the limbs is such that much force is necessary to make any passive movements. The Babinsky phenomenon is present, and all the deep reflexes are exaggerated. The ankle clonus, as well as those of the Achilles and patellar tendons, can be elicited. The intellect, sensation, and the functions of the bladder and rectum are unimpaired, and there is no evidence of the involvement of the upper extremities or of the cranial nerves. The disease, therefore, appears to be limited to the motor tracts of the cord.

Morbid Anatomy and Physiology.—Symptoms like those of spastic paralysis had been observed in connection with various diseases, but Erb was the first to describe this as a separate and distinct disease, whose basis he believed to be a primary sclerosis of the an-

terolateral columns, especially the pyramidal tracts. His views have been quite generally accepted, but yet, it must be acknowledged, there has not been much positive evidence to substantiate them. In a number of postmortem examinations, where this disease was diagnosed during life, lesions in the brain, tumors in the medulla oblongata, diffuse sclerosis, etc., were found. In some instances, nevertheless, the disease appeared to be a primary sclerosis of the lateral columns. But, whether or not a primary disease be usually found, it is probable that the pathological changes in the lateral columns produce the symptoms of this disease, for when spastic symptoms are found with multiple sclerosis, diffuse myelitis, etc., the lateral columns are found to be affected.

The paresis or paralysis is explained by the destruction of nerve fibers in the pyramidal tracts, the tracts conveying voluntary motor impulses. The motor irritation symptoms cannot be so satisfactorily explained. Charcot believed them to be due to dynamic changes in the large ganglion cells, these being placed in a state of irritation by the degenerated nerve fibers of the pyramidal tracts. Hughlings Jackson supposed that in these cases the influence of inhibiting centers in the brain had been removed by the destruction of the pyramidal tracts, and that the excessive motor manifestations were due to the absence of this influence.

Diagnosis.—The symptoms of spastic paralysis may appear with multiple sclerosis, transverse or diffuse myelitis, brain lesions, etc. In order to establish the diagnosis in these cases we must look for the further symptoms of these various diseases, as, for example, the indications of involvement of the gray matter and posterior columns in transverse myelitis; optic atrophy, nystagmus, intention tremor in multiple sclerosis, etc.

Especially in multiple sclerosis there may for a long time be no other symptoms than those of spastic paralysis. For that reason, when the latter symptoms are present, one should always be on the watch for other symptoms, symptoms that may indicate the presence of another disease.

It is to be remembered that this disease is one of long duration, that postmortem examinations have been made only many years after its inception. In those cases, therefore, in which other changes have been found than those in the lateral columns—in Gowers', Goll's, the cerebellar tracts, etc.—the primary disease may have been only in the lateral columns. At present we can only make a diagnosis of spastic spinal paralysis. We cannot be certain, during life, that the disease in the lateral columns is primary, or that it is altogether limited to that part of the cord.

Prognosis.—When uncomplicated the disease does not appear to shorten life. It is sometimes capable of improvement, and even cures have been reported.

Treatment.—The treatment applicable in these cases is that usually adopted in locomotor ataxia and other forms of chronic disease of the cord. Rest in bed for a number of weeks, especially when there seems to be an exacerbation of the disease, may produce amelioration of the symptoms. Hydrotherapy, electricity, massage, applications of the thermocautery along the spine, the administration of various drugs, are among the remedial measures that may be used. In the spinal form of Little's disease tenotomy, transplantation of tendons, and other orthopedic measures, together with rest, have sometimes produced good results. In quite a number of cases the intradural division of several posterior nerve-roots by Foerster's method has given favorable results, though the true value of this measure is yet to be determined.

Amyotrophic Lateral Sclerosis.—For both the description of the symptoms and knowledge of the anatomical character of this disease we are chiefly indebted to Charcot. Though somewhat akin to the disease just described, it presents striking differences both in its symptomatology and in its morbid anatomy. It occurs chiefly in persons of middle age, but has been observed in children.

Symptoms.—The disease usually begins with slowly progressing paralysis of the upper extremities, which is soon accompanied by atrophy and fibrillary twitchings of the paralyzed muscles. Subsequently muscular rigidity and contractures occur, the arms assuming the position found in spastic paralysis, viz., partly flexed at the elbows and pressed against the body, forearms pronated, hands and fingers strongly flexed. These contractures may remain even when the muscles are almost completely atrophied. Usually, after the lapse of a number of months the lower extremities become involved. In them the manifestations are mostly like those of spastic paralysis—paralysis, exaggerated tendon reflexes, muscular rigidity, contractures—while little or no atrophy of the muscles is observed. The electrical reactions are altered according to the degree of muscular atrophy. In the lower extremities there may be a mere quantitative change—diminution of electrical irritability—while in the upper extremities the alteration is usually more marked, and, when the muscular atrophy advances rapidly, as often occurs in the small muscles of the hand, the typical reaction of degeneration may be found.

At a still later period bulbar symptoms, those of glossolabio-laryngeal paralysis—atrophy of the lips and tongue, difficulty in deglutition, indistinct speech, respiratory disturbances—appear, and finally carry off the patient.

The symptoms do not always appear in the order described. Sometimes the disease begins in the lower extremities, extending thence to the arms, and finally to the cranial nerves. Sometimes the disease begins as a bulbar paralysis, though it need not, therefore, run a rapid course. The writer has at present under observation a case which began with bulbar symptoms two years ago, and now presents a typical picture of the disease. In this case the muscles supporting the head upon the trunk are, also, almost completely paralyzed.

The degree to which spastic symptoms, and to which muscular atrophy appear in both upper and lower extremities, is also quite variable, depending upon the part of the nervous system in which the morbid changes began, and upon the extent to which the gray and white nervous tissues are respectively affected.

The duration of the disease is usually from one to three years. The well-marked cases hitherto recorded terminated fatally. Death is generally caused by the bulbar symptoms.

Morbid Anatomy and Physiology.—The morbid changes are almost, if not altogether, limited to the motor central and peripheral nervous apparatus. There is sclerosis—atrophy of the nerve fibers and increase of the connective tissue—of the direct and crossed pyramidal tracts in the cord, often extending above the crossing of the pyramids in the medulla. In some instances the atrophy has been followed the whole length of the motor pathway to the central convolutions, and atrophied pyramidal cells have been found in the cortex of these convolutions. There is atrophy of the large ganglion cells of the anterior cornua, and of the cells of the nuclei of the affected cranial nerves. Certain of the cranial nerves, of the anterior roots of the spinal nerves, of the mixed nerves, and of the muscles, are also found in various stages of atrophy.

As to the explanation of the symptoms, the muscular atrophy is due to the atrophy of the large ganglion cells, the bulbar symptoms to disease of the nuclei of the cranial nerves, the spastic phenomena to sclerosis of the pyramidal tracts. The preponderance of spastic or atrophic manifestations is due to preponderance of the morbid process in the white or gray matter respectively.

Diagnosis.—While the disease is still confined to the

upper extremities it may be mistaken for subacute poliomyelitis anterior, or even for progressive muscular atrophy, for the weakness, fibrillary tremor, and other manifestations—atrophied thenar and hypothenar eminences, claw-hand, etc.—are very much like what is observed in the latter disease. But its progress, even when unusually slow, is more rapid than that of progressive muscular atrophy. Furthermore, spastic symptoms, exaggerated tendon reflexes, some muscular rigidity, etc., are likely to be manifest at an early period, thus aiding us to distinguish it from the aforementioned diseases.

When the disease begins in the lower extremities or as a bulbar paralysis, it is as yet impossible to make a diagnosis of amyotrophic lateral sclerosis. At times in the bulbar form, spastic phenomena—the jaw clonus—are found. When the disease has developed in its typical form, with atrophic paralysis in the upper and spastic paralysis in the lower extremities, as well as with bulbar symptoms, no mistake is possible.

Myelitis, multiple sclerosis, gliosis, syphilis, may be so localized as to simulate this disease. But usually other symptoms—sensory and trophic symptoms and symptoms on the part of the bladder and rectum—will appear and thus differentiate these diseases from amyotrophic lateral sclerosis, which has only motor symptoms.

The prognosis is sufficiently indicated in the foregoing description. Such treatment may be resorted to as is employed in other chronic diseases of the cord.

PHILIP ZENNER.

Sclerosis, Multiple Cerebrospinal.—*Synonyms:* Disseminated sclerosis; Insular sclerosis.

DEFINITION.—This disease may present manifold symptoms, the most common of which are paresis, with muscular rigidity and exaggerated tendon reflexes as in spastic paralysis, tremor brought on by voluntary movements, nystagmus, scanning speech, amblyopia, apoplectiform attacks, and impaired intellect. The anatomical basis of the disease consists of disseminated patches of sclerosed tissue in various parts of the central and peripheral nervous systems.

ETIOLOGY.—An hereditary influence has been traced in a few instances. Charcot states that the disease occurs most frequently in females, but a number of other observers do not concur with him in this view. It occurs most frequently between the ages of fifteen and thirty; occasionally in young children; rarely, if at all, after forty.

Traumatic influences, such as blows on the head, concussion of the whole body, exposure, hardship, overwork, and profound emotional disturbance, may all be mentioned as occasional exciting causes. In a number of instances the disease developed after the existence of an acute disease, typhoid fever, variola, pneumonia, malaria, measles, scarlet fever, diphtheria, whooping cough, erysipelas, dysentery, cholera, influenza or the puerperium. It has also been attributed to metallic poisoning. In very many, if not the majority of cases, no causal factor can be found.

SYMPTOMS.—The area of diseased tissue may be located in any part of the nervous system and there may be quite a number of affected areas. Furthermore, the disease may be of various degrees of severity, and the symptoms, which are but the expression of the locality and intensity of the disease, may make the most varied clinical pictures. There may be an entire absence of symptoms of disease of the nervous system, although nodules of sclerosed nerve tissue are found postmortem; or the disease may simulate various different organic or functional nervous diseases. But, nevertheless, the sclerosis seems to have a predilection for certain parts of the nervous system, and we find, accordingly, in many cases similar, and almost characteristic, clinical manifestations.

A cerebral and a spinal form of multiple sclerosis are sometimes spoken of, but usually both brain and cord become involved in the disease, though it may have been present in the one some time before it developed in the other. Generally the spinal cord is first affected.

The disease usually begins very insidiously and is slow in its progress; in rare instances it has an abrupt beginning, perhaps is ushered in by an apoplectiform attack. The earliest symptoms may be of cerebral origin, such as headache, vertigo ataxic gait, and slight psychic disturbances; or there may be a slight tremor in one or both hands; but more frequently the symptoms are those of spastic paralysis.

At first there is weakness of one leg, then of both, attended by some difficulty in walking. Gradually, with increasing paresis of the limbs, there appear muscular rigidity, especially brought on by active or passive movements, exaggerated tendon reflexes, spastic gait, and, finally, rigid contractures of the limbs. In many instances the gait is not a purely spastic one but has also a cerebellar type, a staggering, reeling character. The paresis, and, to a less extent, the muscular rigidity, etc., at a later period affect the upper extremities, and to these is subsequently added another motor symptom—one of the most prominent and characteristic of this disease—the so-called intention tremor, *i.e.* tremor during the performance of a voluntary act. Before it is otherwise noticeable, it may be observed in the handwriting or other delicate movements of the fingers, especially if the act is slowly performed. The writing, if carefully observed, will be seen to be full of small indentations which occur with great regularity, indicating that the tremor is rhythmical. When the tremor is well marked any voluntary movement will cause it to appear, and it may be seen to some extent during rest. A common method of eliciting the symptom is to ask the patient to put a glass of water to his lips. The tremor increases and the oscillations of the hand are greater as the latter approaches the mouth. The trembling may become so violent that all the water is thrown out of the glass. When the patient is sitting quietly either there is no tremor, or slight movements of the head and trunk may be observed. If he now perform a voluntary act, as lifting an arm, the tremor in the head and trunk increases at the same time that there is tremor of the acting member. When he attempts to walk there may be such violent tremor of the limbs and trunk as to make walking, or even standing, almost impossible. On the other hand, when the patient lies down and every part is well supported no tremor appears. None is observed during sleep. It is increased by emotional excitement.

All the voluntary muscles may be thus affected, the head as well as the trunk and limbs. Tremor in the face is less commonly seen, though there may be irregular movements, choreic in character.

The distinctive features of the tremor are that it is rhythmical, is comparatively slow, four to six oscillations to the second, and that it occurs only with muscular efforts. A very few cases have been reported in which it continued even in rest, but such cases are exceedingly rare. The tremor is not found in all cases. It probably depends on the locality of the disease. It also disappears in any part when the latter has become completely paralyzed.

The tremor can usually be easily distinguished from that of other diseases. In paralysis agitans, in the beginning (and it is only then that the two diseases could easily be confounded), only a few fingers are affected, and the oscillations are fine and very rapid. At the same time the tremor has somewhat the character of coordinated movements. Thus the movement of the thumb upon the fingers has been likened to that of counting money, rolling pills, etc. The tremor of multiple sclerosis is large and coarse, with no appearance of coordinated action. In paralysis

agitans, furthermore, the tremor is, to some extent, controlled by voluntary movement, and increases with rest, and the head is very rarely affected. When the tremor is violent it may have the appearance of the movements of chorea. But the latter occur during repose as well as during volitional acts, and they cause an intended movement to be made very irregularly; on the other hand, in multiple sclerosis the general direction of any movement is maintained, but the line of movement is an undulating one, the undulations playing equally up and down along the central line of direction.

The next two symptoms seem to be similar in character to the tremor. The first is nystagmus, a very common symptom, and of value in diagnosis. The other symptom is scanning speech. Other changes of speech are sometimes present, but this is the most common and most characteristic, and, therefore, of high diagnostic value. The speech is slow and dragging, each syllable being pronounced separately as in the slow scanning of verse, and, therefore, termed scanning speech. If the patient attempts to speak more rapidly, his words are likely to be so jumbled together as not to be at all understood. The voice is monotonous to the highest degree. There is often tremor of the lips at the same time, and, on laryngoscopic examination, there has been found to be diminished tension of the vocal cords.

Other ocular symptoms besides nystagmus are frequently found. Double vision, due to paralysis of some of the external muscles of the eye, occurs, just as in locomotor ataxia, either as a transient symptom at an early period of the disease, or as a permanent condition at a later stage. Myosis also, sometimes occurs, and in rare cases reflex rigidity of the pupils is found. Amblyopia is also a common symptom. In very many instances it is the first symptom, not rarely occurring years before there is any other indication of disease. Generally there is only impaired vision, not complete blindness. The ophthalmoscope reveals, in these cases, a discoloration of the discs, due to a degree of atrophy of the optic nerves. The optic atrophy is frequently limited to, or is more marked on one side. It rarely proceeds to the extent of complete atrophy. In rare cases choked disc has been observed, but even then there is not the degree of swelling usually found in the choked disc of brain tumor.

Headache and vertigo are often present, both in the early and in the later stages of the disease. The vertigo often occurs in paroxysms. Occasionally it is due to the double vision, but more frequently it is quite independent of the latter condition.

The mental symptoms often play an important rôle. Sight psychic symptoms may be manifested in the beginning of the disease if the latter first affects the brain, but the graver symptoms are, usually, late manifestations. Change in disposition, irritability, loss of self-control, a tendency to laughing and crying, are common conditions. Not rarely, and even in the early stages, attacks of uncontrollable laughter occur, not related to the patient's mood, nor to any mental weakness. A certain impairment of intellect—weakened memory, a degree of apathy, etc.—is also not uncommon. But a high degree of dementia is rare. It is likely to occur only when the disease begins at an early age and there is arrested development of the brain, or when the pathological process is very acute. Different forms of insanity are sometimes observed, most frequently melancholia, occasionally delusional insanity.

Apoplectiform seizures, like those seen in general paralysis, are important symptoms. They occur, according to Charcot, in one-fifth of all cases. After slight prodromal symptoms, headaches, etc., coma develops within a few hours, the temperature rapidly rises, often reaching 104° or 105° F., and at the same time the face is flushed and the pulse rapid. Hemiplegia, with flaccidity of the paralyzed muscles, is soon observed. Within a day or two consciousness returns, the temperature falls, and, within a comparatively brief period, the paralysis disappears. Such attacks may occur every few months, or very rarely. They usually leave the patient in a permanently worse condition, thus marking the progress of the disease. Sometimes the patient dies in the attack. These seizures are very much like those of apoplexy, but postmortem examinations reveal no anatomical basis for them.

In the foregoing have been given the most common symptoms of multiple sclerosis, those found in the majority of cases. But, on account of the distribution of the diseased areas, various other symptoms may be manifested. Thus the disease may attack the posterior columns of the cord, and ataxia, pain, anesthesia, paresthesia, etc., will be present; or it may involve the gray matter, when atrophy and paralysis of muscles will ensue. Or the disease may involve the whole thickness of the cord and produce the symptoms of transverse myelitis. When the posterior as well as the anterolateral columns are affected, many of the appearances of spastic paralysis are likely to be absent, especially the exaggerated tendon reflexes. Symptoms referable to the bladder and to the rectal and genital functions are also likely to appear. If the disease involve the nuclei of the facial, hypoglossal, and pneumogastric nerves, the ordinary symptoms of labio-glosso-laryngeal paralysis will be manifested, and various local cerebral symptoms may appear, according to the location of the foci of disease.

In addition I may merely mention some symptoms, sluggish pupils, frequently observed ptosis, ophthalmoplegia, seen in a few cases, and, frequent, though not prominent, pains, also that in a few cases the symptoms were mostly or altogether one sided, and the occasional sudden appearance with preceding vertigo or loss of consciousness of paraplegia, quadriplegia, hemianesthesia, or paralysis of cranial nerves.

The course of the disease is a very chronic one. Charcot has divided it into three stages—a division applicable to those cases which present the common clinical picture.

The first stage is from the beginning of the disease to the period of complete disability from paralysis and contractures of the limbs. This stage may last for from two to six years or longer. The symptoms are very slow in their progress. They begin as spinal or cerebral, but both sets of symptoms appear before this stage is terminated. There is often an arrest of the symptoms, or even improvement, which indefinitely prolongs this stage, and may give rise to delusive hopes of complete restoration to health.

The second stage, that of the fully developed disease, may last also for from two to six years. There seems to be little change in the patient during this period, and, though entirely helpless, he seems not to suffer in general health.

The third stage is that of decline. The general health is affected, there are loss of appetite, wasting, etc. Cystitis, decubitus, pyemia, etc., may hasten the end. Or the latter may be due to an increase in the bulbar symptoms, or to an apoplectiform attack. More frequently a fatal termination is caused by an intercurrent affection—pneumonia, typhoid fever, or, above all, phthisis.

The average length of the disease is from six to eight years. In rare cases it terminates in a year or two; occasionally it lasts twenty years or longer.

Morbid Anatomy.—The pathological changes can usually be seen by the naked eye. They consist of numerous patches or nodules of sclerosed tissue scattered throughout the nervous system. The nodules vary in size from merely microscopical proportions to an object as large as a chestnut or larger; they are rounded or irregular in shape, and may often be seen on the surface as slight prominences or depressions,

but are found in larger number when sections of the brain and cord are made. Their color is mostly of a gray or reddish-gray; they are translucent, and have a firm, often cartilaginous, consistence. Many of the nodules are of the same color as the surrounding tissue, and are only distinguished by their consistence. In rare instances a few may be softer than the normal tissue, probably indicating recent disease; most of the nodules, on the other hand, are firmer than the normal tissue, doubtless being of very old standing, for such cases come to the postmortem table only after the disease has existed a long time. The nodules seem to be quite distinctly circumscribed, but the microscope reveals the fact that they merge imperceptibly into the healthy tissue. They are also quite distinct, as a rule, though occasionally they blend into one another. In rare instances there has been found, in both the brain and the spinal cord, a diffuse sclerosis which, to some extent, has united the scattered nodules. On the other hand, secondary degeneration seems rarely, if at all, to develop from the disseminated disease.

The number of nodules found in a single instance may be very small, or may run into hundreds. Their distribution in the cord is very irregular. In some sections they may be found in the anterior, in others in the posterior, columns; in still others in the gray matter, or they may involve all these parts in the same section. Usually a large number of nodules are found in the medulla, pons, and crura cerebri. It is very rare that these parts are found free from disease. In the hemispheres the walls of the ventricles, corpus callosum, and centrum ovale are favored seats of the disease. In the latter two localities the nodules are often quite large. Usually nodules are also found in the large ganglia, while the cortex generally escapes. But few nodules are, as a rule, found in the cerebellum, and these in the central white matter. Similar nodules may be found in the nerves, most frequently in the optic nerves, but occasionally in the hypoglossal, the nerves of the eye, and the roots of the spinal nerves.

The microscopical appearances are those of interstitial myelitis. The nodules are mostly new connective tissue composed of very fine wavy fibrillæ. But in this new tissue the axis cylinders of the nerve fibers can usually be found in large numbers, though their medullary sheaths have disappeared. This is especially true of the nodules in the spinal cord.

There is as yet no agreement as to the nature and starting-point of the pathological process. Some think it an inflammatory process, others a primary disease of the nervous parenchyma; and others again primarily a neuroglial proliferation.

Diagnosis.—In some instances a diagnosis is made with the greatest ease, in others it is almost impossible. The most common clinical picture—paresis of the extremities with exaggerated tendon reflexes, intention tremor, nystagmus, scanning speech, amblyopia, etc. —is so characteristic that it cannot be mistaken.* But some of the most characteristic symptoms may be wanting, and then the diagnosis is much more difficult. In this case the indications of multiplicity of lesions and the very chronic course of the malady must be the guides to diagnosis. When the disease is limited to the spinal cord one can scarcely do more than guess in distinguishing it from other forms of myelitis. In such cases one must be on the lookout for cerebral symptoms. Optic atrophy is often a valuable diagnostic symptom, not only in this instance, but in excluding hysteria or other functional diseases which may simulate multiple sclerosis.

When the sclerosis affects only the brain it may present some of the manifestations of brain tumor. Here, too, the indications of a multiple lesion and the very slow course of the disease may clear up the diagnosis. But there is another important distinction, in that brain tumors produce to a large extent general symptoms, those of intracranial pressure, such as severe headache, convulsions, and double optic neuritis; while sclerosis produces merely local symptoms, those indicating the loss of function of the part affected by the disease.

The tremor of alcohol, lead, and mercurial poisoning might be mistaken for this disease, but concomitant symptoms and the history of a cause will establish the diagnosis. The tremor of paralysis agitans, with which this disease was formerly confounded, is easily distinguished by the appearance of the tremor, its being controlled to some extent by voluntary effort and increased during rest, and its very rarely affecting the muscles of the head and neck. Furthermore, paralysis agitans is rarely found in persons under forty years of age, while multiple sclerosis rarely occurs after thirty and, apart from the tremor, the symptoms of the two diseases are quite different.

Prognosis.—There are rare cases where the disease runs a very acute course and terminates fatally within a few months or a year or two. But usually it runs a very protracted course. Its duration is indefinite because of the frequency of remissions, or long periods of improvement. Sometimes the improvement is so great that the patient is supposed to recover, and it may be that in some instances symptoms do not recur.

The indications of disease in many parts of the nervous system at the same time, bulbar symptoms, and apoplectiform attacks are all unfavorable for a long duration of the disease.

Treatment.—As in many other organic diseases probably most can be accomplished by shielding the patient from harm. The unfavorable feature in this respect is the usual difficulty for a long time in making a diagnosis, especially the mistaking the disease for hysteria. Overexertion, undue exposure and emotional strain are especially to be avoided. Sometimes much is gained by rest. Hydrotherapeutic, electrical or other physical measures should be of a mild character. The drugs used in other cord diseases are used more or less in this one. The future must show whether any of the recent measures for combating infectious or toxic conditions will have any influence on this disease. Philip Zenner.

*Schuler reported a case of tumor of the right hemisphere, in the neighborhood of the island of Reil, which produced the typical clinical picture of multiple sclerosis, and Westphal reported two cases with similar histories, in which no pathological changes were found postmortem. But these are such rare occurrences as not materially to impair the diagnostic value of this clinical picture.

Sclerostominæ.—A subfamily of round worms. The mouth is armed and the bursa copulatrix is provided with ribs. This group includes the hookworms in the following genera: *Ancylostoma*, *Necator*, *Tridontophorus*, *Œsophagostoma*, *Physaloptera*. See, *Nematoda*. A. S. P.

Sclerotic.—See *Sclera*.

Scolex.—The so-called "head" of tapeworms. This portion is morphologically at the posterior end. It is provided with suckers or bothria, and in many cases with a rostellum and hooks, or denticles. Most tapeworms have two (Dibothrida) or four suckers (Tetrabothrida). The scolex is an asexual generation which buds off a number of proglottids, the sexual generation, thus making a chain of individuals which is called a tapeworm. "Scolex" is also an old generic name used for larval tapeworms. See *Cestoda*. A. S. P.

Scoliosis.—See *Lateral Curvature of the Spine*.

Scolopendra.—A genus of centipedes. Several of the larger species often inflict bites which cause swelling and great pain. Applications of ammonia relieve the trouble. See *Arachnida*. A. S. P.

Scombrin.—The name applied to a protamine obtained from fish spermatozoa. F. P. U.

Scoparius.—*Broom-tops.* The tops of *Cytisus scoparius* (L.) Link. (fam. *Leguminosæ*). This is a densely growing, erect, yellow-flowered shrub of Europe and adjacent Asia, two to five feet high, its branches terminating in thick masses of long, exceedingly slender twigs, which are used like brooms, whence the popular name. These twigs constitute the drug of commerce. They are two to three feet long, one-eighth to one-fourth inch thick, sharply five-angled, of a very dark green, and exhaling a peculiar odor when bruised. This odor largely disappears with time, when the drug becomes inferior. The leaves, which are rarely present, are subsessile, trifoliolate or reduced to one leaflet, the latter oblong or oval or obovate, somewhat hairy. Yellow papilionaceous flowers are often present, and perhaps some flat pods, looking like undeveloped pea pods.

Composition.—Broom contains tannin, fixed and volatile oil, wax, and the two peculiar bodies *scoparin* and *sparteine.* The volatile oil slightly assists the diuretic action of the scoparin. The latter is an amaroid ($C_{21}H_{22}O_{10}$), amorphous or in yellowish crystals, soluble in alcohol or hot water, and diuretic by directly stimulating the renal secretion. It is occasionally given in doses of gr. vii. to xv. (0.5 to 1.0), but is a very expensive remedy. Sparteine ($C_{15}H_{26}N_2$) is a yellow, syrup-like, aromatic, volatile alkaloid, soluble in alcohol and water, and yielding crystalline salts. It is a powerful poison. It has a primary circulatory stimulant action, contracting the arterioles and increasing blood pressure, thus assisting the diuretic action of the scoparin and volatile oil. The secondary action, which is very prompt, is to weaken the heart muscle and partly or wholly to overcome the vasomotor contraction. The drug is thus a cardiac sedative and in overdoses a paralyzing cardiac poison. It is also sedative to other muscles, and may act as a mild anodyne. It was originally used as a cardiac stimulant, but was found disappointing, because of the short duration of the stimulant stage, and is now little used, mostly in the form of the official sulphate, in doses of gr. $\frac{1}{6}$ to $\frac{1}{3}$ (0.01 to 0.02).

Broom is very considerably employed as a diuretic. The fluid extract is official and is given in doses of ♏. 15 to 60(1.0 to 4.0). The five-per-cent. infusion is a better form of preparation, in doses of one-half to one ounce. Henry H. Rusby.

Scopola.—*Scopola Belladonna;* incorrectly, "Japanese belladonna." The dried rhizome of *Scopola carniolica* Jacq. (fam. *Solanaceæ*).

This drug is chiefly of interest at the present time because of the very extensive use of its extract, like that of belladonna root extract, to substitute belladonna leaf extract, which last is officially directed to be used in the manufacture of belladonna plaster (see *Belladonna*). The very similar species *S. japonica* Maxim., of Japan, is the real *Japanese belladonna.* The Japanese Pharmacopœia is said to authorize its use, as an alternative, whenever belladonna is prescribed. This species is not with us a commercial article.

S. carniolica is a native of Central and Southern Europe. The plant somewhat resembles the belladonna plant. The leaves, which are considerably used for adulterating belladonna leaf, are not so large as the latter and are narrowly obovate, instead of broadly ovate, and have a tapering base. The underground portion of the plant is very different from that of belladonna, consisting of a tortuous horizontal rhizome from which descend, vertically, a number of roots, quite closely resembling belladonna roots, though averaging only half the size or less, and of a rather bright yellowish or brownish red, instead of the dull gray color of belladonna root, and usually rather evenly marked with small, transversely oblong, light-colored scars. The rhizome, of which the drug almost wholly consists, is usually from two to four inches in length, as thick as the fingers, sympodial in development, shortly and sharply flexuous, and marked on the upper surface with rather closely set large shallowly cup-shaped stem scars. The outer surface is gray brown, mostly darker than that of belladonna root. Its fracture is accompanied by the emission of the same puff of dust that accompanies that of belladonna root, and the internal color is much the same, though usually somewhat darker than that of the latter.

The important constituents of scopola are its alkaloids, of which the total amount averages about the same as in belladonna root, namely, a little more than a half of one per cent. The composition of this alkaloid is as yet uncertain. It has been believed that about one-tenth of it is hyoscine (scopolamine), but some recent analyses appear to indicate that there is much less. The remainder is a mixture of hyoscyamine and atropine. It has been believed that it is composed mostly of the former, but our ideas of the relations between these two alkaloids, both here and in belladonna, must be regarded as in a transition state. Scopolamine hydrobromide is employed, in conjunction with morphine or narcophine, by hypodermic injection in the production of amnesia during childbirth (the so-called "Twilight Sleep"). The dose recommended by the U. S. P. is gr. $\frac{1}{200}$ (0.0005).

From what has preceded, it is apparent that the action of scopola will be practically that of belladonna in kind, and that their relative strengths cannot be stated positively until questions regarding the constituents shall have been more definitely settled. The present indications are that they are almost equal in strength, and that scopola can be used, in the same doses, for all the purposes for which belladonna root is used. The extract, dose gr. $\frac{1}{4}$ (0.01), and the fluid extract, dose ♏i. (0.06), were official in the U. S. P., 1890. Henry H. Rusby.

Scorpæna.—A genus of fishes. These animals inflict poisonous bites. Three species are known from the Indian Ocean, Mediterranean, and the West Indies. A. S. P.

Scorpionidea.—The order of arachnids which includes the scorpions. These animals have a poisonous sting at the tip of the tail which they use in killing their prey or in defense. Prognosis is usually favorable for an adult person who has been stung, but children are much more susceptible and may die. Ligation, excision, and cauterization with potassium permanganate are recommended in the way of treatment. See *Insects, Poisonous.*

A. S. P.

Screw-worm Fly.—This fly, *Chrysomyia macellaria,* attacks many animals, and is often the cause of human myasis. The flies are attracted by sores, offensive breath, discharge from the ears, etc., deposit eggs, and the larvæ cause much trouble.

A. S. P.

Scrofula.—Precisely analyzed from the standpoint of modern pathological anatomy and bacteriology, scrofula or scorfulosis may be defined as tuberculous lymphadenitis (see *Lymph Nodes, Diseases of*). Clinically it should be considered as the chronic form of tuberculosis of lymph glands. As thus defined it is evident that the term has no excuse for existence *per se,*

and deserves recognition only in a synonymous sense. In fact, because of the confusion attending its proper usage, and because the principal condition to which it is applied can be more specifically designated, it would be better definitely to abandon the word scrofula as has already been advocated. In consideration of its historical interest, and on account of the persistency with which it adheres to popular parlance, scrofula still claims passing notice.

Strictly speaking, then, scrofula is a morbid state whose chief anomaly is a tuberculosis of lymph glands, more especially the nodes of the cervical region and of the mesentery, occurring commonly in childhood, though not confined to this period. Accompanying this adenitis is a constitutional disorder formerly regarded as a distinctive dyscrasia (the "*scrofulous*" or "*strumous*" *diathesis*), but which is now known to be the anemic, cachectic, or debilitated state attending tuberculous infection or intoxication. A broader and more ancient conception included as scrofulous such affections as tuberculosis of bones and joints, of the skin (*scrofulodermas* or, more properly, *tuberculides*), and of the mucous membranes, and even the various forms of visceral tuberculosis. A more serious misuse of the term is that which would comprise all disorders accompanied with hyperplasia or hypertrophy of lymphatic glandular structures. Thus the adenitis of other chronic infections, like the atypical pyogenic, the syphilitic, that of glanders and that of actinomycosis have been regarded as scrofula. Leukemia, and more particularly pseudoleukemia (Hodgkin's disease), have been classed with it at times, and the error still persists of confounding status lymphaticus (see *Status Lymphaticus*) and scrofula. So far as Hodgkin's disease is concerned, there may be some justification for its having been regarded in the same light as scrofula, especially in view of the researches of the last ten years, which tend to show that the diffuse lymphadenitis of so-called pseudoleukemia is occasionally, at least, the result of an infection with the bacillus of tuberculosis in which the morbid changes have pursued an anomalous course.

Besides the more pronounced manifestations such as pertain to the glandular system, other minor affections which we now regard as secondary complications, were included among the evidences of scrofula. Examples of these are the scrofulous keratitis, conjunctivitis and blepharitis, various forms of otitis media, nasal and pharyngeal catarrh, and eczema or other skin diseases. The constitutional types once the subject of much attention, by which scrofulous individuals were classed as the "sanguine," "phlegmatic," and "pretty," are no longer regarded otherwise than indicative of a tuberculous taint either hereditary or acquired.

In fine, used in its most exclusive sense as indicating a tuberculous lymphadenitis, scrofula claims distinction only in that it refers to a sluggish, chronic tuberculous infection in which the exciting agent, the bacillus of tuberculosis, frequently seems to exist in a state of attenuated virulence. Or, it may be, that some of these infections result from other atypical members of the ray-fungus group of parasites allied to the tubercle bacillus in morphology and tinctorial reactions, but endowed with diminished pathogenic powers.

Otherwise scrofula is tuberculosis, as manifested not only by its morbid anatomy and histology, and its bacteriology (as concerns the presence of the specific bacillus both in the diseased tissues and in cultures), and also by the results of inoculation experiments. This conclusion was reached by the more astute pathological anatomists, particularly of the German and Austrian schools even before the advent of the bacteriological era, and there is no disposition to question it to-day after the critical modern studies in which the more precise methods of histological and bacteriological analysis have been employed. Hence a discussion of scrofula is based upon a study of chronic tuberculosis of the lymphatic glands, variously complicated with such anomalies as cutaneous, osseous, and synovial tuberculosis; and the scrofulous or strumous diathesis becomes the dyscrasia attending local or general tuberculosis either in its latent or in its chronic state. For the elucidation of such phases of the question as pathology, etiology, diagnosis, prognosis, and treatment of scrofula, therefore, the student is referred to the treatises upon tuberculosis in its various aspects and more especially those which refer to chronic tuberculous lymphadenitis. An exhaustive résumé of the bibilography of scrofula, mostly of interest from the historical standpoint to-day, is presented by Cornet (Nothnagel's "Specielle Pathologie u. Therapie," Bd. xiv.). A. P. Ohlmacher.

Scrofuloderma.—See *Skin, Tuberculosis of the.*

Scrophulariaceæ (the Figwort family).—A large, widely distributed and diversified family, comprising more than 175 genera and about 2,500 species. It yields the important drugs Leptandra and Digitalis, besides which quite a large number are or have been employed to a lesser extent. Several of these, as follows, are of sufficient importance to be entitled to brief mention. The active constituents of this family appear to be chiefly glucosidal.

Mullein is a title commonly applied in this country to the fresh or dried leaves of *Verbascum thapsus* L., of the National Formulary, an exceedingly coarse, stout herb, with a simple and erect stem, native of Europe, and now growing everywhere as a weed in the eastern United States. The large, obovate, thick leaves are densely woolly, and are sometimes applied as a mild counterirritant, usually in the entire condition, but sometimes made into a poultice. They are mucilaginous and very slightly bitter. They are sometimes made into a tea and used as a demulcent in irritating cough. They possess slight laxative properties. In Europe the name mullein is more commonly applied to the flowers of this and related species, which are also recognized in the National Formulary. They possess constituents similar to those of the leaves and are similarly employed, though they contain a little volatile oil and coloring matter. Olive oil in which they have been macerated has quite a high domestic repute in many localities as an emollient.

Hedge hyssop is the common name of a little perennial herb, *Gratiola officinalis* L., of Europe, which contains one or more glucosides, the very bitter crystalline one, *gratiolin*, being apparently the active agent. Its medicinal properties entitle it to a thorough investigation, since it is so active as to constitute a rather powerful emeticocathartic poison, with marked diuretic properties. Its use, in doses of 0.2 to 1 gram (gr. iij.–xv.), has been wholly unscientific, applying especially to gout and rheumatism.

Figwort is the dried herb of one or more species of *Scrophularia*, the genus from which the family takes its name. Like the last, the drug has not received any scientific investigation. Its bitter crystalline constituent, probably a glucoside, has been called *scrophularin*. There is also a very small amount of a volatile oil. Figwort appears to have some slight anthelmintic powers, but has been chiefly used, like mullein, in the form of a poultice. Its use is far more common in Europe than in this country.

Henry H. Rusby.

Scrotum, Diseases and Injuries of the.—The diseases of the scrotum may be subdivided briefly into two classes, viz., inflammations and cutaneous affections.

Inflammations of the scrotum are usually secondary to inflammatory conditions or injuries involving adjacent organs, notably the penis, bladder and testes.

Edema is the most common inflammatory condition of the scrotum, and is usually the result of an acute epididymitis or orchitis. It is occasionally associated with chronic inguinal bubo, and more often as the result of obstruction to the blood stream, in cardiac, renal and hepatic disease. Certain skin diseases, notably eczema, also may produce this condition.

In most cases, the edema subsides with the passing off of the etiological factor, but in some instances, there is considerable tension of the skin of the scrotum, which persists. This must be relieved by making multiple punctures into the scrotum with a fine bistoury or a needle, followed by gentle yet firm pressure. A mild wet dressing and firm pressure will complete the treatment and effect a cure

Abscess and Cellulitis.—These are usually the result of urinary infiltration or simple infection from external injuries. If the distention is marked, it is important in cases of external injury to determine the presence or absence of urinary infiltration, which this condition so closely resembles. The treatment is along the usual surgical lines, and consists of evacuation of the pus and drainage.

Pneumoscrotum or Scrotal Emphysema.—Entrance of air into a wound of the scrotum, either from one of the body cavities or from without, produces this condition. It is also seen in conjunction with infections caused by the gas-forming bacteria; in these cases, gangrene of the scrotum may follow.

The gas is evacuated by multiple incisions, followed by drainage and the applications of wet dressings. Hydrogen peroxide is especially useful in these conditions.

Elephantiasis of the Scrotum; Lymph Scrotum.—This is a very rare condition in temperate climates, but quite common in the tropics. It is caused by an obstruction in the lymph channels of the scrotal skin. This may be due to the deposit of connective tissue after surgical operations on the scrotum or inguinal glands, or it may be due to the presence in the lymphatics of *Filaria sanguinis hominis*, which interferes with the circulation by obstructing the vessels in which the worms lie.

There is a gradual thickening of the cutaneous and subcutaneous tissues owing to the dilatation of the lymphatics, with the result that the scrotum enlarges enormously, covering and hiding the penis more or less completely. A case is recorded in which such a scrotal mass, when excised, weighed over 200 pounds.

Treatment is apt to be futile, unless the parent worm can be removed from the body. The type produced by mechanical pressure, is best treated by the application of wet dressings, and if these fail, by amputation of the redundant tissue.

Cutaneous Affections.—Briefly stated these include eczema, eczema marginatum, scabies, intertrigo, pediculi pubis, pruritus, steatoma or sebaceous cysts, molluscum contagiosum, lupus, and cancer. Less frequent are sarcoma, osteoma, enchondroma, gumma, and lipoma.

Eczema.—Gouty, diabetic, rheumatic, and stout persons are especially liable to the development of eczema of the scrotum. Excessive perspiration is probably the exciting cause. Itching, smarting, and excoriation are the usual symptoms.

Treatment consists in keeping the parts as dry as possible, preventing friction with the thighs, and the application of dry dusting powders. A well-fitting suspensory, holding in place a few layers of dry gauze, will secure dryness. Stearate of zinc, zinc oxide, talcum, powdered starch, are the most efficient dry dressings. An ointment containing 2 per cent. resorcin in lanolin and lard or Lassar's paste, may be substituted for the powder. The itching may often be controlled by a weak solution of phenol applied on a strip of gauze. The tar preparations are also of value.

Eczema Marginatum; Genito-crural Ringworm.—This is probably more common than eczema proper. It affects the scrotum and the thighs where they come in contact. It may present at one time papules, vesicles, excoriations, and crusts. Itching is not very marked, some patients going about apparently indifferent to the large, red patch. Cooling dressings, containing a parasiticide like bichloride of mercury (1–2,000), are effective; the tincture of iodine has likewise been recommended.

Scabies.—On the scrotum, scabies is usually a manifestation of a general infection by the *Acarus scabiei*. It is probably carried to the genitals by the fingers or clothing. The itching often leads to ulceration, and true eczema may result in long-standing cases. The usual treatment with sulphur applied to the rest of the body, and sulphur ointment applied to the genital lesion, will bring about a cure.

Erythema Intertrigo.—This condition is found in children and unclean elderly persons, as a result of constantly wetting the skin with urine. In the presence of gout and rheumatism, with irritating urine, this is more likely to happen than otherwise.

Treatment consists of cleanliness and dryness, the same as mentioned above for eczema.

Pediculi Pubis.—The diagnosis is easily made by finding the living parasite in the pubic hair. Mercurial (blue) ointment applied several days in succession is usually curative. Occasionally all the hair must be shaved. Calomel ointment (calomelol) is equally effective as the blue ointment and far more cleanly and agreeable. Corrosive sublimate 1–1,000, kerosene oil, and crude petroleum are very effective, the last two being quite disagreeable. Tincture of larkspur or delphinium is also used. Care should be taken in the use of all of these remedies to avoid undue irritation and acute inflammation, by the use of soothing ointments such as zinc oxide, after the parasites have been destroyed.

Pruritus.—This is usually due to constitutional causes (rheumatism, diabetes, and gout), and is very annoying. Dermatitis and thickening of the skin are apt to follow the persistent scratching and rubbing of the affected parts.

Systemic treatment is the first indication; this is associated with local antipruritic measures, including thymol, menthol, and tannic acid. Stearate of zinc, zinc oxide, and similar dry dusting powders are likewise often effective. Turkish and sulphur baths have also been recommended. It is well in all of these cases, to search for the possible presence of parasites of scabies and pediculosis.

Sebaceous Cysts; Steatoma.—Retained secretions in the glands of the skin often attain fairly large size in the form of retention cysts. They are found in all parts of the scrotum and may be as large as a grape. Effective treatment consists in squeezing out the cyst contents, or excising them and applying a moist antiseptic dressing.

Molluscum Contagiosum.—This is also frequently encountered, and should be treated in the same manner as sebaceous cysts.

Lupus.—This is an uncommon condition, and needs but passing mention. It should be especially differentiated from tertiary syphilis. Complete excision is the only effective treatment.

Cancer.—The most common type of scrotal cancer is epithelioma or "chimney-sweep's cancer." This is characterized by the development of a small nodule, which slowly becomes covered with crusts; excoriation, ulceration, and induration follow in turn rather rapidly and may include the entire scrotum, penis, testes, and cords. Death may follow from general constitutional deterioration.

Early and complete excision offers the only chance

of cure; the inguinal glands should also be removed if they are involved.

Sarcoma, osteoma, enchondroma, and lipoma also occur, but very rarely and need but be mentioned. *Gumma* of the scrotum is much more frequent. The latter responds to antisyphilitic measures.

Injuries.—*Contusions.*—The scrotum being liberally supplied with vascular structures, contusions are apt to result in the formation of hematoma and ecchymosis, even though there be no rupture of the outer skin. The pain is comparatively slight. The sac may be distended with blood, and may entirely obscure the penis. This great amount of blood is usually absorbed under the influence of rest and wet applications; inflammation and suppuration, may however, occur, and gangrene supervene. When suppuration occurs, incision and drainage are required. If the blood clot is not readily absorbed, the scrotum must be incised, the clot turned out, and the bleeding vessels tied.

Wounds.—The scrotum may be punctured or lacerated. The testes may or may not join in the injury. These wounds are likely to be attended with considerable bleeding, which is controlled by rest, pressure and cold, local applications. If these wounds become infected, they are to be treated according to usual surgical methods. Recovery is generally prompt.

Fungus of the Scrotum.—This is produced by the prolapse of the testis through an opening in the scrotum, produced by injury or otherwise; the testis is covered by a fungoid mass consisting of exuberant granular tissue, and tightly bound to the scrotum by the adhesions which form.

The granulations should be reduced by the use of the cautery or curette, and the surface is then allowed to heal slowly under antiseptic precautions (see *Fungus of the Testis*).

Malformations and Abnormalities.—The most marked deformity of the scrotum is seen in connection with extreme types of hypospadias. In these cases, the scrotum is cleft in two and greatly resembles the labia majora of the vulva.

Lesser deformities are seen in connection with retention and mal-descent of the testes. When both testes are retained, the scrotum will be found small and undeveloped and sometimes practically absent; when one testis is undescended, the scrotum will be found rudimentary on the corresponding side, and normally developed on the other side, giving the scrotum an asymmetrical appearance.

On the other hand, the scrotum may be exceedingly large and relaxed, as with an extreme hernia or varicocele after operation. These relaxed scrota may often hang down like an apron. Apart from their inconvenience and abnormal appearance, they do not require treatment. For cosmetic purposes, the redundant portion may be excised.

Abr. L. Wolbarst.

Scultetus, Johannes.—Born at Ulm, in Württemberg, Germany, in 1595. He commenced the study of medicine at an unusually early age and received the degree of Doctor of Medicine, Surgery, and Philosophy, in 1621, from the University of Padua, in Italy. His teachers were Adrian Spigelius and Fabricius ab Aquapendente. He practised surgery for a certain length of time at Padua and at Venice, and then returned to his native city, where he soon built up an extensive practice. The date of his death is unknown.

He was a bold but very skilful surgeon, and he appears to have possessed an unusual degree of mechanical ingenuity, as shown by the large number of surgical devices which bear his name. The only treatise written by Scultetus is the following: "J. Sculteti armamentarium chirurgicum 43 tabulis ornatum. Opus posthumum," Ulm, 1553 (also many later editions). A. H. B.

Scurvy.—*Synonym:* Scorbutus.

Definition.—Scurvy is a systemic disease dependent upon an improper or ill-balanced dietary, characterized in its general expression by anemia (secondary), hemorrhages into the skin and subjacent tissues, spongy or ulcerating gums, progressive debility and emaciation, resulting in death unless checked in its course by the necessary dietetic and medicinal treatment. The word scurvy is probably of Scandinavian origin, the Swedish *skörbjugg*, Danish *skojærbug*, being equivalent to the German *Scharbock*, meaning soft or relaxed stomach.

General Considerations.—Throughout all ages scurvy has been one of the classical diseases of mankind, and although it has been successfully eliminated as one of the social and sanitary problems of civilized life, yet it would be a great mistake to infer that, by reason of our better knowledge of its causation and character, it has ceased to be a possibility in our modern surroundings. Cases continue to be reported in our most recent journals. The ancient writers abound in references to it, giving in fanciful terms their theories as to its nature and cause. In his work on "Airs, Waters, and Places," Hippocrates describes the disease in an unmistakable manner, and Pliny and Strabo give us satisfactory accounts of scurvy as it appeared among the troops in the campaigns of Cæsar Germanicus and Ælius Gallus. Indeed, it has been from time immemorial the scourge of armies, ravaging the ranks of the crusaders, the soldiers of the Middle Ages in their long sieges, the cohorts of Napoleon in Egypt, and even the troopers of the last decade of the nineteenth century, in all parts of the world where warfare is carried on under climatic or dietetic conditions new and strange to the soldier. In our own country it has invalided half a garrison, at Council Bluffs (1820) resulting in a mortality of over thirty per cent., and later during the Mexican war our troops suffered from its appearance while in that country. During the civil war the statistics of this disease show a total of 46,910 cases in the Union army, of which 771 proved directly fatal, a small relative ratio, but it undoubtedly expended its force indirectly as a contributary factor in the termination of other cases with which it was concurrent. The same experience is recorded in the Crimean War, where 23,365 cases occurred in the French army, and 17,557 in the British army, while the numbers in the Turkish army were almost countless, as that force was practically decimated by its ravages. The Franco-Prussian war again recorded its appearance, though with a much lessened ratio of invalidism, and the Russo-Turkish War repeated the story. In the German army, as late as 1897, there were seventy-four cases of scurvy, and in the Russian and Austrian armies, the same year, a ratio of over one per thousand strength. During the Boer war the "concentration camp" of tihe British furnished more modern evidence of its votality as a disease to be expected under certain csnditions. But in the popular conception, as well as in the professional mind, scurvy is looked upon as a disease of the sea, and of those "who go down to the sea in ships and have their business in great waters." Beginning with the first known geographical explorations of the fifteenth century, involving long voyages in unknown oceans, the records of those famous discoverers always included with their marvellous tales of "new-found lands" the story of sufferings and death among their intrepid seamen from the disease then known as scurvy. Perre Quirino, Vasco de Gama, and Jacques Cartier

all record the ravages of this disease among the crews of their vessels. As late as the eighteenth century Anson lost more than four-fifths of his men while sailing round the world. Coming down to modern times, the experience of the Public Health Service of the United States, whose function is, in part, to care for sick and disabled seamen of the merchant marine, is the most accurate index to its prevalence among American sailors, as well as a few of other flags who are treated in our marine hospitals. From the statistics compiled for a period of twenty-eight years (1872 to 1899 inclusive) the following table has been constructed to show its occurrence and frequency:

Cases of Scurvy Treated in United States Marine Hospitals from 1872 to 1898 Inclusive.

Year.	Number of cases scurvy.	All diseases treated.	Year.	Number of cases scurvy.	All diseases treated.
1872.....	18	13,156	1888..	17	48,203
1873.....	47	13,529	1889 .	32	49,518
1874.....	59	14,356	1890	28	50,671
1875 ...	25	15,009	1891.....	32	52,992
1876-77....	89	31,983	1892	30	53,610
1878-79....	24	39,155	1893	34	53,317
1880.....	39	24,860	1894 .	27	52,803
1881	42	32,613	1895 . .	14	52,643
1882	55	36,184	1896	24	53,804
1883.....	43	40,195	1897.....	20	54,477
1884.....	27	44,761	1898	6	52,709
1885.....	34	41,714	1899	3	55,489
1886.....	18	43,822			
1887.....	37	45,314		824	1,066,887

This is less than one per thousand cases treated for the period stated. Since that list date the number of cases per annum has not exceeded up to the present time (1915) seven in any one year).

These figures require but little explanation beyond stating that about half of the cases of scurvy treated by the service is reported from the stations on the Pacific coast, principally San Francisco. These cases are taken from vessels coming "round the Horn" from England or elsewhere, a long voyage of several months, in which the conditions of diet, confinement, lack of exercise, etc., aid the development of the disease. While on duty at San Francisco the writer had opportunities to study and treat about seventy-five cases of scurvy in the course of three years, and it is from this experience that he has derived his practical knowledge of the disease. The last cases seen by the writer occurred in 1910 when a dozen or more, with several subsequent deaths, were taken from a vessel, operated by members of a fanatical religious sect, on a return voyage from Africa whither they had gone to convert the negroes. These deluded people had subsisted on canned food and such material as could be obtained from vessels at sea, having had no fresh vegetables for weeks. The leader is now a Federal convict for not observing the law relating to provisions for deep-sea voyages.

Etiology.—Scurvy—speaking in general terms—is a disease dependent on diet and occupation. It exists either in epidemic or in endemic form whenever persons subsist for a prolonged period on a dietary which does not contain fresh vegetables, or vegetables in a properly preserved state. This condition, when aggravated by an unsanitary environment, is thereby accentuated. It is still a subject of controversy what may be the precise elements in this vegetarian problem, to the lack of which are logically due the scorbutic symptoms. Everything, however, tends to the conclusion that the disease is dependent upon the insufficient ingestion or the deprivation of the potassium salts of fruits and vegetables. These salts, in which potatoes, for example, are so rich, must have a very potent influence in maintaining the alkalinity of the blood and preventing acid intoxication. When to this lack of vegetables, with their organic and inorganic elements, is added the enforced adhesion to a meat diet, especially if salted, or preserved by other similar processes, we have the ideal conditions under which scurvy begins and maintains its invasion. Resulting from this is a probable hyperacidity of the blood through the loss of the carbonates derived from the vegetable salts and the following loss of coagulability, with progressive anemia. In this state of theoretical acid intoxication there is an increase in the ammonia-neutralized acid excreted as compared with the free acid. The blood is found to be dark and thin. The morphological changes are those of secondary anemias, as from hemorrhage. Various observers have noted the changes in the count of red cells in proportion to the severity of the disease, the duration, and the hemorrhages. Megalocytes and shrunken microcytes have been seen in grave cases. Red cells in solution in the plasma are reported by Albertoni. The Hb index is low, according to White, while several other investigators have made conflicting statements as to the relative ratios of iron, sodium, and potassium salts and leucocytes. Altogether, the present state of knowledge of the morphology of the blood is not enlightening, and further studies are necessary to determine the significance of the conditions which are claimed by them as pathognomonic.

A contribution to the discussion on this portion of the subject is that made by Albertoni, who has shown in some studies of the chemistry of the blood and of digestion that there is a serious deviation from normal in the free HCl of the gastric juice, that intestinal putrefaction is excessive and that the urine furnishes abundant evidence of the absorption of toxins, while the absorption of fats and carbohydrates is deficient. He concluded that the greenish-yellow color of the serum and the excess of pigments in the urine were proofs of active destruction of the blood cells.

As a corollary to this toxic indication may be mentioned the theory, worthy of investigation, that the disease is in reality a chronic ptomaine poisoning due to putrefactive changes in badly preserved animal food, such as salt beef and canned meats. It is held that if these provisions were properly sterilized there would be no scurvy. It is not an infrequent complaint among seamen suffering from scorbutic conditions that the "salt horse" was of an offensive odor, and this observation was made among the laborers employed on the construction of a transcontinental railroad where scurvy appeared among foreigners who used this tainted meat with a plentiful supply of flour, beans, and peas.

Scurvy is not believed to be contagious or infectious. Thus far no microorganism has been found to be of determining value in such investigations as have been made by investigators. The field has not proved to be an inviting or fertile one for bacteriologists of admitted skill. Some experiments have been made with the blood of scorbutic patients, with portions of the spongy gums and with material taken from the hemorrhagic lesions, but the results are not satisfying nor constant. It has been noted in epidemics that children suckling scorbutic mothers did not develop the disease, and in a given ship from which cases of scurvy have been taken, except in extreme conditions, only the forecastle, where the diet was restricted to certain kinds of food, would be invaded. Isolated cases of scurvy have been found dependent upon conditions that favor either the nutritional, the toxic, or the infectious theories of the etiology of the disease advanced by various writers, but thus far the deficient vegetable dietary offers us the most practical evidence in our search for a factor that responds

to all the tests of probability. Ever since Bachstrom set forth this theory in 1734—viz., the lack of fresh vegetables in the food—it has held its ground through the successive investigations of Garrod, Buzzard, and Ralfe, each carrying on by successive steps the study of this phase of the question. The last-named investigator, last in point of time as well, has formulated this theory in the following terms: The alkaline salts of vegetable acids (malic, citric, tartaric, etc.) are concerned with the normal transformation of the carbonates of the blood; the actual factor is thus a chemical alteration in the quality of the blood, a diminution of its alkalinity; that this follows the withdrawal of salts having an alkaline reaction, such as the alkaline carbonates; that this scorbutic condition is the same as that produced experimentally by injecting acid into the blood of animals, feeding with acid salts, etc., viz., a dissolution of of corpuscles, purpuric spots, and other particular signs of the disease. The morphology of the blood is disappointing in so far as it fails to afford any sure index of the condition. Coplans who had experience in the Boer concentration camp supports the infective theory. He found that the disease prevailed in proportion as the habits of the prisoners were filthy and he could trace no relation between its prevalence and the diet which was identical in all camps.

To sum it is not unlikely that upon a soil suitably prepared by dietary imbalance and insanitary surroundings some specific infection gains access to the system by way of the mouth.

While scurvy is a disease of diet and occupation, it is not a disease of country, race, sex, age, or season. It is found in all zones, among all peoples where the conditions favor it; it knows no sex, though males probably contribute a greater proportion to the statistical tables, for the evident reason that they are more usually subjected to the favoring conditions; and in the matter of age it is met with from infancy to dotage. Naturally, it prevails in those countries and among those peoples whose observances of hygienic laws are "more honored in the breach," but it is found among civilized races as well. Institutions for the aged furnish cases occasionally, but on the whole it can be said that it is a disease of adult life rather than of the extremes of age. The winter season, for obvious reasons, adds to the number of cases when the disease exists in epidemic or endemic form. As to occupation it was once thought to be a disease peculiar to the seafaring life, but it is found more on land than on the sea. Of Pellagra recently declared by Goldberger of the U. S. Public Health Service to be a scrobutic disease, both by clinical and experimental production, through prolonged adhesion to a carbohydrate diet, exclusively reference should be made to the discussion on the subject by another collaborator in this work.

Clinical History.—A progressive upward and downward curve marks the course of a case of scurvy from its onset to its finish. It has no definite attack, no crisis. Unless the patient is under conditions known to him to be causative, as in the case of seamen on a long voyage, the approach is without warning. The preliminary symptoms are those general signs of decreasing strength, mental depression, pallor, loss of flesh, anorexia, and perhaps some gastrointestinal disturbance. This is gradually followed by more characteristic features of the disease. The skin becomes dry, there is "pinching" of the features, the complexion becomes of a dirty hue, for want of a more applicable term, and the gingival mucous membrane at the free margin becomes swollen and spongy. This is one of the typical features of a case of scurvy. The gums bleed upon slight pressure, appear bluish in spots, and often ulcerations follow as the scorbutic condition progresses. The gums seem to develop into this soft, necrotic texture around teeth that are broken and decayed, but it is a matter of observation that in the aged who have lost their teeth and in children before the eruption of teeth, these gingival symptoms are practically absent. In severe cases the gums swell, and rising around the teeth partially cover them with a proliferated mass of foul growth, during which time the teeth become loosened in their sockets and dislodgment may follow. The breath becomes intensely fetid as a result, the flow of saliva is increased, the salivary glands sometimes enlarge, and the tongue appears red and swollen. The eating of food is, under these conditions, not only a painful but a disagreeable function, and the sufferer seeks liquid nourishment as a relief. This condition of the gums, which usually begins near the median line at the incisors, is the first characteristic symptom, and hemorrhagic suffusions into the cutaneous, mucous, and deeper tissues is the second typical development of the disease. It is usually synchronous with or later than the gingival symptoms. These subcutaneous hemorrhages appear at first in the lower extremities, about the ankles, in the form of petechial macules, varying in size and most of them having a hair follicle in the center. They resemble ecchymoses in some cases, in others purpura and similar cutaneous disorders. While they develop spontaneously they may be excited by blows or other injuries. The larger coalesced spots show chromatic gradations of brown, green, and yellow at the periphery similar to the "black and blue" marks following a contusion, but in scurvy there is, in the severe hemorrhagic cases, a distinct elevation of surface upon which vesicles sometimes form. Ulcerations of an indolent type follow this and often destroy a large patch of cutaneous surface. The hemorrhages may be deeper-seated, giving to the limb affected a bosselated appearance, and when the intramuscular, the fibrous, and the subperiosteal tissues are involved the element of pain is introduced. These deeper hemorrhages constitute the one particular symptom of an advanced case of scurvy. At first they feel like doughy masses, pitting or yielding to pressure, but later the tissues lose their resiliency and, as the suffusions become more general and uniform throughout the muscular structure below the knee, the leg, when handled, feels as if it were made of wood. This scorbutic sclerosis, of which the text-books rarely make mention, may extend to the trunk and upper extremities, but it rarely invades the face or the scalp. The joints of the upper extremity, the wrist usually, may be edematous, and this effusion may involve the serous surfaces, the pleura, pericardium, and sometimes the meninges.

Hemorrhagic suffusions into the tissues of a mucous membrane are less constant, but, in the form of epistaxes, often resulting in syncope and exhausting anemia, they are not so uncommon. The tissues involved do not respond to the usual remedies. When the intestinal mucous membrane is the seat of scorbutic lesions, there may be bloody stools, and in advanced cases the kidneys, spleen, bladder, and other internal organs may be included in this process.

Other symptoms noted in well-marked cases are: articular swellings, with pain and local febrile movement, and ulcerations of mucous surfaces, the cornea even being involved. Disintegration of recent callus has been reported, and other similar destructive processes, too numerous to mention, have been seen in advanced stages of the disease and are cited to show how profoundly the disturbed nutrition manifests itself in constitutional effects.

While there are no marked symptoms involving the nervous system, the mental depression is noticeable and the patient seems to be indifferent to his condition and surroundings. Hemorrhages into the meninges may produce convulsions or other abnormal cerebral manifestations. Among seamen the symptoms of hemeralopia and nyctalopia are not uncommon accompaniments.

There is no constant type of temperature. In some cases it may be subnormal. The pulse is often rapid and always weak, and the heart action and respiration are affected by the slightest exertion. Hemic murmurs, common to all anemias, can be detected. The urine is usually albuminous, of high specific gravity, decreased in quantity and of a high color. It may show the results of suffusion into bladder or kidneys. Obstinate diarrhea, sometimes dysenteric in type, showing mucus and blood in the dejections, supervenes, and the loss of appetite and distaste for the foods that constitute the sufferer's diet, particularly at sea, soon give place to nausea and vomiting. These extreme conditions are not uncommon if dietetic relief does not intervene to turn the tide. The sufferer then presents a terrible picture, with sunken orbits surrounded by blackened circles, parted lips, and dingy yellow skin. He looks like a "breathing cadaver," as one writer has graphically expressed it.

Death from exhaustion, septicemia, or some intercurrent infection terminates these advanced cases that have not had treatment.

Diagnosis.—When a number of persons come from a ship after a long voyage, presenting any of the characteristic symptoms above described, or others of a similar character but less pronounced, the difficulties in the way of diagnosis are not great. Single cases seen ashore, in the early stages, might easily be classed under the general diagnosis of "anemia" or "debility" by one not familiar with the symptoms, or not on the lookout for a disease generally believed to be peculiar to sailors. Atypical cases may sometimes confuse the diagnosis, as in all other definite morbid processes, but the differential diagnosis need only be established between it and a very few diseases. The one which resembles it most in external appearance is purpura hemorrhagica, but this disease has none of the special gingival manifestations, the deep hemorrhages into the substructures, nor the hard brawny feel in the lower extremities. In purpura the macules are brighter and the skin not involved is of a cleaner hue, and as a further difference the articular involvement in scurvy is much less marked than in purpura. Peliosis rheumatica (Schönlein's disease), nearly allied to purpura, may give rise to similar doubts of identity. In peliosis the purpuric spots are distributed over the entire surface, in contradistinction to what is observed in scurvy; there is hydrarthrosis of the joints in the upper extremity with general muscular pains, and there may be edema of the face and hands. The spongy condition of the gums does not obtain in peliosis, and the character of the eruption in scurvy differs from that of purpura hemorrhagica. Cases from ships hailing from ports where beriberi is endemic may require a careful differential diagnosis. In a suit for damages entered by the sailors against the ship for scurvy, the defence raised this point in answer and the writer acted as expert witness at the trial. In the edematous form of beriberi, where there is much emaciation, with swelling of the lower extremities, it is necessary to exercise careful scrutiny of the case with particular reference to conditions existing prior to presentation. There are no gingival symptoms in beriberi and the edema is different from the hard nodular feel in the legs of a scorbutic patient. It may be necessary, in cases involving litigation between seamen and vessel owners charged with furnishing improper food, and thus causing scurvy, to be able to eliminate the question of the syphilodermata and specific infection complicating the case. Such allegations are usually resorted to by defendants in these cases. It will only be necessary to mention the fact, as the differential diagnosis should be easy for the medical attendant.

Prognosis.—The mortality from scurvy should not reach five per cent., except in epidemics, military campaigns, or in exceptional conditions on shipboard. During the civil war the rate was sixteen per cent., which considerably exceeds that obtained in our marine hospitals. In the ordinary cases met on land a favorable termination may be expected as soon as the proper measures are instituted for correcting the diet. Recovery is naturally slow and sometimes weeks and months elapse, especially in the aged and feeble, before health is fully restored. In the grave cases seen on shipboard after long voyages, or after rescues from shipwrecks, the patients may succumb to exhaustion, hemorrhages, or some intercurrent affection, but cases which seem hopeless from their general appearance quickly rally under appropriate treatment.

Pathology.—From what has been said of the nature of the disease it can be readily surmised that the pathology is unimportant. There are no characteristic anatomical changes, beyond the subcutaneous hemorrhages and suffusions into the deep structures and occasionally into the viscera. These have already been referred to. There may be serous effusions into the pleura or pericardium, but the peritoneum is not so affected. Parenchymatous degeneration takes place in the internal organs. The stomach and intestines present the hemorrhagic patches common to the cutaneous surface. The blood flows from these suffusions, when cut, as in a living subject. The spleen is soft and quite constantly enlarged. The condition of the buccal cavity is merely that which was previously observed at the bedside. Microscopical examination of the gingival tissues has revealed nothing worthy of special mention.

Treatment.—Scurvy is a preventable disease, and therefore the question of treatment partakes of two phases, the prophylactic and the curative. The first may be applied in the case of ships about to proceed on long "deep-sea" voyages, whalers bound for the frozen sea, merchant ships sailing "round the Horn," or in the case of large institutions for the poor and indigent in which, for economical reasons, the diet must be restricted to the actual necessities. The United States statutes contain certain requirements respecting these matters. One relates to the supply of lime juice and vinegar (Sec. 4,569), which must be provided on voyages across the Atlantic or Pacific oceans or around Cape Horn or the Cape of Good Hope. The other (Sec. 4,612) defines what shall be the daily minimum of articles and quantities of food supplied, a not altogether satisfactory or scientific table. As each municipal institution for the care of the poor has a medical officer in attendance it will be incumbent upon him to advise the managers as to the quality and variety of food required for the proper nourishment of inmates, in order to avoid the occurrence of scorbutic symptoms among these ill-conditioned people. This can be accomplished by a judicious variation in the daily diet schedule. This diet should include not only fresh vegetables in season, but, what is equally to the point, fresh meat. In all almshouses there will be found a large proportion of persons laboring under the depressing influences of such places, persons in feeble condition or advanced life, who may confine themselves to a portion of the prescribed diet for a long period, and in whom scorbutic symptoms are inevitably set up. Osler cites a case of a woman who subsisted for many months on bread and tea, and it has been noted that in logging camps and among charcoal burners, where a diet of bread, molasses, and bacon is staple, scurvy will be found. The old maxim that "variety is the spice of life" is the keynote to the prophylaxis of scurvy when considering the dietetic question. It is not quantity nor quality, but variety that is the inviolable canon in the alimentation of mankind. Scurvy is not a disease of starvation, it is nature's revolt against lack

of dietetic balance. None of the professional "fasters" ever developed the characteristic signs of the disease.

The therapeutic indication in the curative treatment of scurvy is one of dietetics rather than of medication. When the patient is first seen he should be removed from the environment responsible for the condition, whether ship, house, or room, and given such benefits as arise from change of air and surroundings. If possible, a warm bath should be given and clean clothes and a clean bed provided. These attentions are possible if the case can be removed to a hospital. The first symptom that will claim attention in an advanced case is the spongy or bleeding condition of the gums and the consequent fetor of the breath. The relief of this is a preliminary to attractive alimentation and may be accomplished by the use of any of the mild antiseptics in the form of mouth washes. It is not necessary to enumerate them. The juice of a lemon, which possesses some astringent as well as other useful properties, is a simple and effective aid in this process. More pronounced astringents, as catechu or krameria, may be employed by brushing them on the spongy mucous surfaces. Alum may be applied in the form of a powder to small ulcerative patches, and a weak solution of lunar caustic, pencilled with a camel's-hair brush, enables the operator to reach such surfaces between the teeth.

Food is to be administered cautiously at first, and the first indication is the exhibition of fresh vegetables in the form of a strained soup. The condition of the gums and teeth may not permit the process of mastication. Lemons or limes can be given in the intervals between regular meals. Spinach, boiled, is an excellent form of vegetable, possessing highly nutritious qualities and having the advantage of softness in consistence. Sauerkraut, and vegetables used as "greens," with vinegar, are also valuable variants. To this basis may be added, as a change, fresh milk, and well-cooked beef, in judiciously graduated quantities. Occasionally the vegetable diet may be distasteful, paradoxical as it would seem, but it must be enforced until the condition of the patient shows its good effects in an improved color, increased strength, and general resumption of normal conditions. That a plan of tonic treatment is indicated need hardly be said. Iron in some form, preferably the citrate, or the tincture of the chloride, is an excellent medicament in scurvy. The use of potassium in one of its salts, to replace theoretically the loss of the vegetable potassium, as advocated by Garrod, an early authority on the disease, has not given very satisfactory results. If nausea and vomiting, due to a distaste for food previously constituting the patient's diet, be present they will soon cease after the proper alimentation is instituted; but if they continue they may be stopped by such gastric sedatives as bismuth, hydrocyanic acid, or the carbonated waters. The last named are preferable. If digestion be feeble, the bitter tonics—gentian, quassia, or strychnine—may give a necessary tone to this function. Constipation and its opposite condition, either of which may be present, are to be treated with care. The changed diet should be allowed to operate for a few days as a natural stimulus to normal action. According to my experience it may be expected to act in this way. Diarrhea, if persistent, needs some astringent, but constipation should cause but little anxiety. Intestinal hemorrhages require more active handling, and ergot, iron, lead acetate, or any approved hemostatic must be exhibited. Calcium chloride can be advantageously given in doses of gr. xx. t.i.d. for this condition. The stiffened joints should be treated with massage and passive motion. Gentle friction over the ecchymosed regions and at points where there are signs of deeper suffusions, will prove of benefit in promoting absorption. All treatment, however, beyond the dietetic, may be classed as symptomatic.

Infantile Scorbutus.—*General Considerations.*—Within the past few decades there has been added to the list of diseases, for the special consideration of pediatrists, the scurvy of infants, following prolonged artificial feeding. To a number of English physicians, notably Dr. Barlow, who reported thirty-one cases in 1883, our knowledge is originally due, and from this physician the disease has come to be known in medical literature as "Barlow's disease," from its first reporter. Since that period it has been the subject of special study by observers in Europe and America, and scarcely an issue of journals devoted to pediatrics is wanting in some reference to the disease, its etiology, pathology, or clinical history. The American Pediatric Society considered a lengthy report on the subject in 1891 made by Dr. Northrup, and among the conclusions of the author was this: "It is a significant fact that the country which furnishes most of the literature of scorbutus in children is the same which is posted from end to end with advertisements of proprietary foods." Indeed it may be said that the appearance of this disease has a close relation, chronologically, to the development of the industry of artificial feeding of infants.

Etiology.—Like scurvy in the adult, this disease of infancy is due to the continued use of an artificially prepared food which lacks some essential element required for nutrition. It is a disease found oftenest among the children of the rich and well-to-do, because in their homes are found the mothers who cannot, or will not, nurse their children, and who are able to provide themselves with prepared infant foods and the apparatus for the "pasteurization" of milk. It may be stated as a general proposition that infantile scurvy is a disease of affluence and rachitis a disease of poverty, for though having some general resemblance to each other, these affections are distinct. As scurvy is a disease due to improper feeding, it may be further said that neither age, sex, race, nor season has any causal relation to its manifestation. It may occur at any age, but is oftenest found in infants between the eighth and twentieth months, or during the period of the eruption of the teeth and before the child is put on the enlarged diet which follows the ability to masticate. Children who are fed on the bottle later than this may also have the disease. In nearly all the cases that have been reported the patient has been fed on some one of the following foods: Proprietary or cereal foods, condensed milk, peptonized milk, pasteurized milk, any of the cereals (as barley water), or milk too much diluted with water. Of these causes it seems pretty safe to say that the pasteurization process enjoined by many physicians and adopted by the laity as a tribute to bacteria, in the preparation of these various foods, is responsible to a great extent for the conditions which follow. From observations made in cases which have developed in infants it has been found that the scorbutic symptoms will begin to manifest themselves in from six to eight weeks after the institution of the improper diet. As in scurvy of the adult the exact etiological factor is still undetermined, but it would seem that fresh milk when ingested possesses antiscorbutic properties not unlike those possessed by the vegetable elements when administered to adults.

Clinical Symptoms.—An infant fed on artificial food, and especially on pasteurized (even conservatively for a half hour at 145° F.) cow's milk will begin to show according to the extended investigation of Hess and Fish, the general signs of systemic disturbance, pallor, restlessness, disinclination to be moved. This is followed by particular evidences of pain in the lower limbs, usually localized in the femur, and in an increasing immobilization of the legs as the disease progresses. The pains grow more intense, the knees are drawn up, held motionless, or rotated outward and fixed, simulating paralysis. It will be seen that there is a cylindrical swelling of the lower end of the

diaphysis of the femur, due to hemorrhagic suffusions into the subperiosteal space, either in one or in both thighs, and as a result in advanced cases this condition is often accompanied by fractures of the bone underneath. Swelling and softening of the gums present the typical scorbutic feature almost synchronously with the above condition, but this manifestation is not usually seen in infants in whom some of the teeth have not erupted, and this gingival symptom is usually most pronounced about the incisors or about the teeth that may have pierced through. The condition of the gums is the same as in adult scurvy, with this exception: If teeth are in the upper jaw and not in the lower, the latter will not show the spongy and bleeding and ulcerated condition surrounding teeth that are present in the former. This symptom is usually followed by another characteristic scorbutic sign—subcutaneous hemorrhagic suffusions showing purpuric spots and coalesced macules of greater or less size and the appearance of multiple tumefactions of the deeper tissues. The picture is not so different from that of the adult disease, viz., the ashen hue, the foul breath, the circles about the eyes, the swollen, tender joints, and the listless mental condition. There is no temperature characteristic of the disease unless it be subnormal. Examination of the blood affords no more satisfactory results than in adult scorbutus. Hemorrhages into the cavities of the body occur, and Hess claims that there is not only involvement of the circulatory system but enlargement of the right heart. That there is edema into the tissue not unlike the manifestation of beriberi, also a dietetic deficiency disease, is also pointed out by the investigator. Diarrhea is more frequent than constipation.

Diagnosis.—From the description above given the recognition of this disease in a developed case should not be difficult. It may be confounded in the early stages with rheumatism, rachitis, purpura, acute anterior poliomyelitis, infantile paralysis, and possibly syphilis. The first named may offer the greatest field for error. In rheumatism the joint itself is affected; while in scurvy the tissues about the joints, especially the knee, are involved. In scorbutic hemorrhages the blood escapes practically always into the diaphysis of the long bones. With proper protection of the femur the knee-joint can be moved without discomfort in scurvy. The differentiation from purpura is made in the same way as it is in scurvy of the adult type. In purpura the maculations are more evenly distributed over the entire surface, in scurvy the lower limbs are mostly affected. In infantile paralysis and poliomyelitis the immobility of the limbs is due to palsy of the muscles, while the failure of movement in scurvy is because of pain. The disease may be distinguished from rachitis by the absence of the rosary and by the typical skeletal signs of that disease. The characteristic scorbutic signs in the gums should always enable the observer to exclude rachitis from the problem. Dietetic treatment will usually settle a diagnosis in a few days. Other diseases to be borne in mind are hemophilia, erythema nodosum, leucemia, and local periostitis.

Pathology.—The special lesions found postmortem are those relating to the hemorrhages occurring in the course of the disease, but differ in no way from those observed in the adult type. Up to the present time no characteristic signs have been found which add to our knowledge of the pathology of the disease.

Treatment.—Being a preventable disease it has its prophylaxis as well as its cure. The first relates to the use of proper food. If a child must be given artificial alimentation, it is necessary that it have the nearest succedaneum to human milk that can be readily procured. This to a certain extent involves the whole question of infant feeding, which cannot here be considered. This much may be said, that cow's milk is the best substitute because the cheapest and most easily procured, as well as because it contains all the necessary elements. The proportions of the constituents differ from those of human milk, but a scientific effort to "follow nature" has not been productive of happy results. Properly diluted with water and raised to a moderate degree of heat, not over 140° F., for ten or fifteen minutes, cow's milk is the most available and natural food for infancy. This heat will effectually dispose of all bacteria that need give cause for anxiety. The effect, upon milk, of heat sufficient to pasteurize it has the apparent effect of rendering the antiscorbutic properties inert. Milk is a delicate complex form of protoplasm, and the effects which "pasteurization" produces upon the caseinogen, nucleins, and the calcium salts by which their combinations are disturbed, have undoubtedly to do with their efficiency as antiscorbutic agencies. This much has been learned by practical experience and points the way to the preventive treatment of the disease.

The curative treatment is upon the same order as that of the adult type—the restoration of the food that the infant has been deprived of, viz., *fresh* milk in properly diluted form. This milk may be given in alternation with a teaspoonful or two of orange juice every hour throughout the day. This is our most efficient antiscorbutic as well as the most easily obtained and most palatable. The expressed juice of the rind prepared with sugar is equally satisfactory and in large institutions is to be considered as an economical factor in the treatment of infantile scurvy. Raw beef juice, salted, may be used for a change, and barley water can afford a satisfactory alternative. But the main reliance must be upon fresh milk fed with due consideration to the condition of the infant's digestive apparatus. All other forms of treatment are symptomatic and need not be detailed. As in the adult type the most desperate cases, so far as may be judged from external signs, recover rapidly when proper food is furnished. CHARLES E. BANKS.

Scutellaria.—SKULLCAP.—The dried herb, *Scutellaria lateriflora* L. (fam. *Labiatæ*). This genus consists of bitter perennials, nearly destitute of the aromatic properties found in most species of this large family, and further distinguished by a peculiar helmet-like development of the upper sepal, to which it owes its name.

The drug is thus described:

Dark green, smooth, or slightly puberulent on the younger portions, the branches elongated, slender, sharply quadrangular; leaves opposite, exstipulate, shortly petioled, the blades rarely exceeding eight centimeters (three inches) long and about a third as broad, ovate, rounded or truncate at the base, acuminate, obtusish or acutish, shortly and obtusely serrate, thin, veiny; flowers in axillary, peduncled, mostly simple and secund racemes, nearly sessile, about six millimeters (one-fourth inch) long, the calyx bilabiate, in fruit becoming closed and developing a large helmet-shaped crest, the corolla deep blue, bilabiate, the stamens didynamous, ascending under the upper lip of the corolla; fruit of four depressed, globose, papillose nutlets.

So-called "Western scutellaria," more or less rough gray hairy and with much larger flowers, in terminal panicles, is not of this species.

S. galericulata is often substituted. Its flowers are solitary in the leaf-axils.

Skullcap contains a very little volatile oil, and its bitter principle has been called *scutellarin.*

The Scutellarias have had from time to time some transient or popular reputation in medicine for the cure of mad-dog bites, chorea, epilepsy, or other nervous diseases; also as tonics, antiperiodics, etc. The species here described is considerably used by the eclectic school of practitioners and in home medication. It is reputed to be antispasmodic, anticonvul-

sant, etc., and is given for restlessness and wakefulness. It certainly possesses bitter tonic and mildly laxative properties. H. H. Rusby.

Scutigeridæ.—A group of peculiar myriapods in which the antennæ are at least as long as the body; faceted eyes are present. These are the house centipedes, which sometimes occur in the human body as parasites in the nasal cavities or the intestine. See *Arachnida*. A. S. P.

Sea-bathing.—See *Thalassotherapy*.

Seattle, Washington.—Situated on Puget Sound, this city together with Tacoma, some thirty miles south on the same body of water, may be taken to represent the somewhat peculiar climate of this region.

There are two distinct and widely differing climates in the State of Washington represented by the two unequal divisions of the State, made by the Cascade range of mountains, which run north and south. To the west of this range is a region of "abundant rainfall, cool summers, and mild winters," and it is for the most part thickly wooded. The eastern—the larger division—is a region of "moderate (over much of its area scanty) rainfall, hot summers, cold though not severe winters, and the greater portion of it is treeless." West of the Cascade range is the wet region, and east of it is the dry region. The clouds and storms coming from the Pacific Ocean precipitate a large part of their moisture on the western slopes of the mountains, and the air reaching the eastern slopes is both dryer and blows over a region that has a greater capacity for moisture.

The wet and dry regions can again be divided into the "moist and very wet, and the semi-arid and dry." The wet district lies between the ocean and the summit of the Coast Range and Olympic Mountains. It has a rainfall of 60 to 120 inches annually, seventy-five per cent. of which occurs during the so-called wet season, from November to April inclusive. The moist district occupies the Puget Sound basin between the Olympic and Cascade Mountains, and has a precipitation of 25 to 60 inches annually, three-fourths of which occurs in the wet season from November to April. The dry district, comprising the eastern and northern portions of the state, has a precipitation from rain and snow of 12 to 25 inches annually. The very dry and semi-arid district occupies the central portion of the state east of the Cascades, and has everywhere a precipitation from rain and snow combined of less than 12 inches annually.

The climatic characteristics of the moist district—the Puget Sound basin—are represented by the following table of observations taken at Seattle lying in this region:

As is seen from the above, the annual mean temperature (52°) is one which shows a temperate climate, and one of comparative uniformity throughout the year; the average for the summer (63°) being noly 21° lower than that of winter (42°).

The following table gives a comparison of the temperature of Seattle with that of various other cities in the U. S. which have nearly the same mean annual temperature.

Mean Annual and Seasonal Temperatures

	North latitude.	Spring.	Summer.	Autumn.	Winter.	Annual.
Seattle.....	47°, 38′	50°	63°	52°	42°	52°
Boston.....	42°, 21′	46°	69°	53°	29°	49°
New York...	40°, 43′	49°	72°	55°	32°	52°
Washington.	38°, 54′	53°	75°	57°	35°	55°
Chicago.....	41°, 53′	46°	70°	52°	26°	48°
Denver.....	39°, 45′	48°	70°	51°	31°	50°
Spokane.....	47°, 40′	48°	66°	48°	29°	48°

From the above it will be seen that although Seattle lies considerably to the north of the other cities, with the exception of Spokane, and has, as has been said, about the same mean temperature, it is quite considerably warmer in winter, and cooler in summer, and throughout the year it is markedly more equable.

The next table gives a comparison of the humidity, precipitation, and sunshine of the above cities.

As will be seen, the relative humidity at Seattle is somewhat higher, especially in the autumn and winter, than in the other cities, and very much more so than in Denver and Spokane. In the summer, however, it is about the same as that of the other cities, except the two exceptionally dry ones above mentioned. The annual precipitation is lower than that of Boston, New York, and Washington, but higher in the winter; three-fourths of the precipitation, as has been said, occurring from November to April. The percentage of sunshine is considerably less than in any of the other cities, especially in the winter months. From the foregoing, then, we can sum up the climatic characteristics of Seattle as follows: The temperature is moderate throughout the year, and quite equable. The winter is comparatively mild, but there is much rain at this season, and the humidity is high. There is a marked lack of sunshine in the colder months of the year. The summer is cool, and there is no extreme heat.

The city of Seattle itself is a very flourishing modern one with a population of 286,322 (census 1912). It is well governed and its sanitary system is most

Climate of Seattle, Washington Lat. 47° 38′ N.; Long. 122° 20′ W. Elevation 40 Feet.

From U. S. Weather Bureau Observations.

	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Spring.	Summer.	Fall.	Winter.
Temp. (degrees Fahr.)—																	
Average or normal.....	41°	42°	45°	50°	55°	60°	64°	64°	58°	52°	46°	43°	52°	50°	63°	52°	42°
Mean of warmest	45°	47°	52°	58°	64°	69°	73°	74°	66°	58°	50°	47°	59°	58°	72°	58°	46°
Mean of coldest.....	36°	36°	38°	42°	47°	51°	54°	55°	51°	46°	41°	38°	45°	42°	53°	46°	37°
Average daily range.....	9°	11°	14°	16°	17°	18°	19°	19°	15°	12°	9°	9°	14°	16°	19°	12°	9°
Highest or maximum....	62°	67°	81°	85°	92°	96°	91°	92°	87°	81°	68°	62°	96°				
Lowest or minimum.....	3°	4°	20°	32°	37°	41°	46°	46°	36°	31°	15°	26°	3°				
Humidity—																	
Average relative, per cent	84.5	79	75	71	71.5	69	67.5	70.5	75.5	81.5	83.5	84.5	76	72.5	69	80.5	83
Precipitation—																	
Average in inches.....	4.3	4.0	3.5	3.0	2.3	1.6	0.8	0.5	2.1	2.7	6.3	5.9	37.0	8.8	2.9	11.1	14.2
Wind—																	
Prevailing direction.....	S. E	S. E.	S.	S. E.	S. E	S. E.	N. W.	W.	S. E.	S. E.	S. E.	S. E.	S. E.	S. E.	S.	S. E.	S. E
Weather—																	
Av. No. hours of sunshine	65	111	170	207	230	247	299	254	182	118	43	47	164	202	267	115	74
Percentage of.....	23	29	46	50	49	52	62	57	48	35	16	18	41	48	57	33	27

SEASONAL AND ANNUAL RELATIVE HUMIDITY, PRECIPITATION, AND PERCENTAGE OF SUNSHINE.

	Spring.			Summer.			Autumn.			Winter.			Annual		
	Humidity relative, per cent	Precipitation, inches	Percentage sunshine.	Humidity	Precipitation.	Sunshine.	Humidity.	Precipitation.	Sunshine	Humidity	Precipitation.	Sunshine.	Humidity.	Precipitation.	Sunshine.
Seattle	72.5	8.8	48	69.0	2.9	57	80.5	11.1	33	83.0	14.2	27	76.0	37.0	41
Boston	68.5	11.2	54	73.0	10.5	60	75.0	11.1	54	71.5	10.9	53	72.0	43.7	55
New York	70.0	10.6	56	74.0	12.3	59	75.0	10.8	54	73.0	11.1	54	73.5	44.8	56
Washington	68.5	11.1	52	75.0	12.5	64	76.0	9.4	60	71.5	10.1	51	73.0	43.1	57
Chicago	74.0	8.7	59	71.5	10.1	69	73.0	8.2	55	82.0	6.4	46	75.0	33.4	57
Denver	51.0	5.4	65	48.5	4.4	68	46.0	2.2	74	54.0	1.7	69	50.0	13.7	69
Spokane	60.5	4.1	57	46.5	2.7	73	67.0	4.7	52	82.0	6.8	25	64.0	18.8	52

efficient. The water supply is abundant and good and is very carefully guarded. Besides a sewage system which serves the thickly settled portion of the city and empties into Puget Sound, there are septic tanks and other sanitary devices for the safe disposal of the sewage and garbage. There is a careful supervision of stables, public markets, restaurants, bakeshops, etc., and as a result the fly is said to have been practically eliminated. By a city ordinance, every individual coming in contact with food products must obtain from the Commissioner of Health, or an accredited representative, a health certificate stating that he is free from communicable disease. The milk supply is safeguarded by regular inspection by the Department of Health of every dairy sending milk into the city. To the excellence of the milk supply and the absence of hot weather is attributed the very low death rate among infants, which is said to be less than one-third of the similar death rates in many eastern cities. The general death rate for 1912 was 8.53 per thousand, and in 1910 it was 10.4, which was lower than any other city in the United States or Europe, Los Angeles coming next in this country with a rate of 14.0; and London in Europe with a rate of 12.7. The number of deaths from zymotic diseases is small. An interesting fact in connection with the sanitary management of the city is the precaution taken against the entrance of the bubonic plague in the destruction of rats, over 50,000 having been killed in 1911. There are medical inspection of schools, with school nurses, a city hospital, with free medical and dental dispensary, and a new and complete tuberculosis sanatorium. With an intelligent public opinion and an efficient department of health and sanitation, Seattle appears to be an ideal city in the maintenance of the health and well-being of its inhabitants and the avoidance of disease.

Seattle is well built with many fine buildings, parks, play-grounds, drives, and boulevards. The University of Washington is located here. The harbor, situated on an arm of Puget Sound, 125 miles from the ocean, is extensive and deep, and from here come and go vessels to Alaska, Oregon, California, and across the Pacific to Asiatic ports. Many railroads also enter the city or have their terminus here. Many attractive excursions can be taken from Seattle: by water or land to Tacoma; by automobile to Mt. Tacoma-Rainier and Ranier National Park; by boat to Victoria; to the ocean down the Sound; to Alaska, and others. One can either end or begin that wonderful trip across the Canadian Pacific R. R. at Seattle.

The accommodations are such as are offered by any large modern city. EDWARD O. OTIS.

Seasickness.—See *Naupathia.*

Sea Voyages.—See *Thalassotherapy.*

Seborrhea.—See *Dermatitis Seborrhica.*

Secretin.—If a hydrochloric acid extract of the intestinal mucosa is introduced into the blood stream a flow of pancreatic juice follows. The active substance present has been called secretin and treatment with acid is essential since in the intestine the substance is ordinarily (that is in the absence of acid) inactive. In the inactive form it is known as prosecretion. It is believed that the natural excitant of pancreatic juice flow is secretin. The acid of gastric digestion enters the duodenum, comes into contact with prosecretin, transforms it into an active state, absorption follows and the absorbed secretin acts specifically upon the pancreas. Secretin is not an enzyme as it loses none of its activity upon boiling. See also *Pancreatic Juice.*

F. P. U.

Secretion, Physiology of.—By secretions we mean the products of the activity of gland cells. Usually these products are liquid or semi-liquid in character. In recent years a distinction has been made between internal and external secretions. By the latter term we designate a secretion that is discharged upon a free epithelial surface that communicates with the exterior. Such, for example, are the secretions of the glands of the skin or of the mucous membrane of the alimentary or respiratory tract. The name internal secretion is used to designate those secretions that are discharged into the blood or the lymph. The term is used especially in connection with the so-called ductless glands, such as the thyroids or the adrenal bodies, but it happens that in some cases a gland possessing a duct may form an internal as well as an external secretion. A good example of this combination of functions is found in the case of the pancreas. The external secretion of the pancreas, the pancreatic juice, is emptied through its duct into the duodenum, while its internal secretion, of an unknown character chemically, is discharged into the blood. As will be described later, the two secretions in this case are formed in all probability by two different kinds of gland cells. It will be convenient to consider these two kinds of secretion separately.

EXTERNAL SECRETIONS.

The composition of the external secretions varies greatly, but in general we may say that they consist of water, inorganic salts, and certain organic constituents. The organic elements in the secretions have aroused the greatest interest since they may be characteristic of the secretion. They are found in some instances (for example, the urea of the urine) preformed in the blood, and the function of the gland cell is a selective one, picking out this particular constituent and discharging it into the lumen of the gland. In other cases the organic element is not present in

the blood or lymph, and must therefore be formed within the substance of the gland cell. In both cases there is a general agreement, speaking broadly, that the gland cells take an active part in the secretion and that the production or elimination of the organic products involves the expenditure of energy on the part of these cells. We picture this energy as dependent upon the chemical changes, the metabolism within the gland protoplasm, and naturally the character of these changes may vary greatly. General theories of secretion have concerned themselves chiefly with the physiological mechanisms by which the secretion is excited, and the means by which the inorganic constituents of the secretion are produced, whether in response to purely physical forces such as filtration, osmosis, and diffusion, or by means of unknown activities of the living protoplasm. The general nature of the theories proposed and the modifications suggested for the different secretions can be given best by describing the physiology of the most important secretions.

Secretion of the Salivary Glands.—Under the designation salivary glands we must include all the glands whose ducts open into the mouth cavity and whose secretions contribute to the formation of the saliva. Ordinarily, however, the term is applied to the three large pairs of glands, the parotid, the submaxillary, and the sublingual. The duct of the parotid, duct of Stenson, opens opposite the second molar tooth of the upper jaw; the duct of the submaxillary, duct of Wharton, opens at the side of the frenum of the tongue; the duct or rather ducts of the sublingual, open into the floor of the mouth and are usually known as the ducts of Rivinus; although in some animals, and sometimes it is said in man, one of these ducts, the duct of Bartholin, may be especially conspicuous and runs parallel with the duct of Wharton. The portion of this gland which empties into the mouth by the duct of Bartholin is designated by Ranvier by the separate name of the retrolingual gland. Histologically these large glands show certain differences in structure. The secreting cells of the

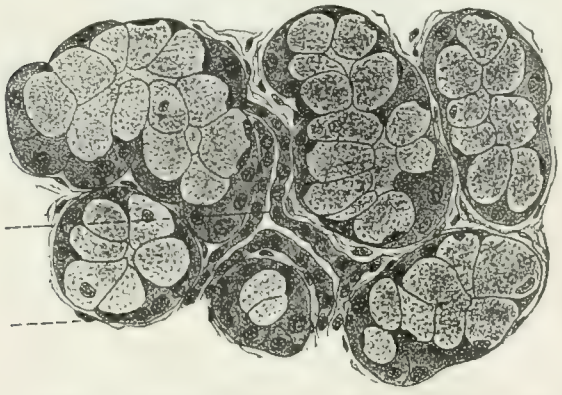

Fig. 4478.—A Section through the Human Sublingual Gland. (Böhm-Davidoff.)

alveoli may belong either to the albuminous or to the mucous type. In the former the cells are relatively small and densely granular in appearance, so that in fresh sections of the living gland the outlines of the individual cells cannot be distinguished readily. In the mucous type the secreting cells are larger and much clearer. In the living condition they present a homogeneous ground-glass appearance, but on appropriate treatment display a few large granules much less opaque than those in the albuminous cells. These two types of cells may be found in the same gland or even in the same alveolus: but, speaking generally, the parotid in man contains chiefly albuminous cells, and the submaxillary and especially the sublingual, chiefly mucous cells. This difference in histological structure is associated with a chemical difference in the secretion. The saliva from the submaxillary and the sublingual contains mucin and is thick and stringy, while the parotid saliva, although it contains some albumin, is free from mucin and is thin and limpid. Each of these glands receives a double nerve supply, one set of fibers coming from the cervical, sympathetic and the other directly from the cranial nerves. The parotid receives its cranial nerve fibers by a very indirect path. In the dog in which their course has been worked out experimentally the fibers arise from the brain in the glossopharyngeal, pass into the tympanic branch of this nerve, also known as the nerve of Jacobson, and thence to the small superficial petrosal through which they reach the otic ganglion. In branches from this ganglion they pass to the auriculotemporal branch of the inferior maxillary, and thence by several small branches to the gland. This path is supposed to involve two nerve units, the first which may be designated as the cranial or preganglionic neurone ending in the otic ganglion; the second, the sympathetic or postganglionic neurone, arising in the otic ganglion and ending in contact with the gland cells. The cranial fibers for the submaxillary and sublingual are found in the chorda tympani nerve. They arise with this nerve from the facial and pass with it to join the lingual branch of the inferior maxillary. After running in the lingual for a short distance the secretory (and vasodilator) fibers branch off in several small strands which pass toward the hilus of each gland following the course of the ducts. This path also involves two nerve units. The cranial or preganglionic neurone ends in nerve cells of the sympathetic type, which, in the case of the submaxillary, are found in its hilus or along the duct, while in the sublingual they form a collection, conspicuous enough to be seen with the eye, and located in the angle made by the strands of fibers as they leave the lingual nerve. This collection of nerve cells was formerly designated as the submaxillary ganglion, but since Langley has shown by the use of the nicotine method that they are intercalated in the course of the nerve path to the sublingual gland, it is more appropriately named the sublingual ganglion. These sympathetic cells constitute the second or postganglionic neurone which ends in the gland cells. The sympathetic nerve supply to the three glands is in general the same. The fibers emerge from the spinal cord in the upper thoracic nerves, pass over to the sympathetic chain in the corresponding rami communicantes, ascend in the neck in the cervical sympathetic, and terminate, so far as the first neurone is concerned, in the cells of the superior cervical ganglion. From this ganglion sympathetic neurones pass out in strands that form a plexus in the coats of the arteries supplying the glands. These fibers are usually stimulated while in the cervical sympathetic or by applying the electrodes to the superior cervical ganglion.

Composition of the Saliva.—The saliva of the mouth consists, or may consist, of the mixed secretions from the large salivary glands together with the secretions of the small unnamed glands of the buccal mucous membrane. In addition to accidental constituents, such as epithelial cells, it contains mucin, a small proportion of albumin, an amylolytic enzyme known as ptyalin, and inorganic salts. The saliva of each gland may be collected separately by inserting a cannula into its duct. By this means it can be shown that the secretion of each gland has its own characteristics, the parotid saliva, for instance, being free from mucin, while the sublingual and the submaxillary saliva have varying proportions of this substance, but contain little or none of the ptyalin. Experiments by Pavlov indicate that the secretion of each gland may be excited differently under normal

conditions. He found that in dogs the submaxillary secretion is readily excited by sapid bodies in the mouth or by the sight or smell of food, while the flow of parotid saliva is especially marked when dry substances are placed in the mouth.

Secretory Nerves.—The discovery that these glands are supplied by secretory nerve fibers, we owe to Ludwig. In 1851 he found that stimulation of the lingual nerve causes a flow of saliva from the submaxillary gland. Bernard showed that the fibers in question belong to the chorda tympani, and discovered in addition that during the stimulation of this nerve there is a greater flow of blood through the gland. We now know that the chorda tympani conveys both secretory and vaso-dilator fibers to the submaxillary and sublingual. The natural suggestion that the increased secretion on stimulation of this nerve is due to the greater blood flow has been disproved by a series of experiments. It has been found, for instance, that after administration of atropine stimulation of the nerve is followed by a vascular dilatation without any secretion, and, on the other hand, that injection of quinine may cause a dilatation of the vessels without a secretion, which, however, is readily obtained if the nerve is stimulated. Evidently the glands possess true secretory fibers capable of starting and maintaining a secretion from the gland cells. It was found, subsequently, that stimulation of the cervical sympathetic nerve gives a small flow of saliva which is characterized by its large amount of solids and by the fact that during the stimulation the blood flow through the gland is diminished in consequence of the simultaneous stimulation of vaso-constrictor fibers. Corresponding to these facts, Heidenhain found for the parotid gland that stimulation of the cranial nerve fibers in the nerve of Jacobson, gives an abundant secretion of thin saliva, while stimulation of the cervical sympathetic gives little, or, in the case of the dog, no secretion. In the latter case, however, it was discovered that stimulation of the sympathetic fibers has an effect on the gland, although no visible secretion is produced. Sections of the gland, for instance, after such a stimulation show that the lumina of the alveoli and the ducts are distended with secretion, and if the cranial fibers are stimulated simultaneously with or subsequently to that of the sympathetic fibers, the secretion that forms instead of being thin and watery is thick, and on chemical examination shows a much larger percentage of solid matter. We are justified therefore in stating for all the salivary glands that each receives a double nerve supply, and that the sympathetic saliva, as it is called, is much smaller in amount and much richer in solids than that obtained by stimulation of the cranial fibers, the chorda or tympanic saliva. The physiological significance of this double supply of secretory fibers is not understood at present. The evidence that we have shows that reflex stimulation of these glands takes place through the cranial fibers alone, and, on the other hand, that injury to or experimental section of the cranial fibers is followed by a loss of function of the glands. In what way the sympathetic nerve supply participates in their functional activity is not explained.

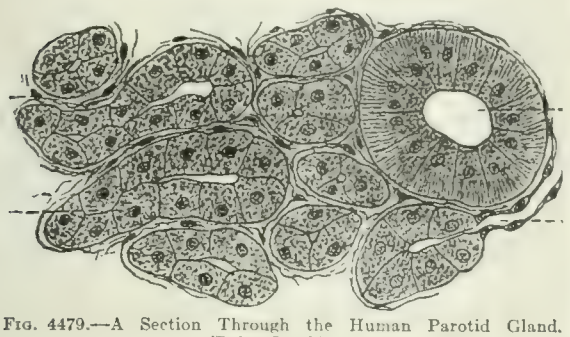

Fig. 4479.—A Section Through the Human Parotid Gland. (Böhm-Davidoff.)

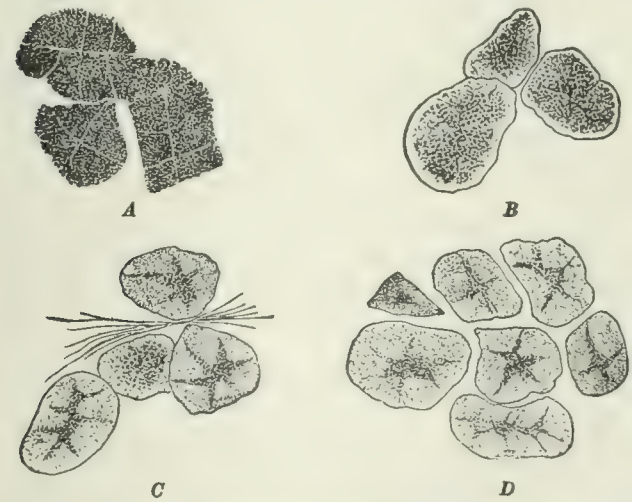

Fig. 4480.—Parotid Gland of the Rabbit in a Fresh State, showing Portions of the Secreting Tubules. *A*, In a resting condition; *B*, after secretion caused by pilocarpine; *C*, after stronger secretion, pilocarpine and stimulation of the sympathetic; *D*, after long-continued stimulation of the sympathetic. (Langley.)

Relation of the Secretion to the Strength of the Stimulus.—As in the case of the neuromuscular apparatus, it is found that the extent of the secretion varies with the intensity of the stimulus, or, in other words, we can get a series of submaximal secretions by varying the stimulation. The experiments upon this relationship have been made in connection with the cranial nerve supply. According to Heidenhain, the quantity of water and the percentage amount of inorganic salts increase as the stimulus increases up to a certain maximum, while the percentage amount of organic substances shows a more variable relation. If the gland is unfatigued at the beginning of the experiment the proportion of organic substances increases rapidly as the stimulus grows, but the maximum reached is not maintained if the stimulation is continued. On the contrary, continued stimulation may give a saliva containing less and less of the organic constituents, although the water and salts may continue to show a maximal proportion. The absence of parallelism under these conditions led Heidenhain to conclude that the conditions controlling the secretion of the organic material are different from those governing the formation of the water and salts. This conclusion is expressed in his theory of salivary secretion which will be mentioned briefly below.

Normal Mechanism of the Secretion of Saliva.—The secretion of saliva may be excited reflexly by stimulation of various sensory nerves, particularly those of the mouth. The action in this case is, of course, reflex, and, as said above, the efferent path to the glands is through the cranial fibers, for if these fibers are cut a reflex secretion cannot be obtained. Although this reflex secretion may be obtained by electrical stimulation of the sensory nerves of the mouth, it may be produced most easily and abundantly by the chemical stimulation caused by sapid substances. We may assume therefore that under normal conditions the sapid substances of the food

stimulate the sensory endings of the lingual and glossopharyngeal nerves in the mouth cavity and start afferent impulses to the medulla which reflexly stimulate the motor cells giving origin to the cranial secretory fibers. We have abundant evidence that the same motor cells may be stimulated reflexly through other sensory paths. The idea of food, for instance, or the sight or smell of agreeable food to a hungry person may make the mouth water, and, on the other hand, gastric irritation may give the same reaction, as is shown by the disagreeable flow of saliva that accompanies an attack of nausea. Under normal conditions the large salivary glands in man secrete only when reflexly stimulated; the secretion in other words is not continuous but is dependent on stimulation through the nerves. Since, however, the mouth cavity is always more or less moist even in sleep, it is probable that there is a continuous secretion from the smaller unnamed glands embedded in the buccal mucous membrane.

Histological Changes in the Gland during Secretion.—Much experimental work has been done upon the changes in microscopic appearance of the gland cells during secretion. This work was of great importance in proving that the gland cells take an active part in the secretion. Sections made of the fresh or of the hardened gland show that after prolonged secretion the gland cells are smaller than in the resting state. Moreover, in the gland at rest granules are formed within the cells, and during active secretion these granules slowly disappear. The most interesting observations are those made by Langley on sections from the living gland. He finds that in the parotid gland the cells during the resting stage are densely granular throughout. As the gland is made to secrete the granules begin to disappear first from the outer border, and after prolonged stimulation they may disappear almost entirely, the few that are left being clustered round the margin of the cells bordering on the lumen. In the mucous glands the granules are larger and clearer and much less numerous. They swell and disappear on the addition of water, and it may be assumed that they represent the mucin found in the secretion, or a preparatory material which during secretion is dissolved by the water formed, and is thus discharged from the cell.

Action of Atropine, Pilocarpine, and Nicotine on the Salivary Glands.—The three alkaloids named exert an interesting and typical action on the secretion of the salivary glands. Atropine injected into the circulation or into the gland directly through its duct will destroy its power of secretion. The gland cannot be made to secrete either by direct or by reflex stimulation. Inasmuch as the gland refuses to secrete when the stimulus is applied directly to the hilus, we may conclude that the action of the drug is either upon the gland cells themselves or upon the ending of the nerve fibers in their cells. Since stimulation of the sympathetic nerve supply may produce the usual flow of sympathetic saliva, we may conclude that the gland cells are still functional, and that the effect of the atropine is to paralyze the endings of the cranial secretory fibers. Pilocarpine or muscarine has a directly opposite effect. In proper doses each sets up a continuous secretion of saliva, and this effect may be prolonged by repeated injections of the drugs. It is assumed that these alkaloids stimulate chemically the endings of the nerve fibers in the gland cells. Atropine and pilocarpine exhibit toward these and many other glands the same antagonistic action that they exert upon the inhibitory nerve fibers of the heart. The action of nicotine has been studied chiefly by Langley. He finds that injection of this alkaloid causes first a slight stimulating effect followed soon by a temporary paralysis of both the cranial and the sympathetic fibers. After the stage of paralysis is reached it is found that stimulation of the second or postganglionic neurone of each path will give the customary secretion. It would seem from this result that the nicotine paralyzes the connection between the first or preganglionic and the second or postganglionic neurone. This action of nicotine takes place for other kinds of nerve fibers in which the path involves the union of a cerebrospinal with a sympathetic neurone.

Paralytic Secretion.—After section of their cranial nerve supply, chorda tympani and nerve of Jacobson, the salivary glands give a slow continuous secretion which may keep up for several weeks. Eventually, however, the glands undergo atrophy and lose their normal structure in spite of the fact that they still possess a connection with the central nervous system by way of the sympathetic nerve fibers. This paralytic secretion occurs only when the cranial secretory fibers are destroyed, injury to the sympathetic supply alone has no such effect. The cause of the continuous secretion is not evident. Langley is inclined to the view that it is dependent upon a continuous excitation of the nerve cells within the gland, the postganglionic neurone. Section of the chorda, or the nerve of Jacobson, would be followed in a few days by a total degeneration of the preganglionic neurone, but the second or postganglionic neurone would probably retain its structure and irritability for some time. Langley's view is not very satisfactory, inasmuch as it throws no light on the nature and origin of the supposed excitation.

Theory of Salivary Secretion.—Some of the constituents of saliva, *e.g.* mucin and ptyalin, do not occur in the blood and must therefore be formed within the gland cells as a result of a special metabolism. The histological changes in the gland cells during secretion corroborate this conclusion. Heidenhain has suggested the hypothesis that the metabolism giving rise to the organic products in the secretion is under the control of a special variety of the secretory fibers for which he proposed the name of trophic fibers. A second set of fibers which he designated as secretory fibers proper control the formation of the water and salts. The action of the trophic fibers is readily understood. Like the motor fibers to the muscles, their impulses set up katabolic changes which result in the formation of mucin, ptyalin, and the peculiar proteid found in the secretion. The action of the fibers supposed to control the production of the water and salts is more difficult to explain. When the gland is at rest there is no flow of water through the gland cells from the blood and lymph. In this condition therefore the protoplasm of the cells is impermeable to the water and salts. When the secretory fibers are stimulated the flow begins promptly, and we might suppose that the action of the impulses conveyed by the nerve fibers causes a physical alteration in the gland cells, in consequence of which they become permeable to the water and salts. Since, however, under continuous stimulation of the secretory fibers the hydrostatic pressure in the occluded ducts may exceed the pressure in the capillaries and arteries, it is evident that mere filtration through the cells will not explain the flow of water. There must be some substance within the gland cells possessing a high osmotic pressure and capable therefore, if we may use the expression, of attracting the water. Heidenhain makes such an hypothesis. He assumes that normally the gland cell at rest contains water under tension in consequence of the osmotic pressure of its substance, but that this water cannot escape into the ducts in consequence of the impermeability of the limiting layer of the cells bordering upon the lumen of the alveolus. The effect of the secretory impulses is to alter the structure of this limiting layer so as to make it permeable, and the stream of water and salts will continue as long as this permeability is maintained. It would seem necessary for the completeness of the hypothesis to assume that the border of the cells resting upon the basement

membrane is constantly permeable to the water, but only in one direction, that is, from the lymph toward the interior of the cells. Langley is inclined to believe that the hypothesis of two kinds of nerve fibers is unnecessary, and that it is preferable to assume that one and the same set of fibers may cause the katabolic changes leading to the formation of the organic products and at the same time control the flow of water and salts. On the histological side it may be said that there is no indication of two kinds of fibers or two sets of nerve endings in the gland.

The Secretion of the Pancreas.—The pancreas has much the same general histological structure as the salivary glands. The alveoli contain granular cells belonging to the albuminous type, but characterized in the resting stage by a clear non-granular zone on the basal side. The histological changes during secretion are especially distinct and resemble those described for the parotid gland. During active secretion the size of the cells is diminished, the granules disappear from the basal side, and the non-granular zone extends farther toward the inner margin of the cells. In the resting stage, on the contrary, granules are again formed within the cells, and the non-granular zone is reduced in size. Physiological evidence indicates that the granules within the cells consist of a preparatory material from which the several enzymes of the secretion are formed, and they are therefore designated usually as zymogen granules. In addition to this type of cell, which is undoubtedly responsible for the formation of the pancreatic secretion, the pancreas contains an entirely different kind of cell found in groups that are known as the islands of Langerhans. These cells seem to be connected with the production of the internal secretion of the pancreas, and will be described more fully under that head. The chief duct of the pancreas in man, the duct of Wirsung, opens into the duodenum together with the common bile duct at a distance of eight to ten centimeters below the pyloric orifice. The nerves of the pancreas are derived from the solar plexus, but physiological experiments indicate that ultimately the gland receives nerve fibers from two sources, the vagus and the sympathetic nerves.

Composition of the Secretion.—The pancreatic secretion is an alkaline liquid, which in some animals is clear and limpid and in others thick and glairy. From a physiological standpoint the most important constituents are the enzymes of which three or four have been described. These are trypsin, a protein-splitting enzyme; lipase, a fat-splitting enzyme; amylopsin or amylase, a starch-splitting enzyme, and in some animals rennin, a milk-curdling enzyme. The strong alkaline reaction of the secretion is due to sodium carbonate. A number of organic substances may also be present in small amounts, such as albumin, peptones, leucin, tyrosin, xanthin, soaps, and fats.

Secretory Nerve Fibers.—Direct observations on animals like the dog, in which the processes of digestion are not continuous, have shown that the flow of pancreatic juice is intermittent and related to the periods of digestion. This fact would indicate that its secretion, like that of the salivary glands, is caused by reflex stimulation. Direct experimental attempts to prove the existence of secretory fibers were unsuccessful until the beautiful work done by Pavlov and his pupils. These workers found that stimulation of the peripheral end of the cut vagus or splanchnic under proper conditions causes a secretion of the juice. The latent period between the stimulation and the beginning of the flow from the pancreatic duct is quite long, from three to five minutes, and has been explained on the hypothesis that the nerves stimulated carry secretory as well as inhibitory fibers, both of which would be stimulated by the method used. The existence of inhibitory fibers is made probable also by the fact that when a secretion is in progress stimulation of the peripheral end of the cut vagus may bring the flow to a standstill. If the existence of both secretory and inhibitory fibers to the gland be accepted, recent work, which will be described in the following paragraph, makes it probable that these nerve fibers have only a regulating control over the secretion. Even when all the extensive nerve connections are severed the gland may secrete in connection with the digestive processes. Unlike the salivary gland the secretory fibers from the central nervous system are not apparently essential to secretion, but regulate it after the manner that the extrinsic nerves regulate the movements of the stomach or the heart.

Normal Mechanism of the Pancreatic Secretion.—After Pavlov's discovery of the secretory fibers to the pancreas the natural supposition was that the mechanism of secretion is analogous to that of the salivary glands, that is, some peripheral sensory stimulus in the intestines stimulates these secretory fibers reflexly. It was supposed, in fact, that the acid chyme ejected from the stomach acts upon the sensory fibers of the mucous membrane of the duodenum and sets going the normal reflex that causes the pancreatic secretion. This view was founded upon the fact, demonstrated by several observers, that acids applied to the duodenal membrane will start the pancreatic secretion. Popielski, however, asserts that the same reaction is obtained when the vagi and sympathetic are cut on both sides, so that if the reaction is effected by a nervous reflex this reflex does not involve the central nervous system. More recently an entirely new light has been thrown upon the subject by some most interesting investigations made by Bayliss and Starling. These authors find in the first place that acid (0.4 per cent. HCl) placed in the duodenum or jejunum will cause a secretion of the pancreatic juice when the loop of the intestine used (jejunum) has all of its nervous connections severed. Moreover, if the mucous membrane from the duodenum or jejunum is scraped off and treated with the acid, the solution so obtained when injected into a vein causes an active secretion by the pancreas, although the acid alone or the extract of the mucous membrane without treatment by acid is ineffective. The authors apparently have proved that normally the acid from the stomach or the fatty acids formed during digestion act upon the mucous membrane and produces a substance which they designate as secretin. The secretin is absorbed, carried to the pancreas, and either stimulates the pancreatic cells directly, or possibly, acts upon the intrinsic nerves of the gland. Secretin is not an enzyme; boiling or the action of absolute alcohol does not destroy it. According to this new and interesting discovery the secreting nerves play no necessary part in the normal mechanism of pancreatic secretion, and if this turns out to be the case we shall have to attribute to them merely a regulating influence upon the secretion. The flow of pancreatic juice caused by secretin is characterized by the fact that it does not contain an active trypsin, but recent experiments go to indicate that any normal flow of pancreatic juice possesses the same peculiarity. It would seem that in the normal secretion the trypsin is contained in the form of zymogen or pro-enzyme, and that it becomes converted to the active enzyme when it comes in contact with the intestinal mucous membrane. The conversion is made by the peculiar enzyme found in the intestinal secretion by Schepowalnikow and to which Pavlov has given the name of enterokinase (see heading of Intestinal Secretion). The normal sequence of events, then, in the secretion of pancreatic juice is, first, the formation of secretin by the action of the acid of the gastric juice on the mucous membrane of the small intestine; second, the action

of this secretin, after absorption into the blood, upon the pancreatic cells; third, the conversion of the zymogen of the secretion into the active enzyme by the enterokinase of the succus entericus. This last act may be necessary only for the trypsin.

The curve of secretion of the pancreatic juice has been determined with care in the case of dogs. According to experiments made upon animals with a pancreatic fistula, the secretion begins shortly after the introduction of food into the stomach, and increases in volume to a maximum, which is reached between the first and the third hours. The curve then falls again more slowly to the base line, although there may be a second smaller rise from the fifth to the tenth hour.

Relation of the Composition of the Secretion to the Character of the Food.—The work from Pavlov's laboratory indicates that the composition of the secretion varies somewhat with the character of the food, and that the variation has the appearance of a beneficial adaptation. That is, protein foods cause in some way the secretion of a juice rich in proteolytic enzyme, and oily foods a secretion with an increased amount of lipase. This statement needs further experimental confirmation. If correct it shows a kind of biological reaction between the food and the secretion which it is difficult to explain satisfactorily. Pavlov maintains that similar specific stimuli in the food influence or control the composition of the gastric and salivary secretions. We have here a relationship which, when more fully investigated, may prove to be of much practical importance in dietetics.

Secretion of the Gastric Glands.—The accepted method of obtaining the gastric secretion dates from the famous work of Beaumont. His use of an accidental fistula in the case of St. Martin indicated at once that similar fistulas might be established upon animals for experimental purposes. Operations of this kind were performed first by Basson and by Blondlot in 1842, and were used subsequently by many investigators. At first, metal cannulas were placed in the fistulous openings to facilitate the collection of the secretion, but modern surgical technique has enabled experimenters to avoid this clumsy and often injurious device by converting a portion of the reflected mucous membrane into a tube opening on the surface of the skin. With a fistula of this character the stomach contents cannot escape to the exterior and yet can be drawn off at any time by the insertion of the catheter. The difficulty in such experiments is that the secretion becomes contaminated with the food, and its analysis is therefore difficult or impossible. Heidenhain obviated this difficulty and opened the way to successful investigation of the secretion by his device of cutting off a portion of the stomach, especially the fundic end, so as to form an isolated sac opening to the exterior. The remainder of the stomach was closed off by sutures so as to maintain the continuity of the alimentary canal. In such animals the food does not enter the isolated fundic sac, but nevertheless starts a secretion in it which may be obtained through its fistulous opening entirely free from mixture with the food. By this means the quantity, rate of flow, and composition of the secretion may be studied satisfactorily under various conditions. This operation was subsequently improved by Pavlov, who introduced a variation by means of which the nervous supply, as well as the vascular supply of the isolated sac, was maintained intact. The character of this operation is shown in the accompanying diagram (Fig. 4481). Pavlov devised also a secondary operation which in his hands has led to important results. In this operation the esophagus was divided in the throat, and both upper and lower ends were brought to the surface of the skin to form permanent fistulas. After such an operation the food that the animal chewed and swallowed did not enter the stomach, but escaped to the exterior through the upper esophageal fistula. By this means the effect of the act of eating upon the gastric secretion was determined. It was found that a sham meal of this character causes an abundant secretion of gastric juice in spite of the fact that none of the food enters the stomach, and this fact in turn led to the discovery of secretory nerves to the gastric glands.

Composition of the Secretion.—In addition to the mucus formed by the columnar epithelium on the surface of the mucous membrane, the secretion as collected contains water, inorganic salts, hydrochloric acid, pepsin, rennin, and usually a trace of peptones. The amount of the hydrochloric acid may be as great as 0.56 per cent. in the dog, but in the human gastric juice is usually given as 0.2–0.3 per cent. The secretion does not decompose easily—in fact, specimens may be kept for long periods without undergoing any putrefaction and without losing their digestive action. Evidently the secretion has marked antiseptic properties which are doubtless due to the free hydrochloric acid it contains. There has been considerable discussion as to the composition of the secretion from different parts of the stomach. The marked difference in histological structure between the glands of the cardiac and those of the pyloric end would suggest that their respective secretions might vary in character. According to most observers, the pyloric mucous membrane, when isolated from the rest of the stomach, gives a secretion that is alkaline in reaction but contains some pepsin and rennin. The hydrochloric acid, therefore, must be formed in the glands of the cardiac end. As far as is known, the glands of the pyloric end add nothing that is characteristic or essential to the secretion.

Nervous Control of the Secretion.—Much experimental work has been done to ascertain whether or

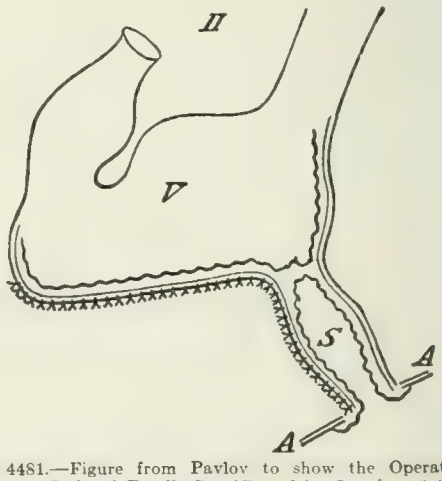

Fig. 4481.—Figure from Pavlov to show the Operation of Forming an Isolated Fundic Sac (*S*) and its Opening at the Abdominal Wall. *A, A;* V, cavity of the stomach.

not the flow of gastric juice is under the control of secretory nerves. The earlier experiments were inconclusive and need not be recalled, since in recent years Pavlov has obtained positive evidence of secretory nerve fibers. With the aid of his pupils and co-workers he has demonstrated the following facts: When a dog is given a fictitious meal by means of the esophageal fistulas described above, there is a flow, often an abundant flow, of gastric juice, although no food gets into the stomach. If, however, the two vagi are cut previously, the sham meal does not cause a secretion. Evidently, therefore, the act of eating must occasion a reflex secretion of gastric juice, and

the efferent paths in this reflex must pass to the stomach by way of the vagi. By the same means it was shown that the sight or smell of food will cause a reflex secretion in a hungry animal. After these preliminary experiments had indicated the existence of secretory fibers positive proof of their existence was obtained by direct stimulation of the peripheral end of a cut vagus. Under proper conditions of stimulation a flow of gastric juice can be obtained in this way, although the latent period of the secretion is unusually long, from four to ten minutes.

Normal Mechanism of the Gastric Secretion.—Beaumont and later observers held that mechanical irritation of the gastric mucous membrane is capable of provoking a secretion, and that the food therefore acts in part, especially in the beginning of digestion, as a mechanical stimulus. Pavlov, however, states positively that this belief is erroneous, and that mechanical stimuli are entirely ineffective. Heidenhain gave convincing evidence that the normal stimulus is a chemical one derived from the food, and this fact was afterward confirmed by the more detailed and satisfactory experiments made by Pavlov, who has given us a nearly complete account of the means by which the flow of gastric juice is started and maintained during digestion. According to this author, the first flow of the gastric juice is caused reflexly by the sight or smell of food, or more especially by the act of eating, and constitutes what he calls the psychical secretion. This term is used because the sensory nerves stimulated are the gustatory, olfactory, or optic nerves, and the reflex is accompanied by the conscious and agreeable sensations associated with eating. The term seems to imply also that the reflex arc involves the cerebral cortex, and is thence continued to the secretory fibers in the vagus. The secretion produced in this way appears promptly, and under favorable conditions may be abundant in quantity. In one experiment in which the fictitious feeding was continued for several hours, it is stated that about 700 c.c. of pure gastric juice were obtained. A further flow of the secretion is caused by the action of the food upon the stomach itself. According to the experiments reported, there are some foods which contain substances capable of acting chemically upon the mucous membrane and arousing a flow of gastric juice, probably by a nervous reflex; such foods are the meats, meat extracts, milk, gelatin, and water. Other foods, such as bread or white of eggs, do not possess this power. If introduced into the stomach through a fistula without the animal's knowledge so as not to arouse a psychical secretion, they remain undigested. If, however, these foods are digested for a time they then acquire the power of stimulating a flow of gastric juice. Under the normal conditions of eating, such foods would first start a psychical secretion, and after they had begun to be digested by this secretion the flow would be maintained by the chemical stimuli developed from them in the process of digestion. These chemical stimuli upon which the flow of gastric juice depends mainly, which are present already formed in some foods and are developed in others by digestion, Pavlov groups under the general designation of secretagogues. He has not been able so far to ascertain their chemical nature. The dietetic value of meat extracts seems to lie largely in the fact that they contain much of these secretagogues and thereby favor the digestion of other foods.

Curve of Secretion and its Variation with the Character of the Food.—In its general features the curve of gastric secretion, so far as its quantity is concerned, resembles that of the pancreatic juice. The flow begins promptly after the act of eating, increases somewhat rapidly to a maximum, which in dogs fed on a mixed diet is reached at about the second hour, and then falls slowly toward zero as the stomach is emptied. The composition of the secretion during this period varies somewhat, the first flow being relatively weak in the two important constituents hydrochloric acid and pepsin. Pavlov states that in a general way the quantity of secretion varies with the amount of food, a relation which is easily understood when we remember that the food itself supplies the stimulus for the secretion. The same worker has given some proof that the composition of the secretion is related to the composition of the food, and that it may be possible, when the relation has been more completely investigated, so to modify the food as to increase one or the other of its important constituents.

Histological Changes during Secretion.—The gastric glands in the cardiac end of the stomach contain two types of cells, the chief cells, and the cover or border cells. The latter vary in number in different regions, but in most cases form a discontinuous layer along the length of the tubes, and in the pyloric region they are lacking entirely. Histological and experimental evidence indicates that the chief cells are responsible for the secretion of the enzymes of the juice. During the resting stage these cells are filled with zymogen granules which disappear to a greater or less extent during active digestion. In accordance with this histological fact it is found that aqueous extracts of the mucous membrane in the resting stage may contain but little active pepsin or rennin, but that if this extract or the mucous membrane before extraction is treated with certain reagents such as dilute acids, an abundant yield of enzyme is obtained. In normal secretion the presence of the hydrochloric acid is sufficient in itself to convert the zymogen to enzyme, so that in the normal gastric juice no zymogen or proferment is found. With regard to the enzymes, therefore, we may assume that, as in the other digestive glands, they are formed within the cells as a result of their metabolism, that they are stored during rest as zymogen granules, and that, during or immediately subsequent to their secretion, the zymogen is changed to the active enzyme. With regard to the secretion of the acid prevalent theories are much less satisfactory.

Origin of the Hydrochloric Acid.—It is not known definitely which of the two cells found in the gastric tubules gives rise to the hydrochloric acid. The fact that the pyloric glands do not contain border cells and that their secretion is alkaline instead of acid suggests the view that these border cells are concerned in the formation of the acid, hence they are sometimes designated as oxyntic cells. No direct proof, however, has been furnished to show that these cells have anything to do with the production of the hydrochloric acid. On the chemical side also the mode of origin of the acid is still obscure. In general, it is believed that the hydrochloric acid must arise ultimately from the chlorides, especially the sodium chloride of the blood, and, according to one hypothesis, the acid is formed by a reaction between the chlorides and the phosphates of the blood according to the formula $NaH_2PO_4 + NaCl = Na_2HPO_4 + HCl$, the reaction being effected in some way through the activity of the gland cells. Another hypothesis is that the chlorides are decomposed by the mass action of the CO_2 formed in the metabolism of the gland tissue, and that the reaction is facilitated and the liberated base combined by an acid nucleo-protein known to exist in the gastric mucous membrane. Neither hypothesis helps us much to understand why the hydrochloric acid is formed only in this particular tissue and not elsewhere in the body. Acid indicators, such as acid fuchsin cyanimin or neutral red, show that the free acid is present only on the surface of the membrane or in the lumen of the neck of the gland and not within the substance of either the border cells or the chief cells. In view of this result it has been supposed that the acid is not actually formed within the cells, but in the secretion after its discharge; or if formed within the cells, it is eliminated as rapidly as it is formed, so that there is no accumulation within

the cell itself as in the case of the zymogen. In accordance with this hypothesis it has been suggested that the hydrochloric acid is actually formed outside the mucous membrane from the chlorides of the stomach contents. This view assumes that the mucous membrane is impermeable to the chlorine ions, but permeable to the hydrogen ions, and that the latter passing through the mucous membrane from the blood, combine with the chlorine of the dissociated chlorides of the stomach contents. The hypothesis can scarcely be considered a probable one, since an abundant secretion of acid juice may be obtained by stimulation of the vagus nerve or in the isolated fundic sac when the stomach is entirely empty. Nor does the hypothesis help us to understand at all the part taken by the secretory cells. We must, in fact, confine ourselves at present to the general statement that the chlorine of the hydrochloric acid is derived ultimately from the chlorides of the blood.

Secretion of the Small Intestines—the Succus Entericus.—Although there is no question that the cells of the small intestine form enzymes which take an active part in the digestion of the food, there is some doubt whether these substances are actually discharged in a liquid secretion upon the inner surface of the intestine. Some mucus is formed and secreted by the epithelial cells, particularly those of the large intestine, but this mucus is not known to have any digestive action of a chemical nature. To ascertain whether a liquid secretion other than the mucus is formed in the small intestine, recourse has been had usually to experiments with a Thiry-Vella fistula. In this operation a loop of the intestines is isolated and the two ends are sutured into the skin of the abdominal wall, giving thus a portion of the intestine whose contents can be examined without possibility of contamination from the food or from the secretions of the pancreas or liver. Experiments of this kind agree in showing that an alkaline liquid forms in the loops, and indeed more abundantly in loops from the lower than in those from the upper portions of the small intestines. From experiments of this kind Pregl estimates that as much as three liters may be secreted in twenty-four hours from the entire intestine. The estimate must be received, however, with caution. Most observers agree that this liquid has no digestive action on proteins, but may contain an amylolytic enzyme. Extracts of the walls of the small intestine, on the contrary, give solutions that contain four or possibly five important enzymes. There are, first, the important group of sugar-splitting enzymes capable of converting the disaccharides to the monosaccharides, namely, maltase which converts maltose to dextrose, invertase which converts cane sugar to dextrose and levulose, and possibly lactase which converts lactose to dextrose and galactose. In addition it has been shown recently by Cohnheim that these extracts contain a powerful protein-splitting enzyme, erepsin, which splits the peptones and proteoses into their constituent amino-acids—leucin, tyrosin, arginin, etc. Whether or not these enzymes are actually discharged into the intestines as a liquid secretion, they must be regarded as formed within the substance of the intestinal epithelial cells by a metabolism peculiar to these cells and analogous to the process of secretion in other glands. We must place the intestinal epithelium among the important digestive glands. Quite recently also the intestinal secretion from the upper part of the small intestine at least has been found to contain an enzyme-like substance, enterokinase, which, while it has no digestive action of its own, seems to be able to increase greatly the activity of the enzymes of the pancreatic juice. This effect is particularly marked in regard to the important proteolytic enzyme trypsin. Apparently this latter enzyme is secreted entirely in the form of a zymogen and can have no effect upon the food until it is "activated" by the enterokinase. We owe this important addition to our knowledge of intestinal digestion to Schepowalnikow, working under Pavlov's directions. This work has since been confirmed by several observers, and it is claimed by Delezenne that the enterokinase can be obtained also from leucocytes and lymph glands, and in the small intestine is found most abundantly in the mucous membrane overlying the Peyer's patches.

Secretion of Bile.—As in the case of the other glands many efforts have been made to demonstrate the existence of secretory fibers to the liver controlling the flow of bile. The secretion of bile is continuous, the metabolic processes in the liver cells leading to its formation and discharge are in progress at all times although the velocity of the flow varies. Experimentally the velocity of the secretion may be increased or decreased, but the variations are so strictly parallel to the concomitant changes in the circulation that a causal connection between the two is rendered most probable. Stimulation of the spinal cord or the splanchnic nerves diminishes the flow of bile in proportion as it causes a diminution in the blood supply. Section of the splanchnics, on the other hand, which causes a dilatation in the blood-vessels of the abdominal viscera, is said to increase the secretion of bile. The usual view, therefore, is that the velocity of secretion of the bile varies with the volume of the blood flow through the liver. This belief seems to imply that the secretory activity of the liver cells as regards the bile is controlled by the composition of the blood. With regard to the excretory products of the bile, the bile pigments, lecithin, and cholesterin, one can understand that the greater the quantity of blood flow through the organ the greater will be the excretion. It is more difficult to comprehend the relationship between the blood flow and the increased secretion of water, salts, and bile acids, and no satisfactory hypothesis has been suggested to explain the relationship.

Curve of the Secretion of Bile.—Owing to the ease with which a biliary fistula may be established in man as well as in the lower animals, our knowledge of the daily curve of the secretion is fairly accurate. In man the quantity secreted varies between 500 and 800 c.c. in the course of a day, or taking into account the weight of the individual the secretion averages from 8 to 16 c.c. per day for each kilogram of body weight. Although the secretion is continuous, it shows a marked acceleration during the period of digestion between the third and the fifth hours after the ingestion of food, that is, during the period of maximal activity in the small intestine. Upon the general theory of secretion stated above, this increase in the secretion should be related to the greater blood flow through the liver at this period, and the altered composition of the blood following absorption of the digested products. Absorption, which is at its maximum during this time, must lead to a greatly increased metabolism in the liver cells, and the augmented secretion of bile is one expression of this increased activity. Although the secretion is continuous, the actual injection of bile into the duodenum through the common bile duct is intermittent in those animals which possess a gall-bladder. The secretion in such animals is stored in the gall-bladder, and by means of a definite nervous mechanism this reservoir is emptied at intervals during the course of digestion.

Ejection of Bile into the Duodenum.—The mechanism by which the bile is emptied into the intestine does not seem to have been investigated very exhaustively. According to Bruno, the ejection through the common bile duct is dependent upon the passage of chyme from the stomach into the intestine, and varies with the character of the food. As long as the

stomach is empty no bile is found in the duodenum. The chyme therefore must contain substances which, acting upon the sensory surface of the duodenum, lead to a reflex contraction of the gall-bladder. Bruno thinks that the digested proteins (proteoses and peptones) and fats furnish the efficient stimuli. Acids, alkalies, and starches were found to be ineffective. There seem to be no data regarding the frequency of occurrence of these contractions during digestion or the action of stimuli other than the chyme. The nervous mechanism involved in this reflex has been studied by Doyon and by Oddi. It appears from their work that the afferent fibers for the reflex run in the vagi, since stimulation of the central end of a cut vagus causes a reflex contraction of the gall-bladder together with an inhibition of the sphincter supposed to exist at the opening of the common bile duct into the duodenum. The efferent path, on the contrary, is through the splanchnics. Stimulation of the peripheral end of a cut splanchnic causes a contraction of the gall-bladder and bile ducts.

Modification of the Bile in the Gall-bladder.—It is well known that the so-called mucin of the bile is not formed in the liver cells but from the epithelium of the mucous membrane of the gall-bladder and ducts. The chemical nature of the substance seems to vary in different animals; in some cases it is a glycoprotein of the general nature of the mucin of the salivary glands, but in most cases, according to Hammarsten, it is a form of nucleoprotein. According to Naunyn, the cholesterin of the bile is also added through the epithelium of the bile passages, and does not constitute a portion of the bile as secreted by the liver cells. According to the analyses published, the bile of the gall-bladder (bladder bile) contains more solids than that of the hepatic ducts (hepatic bile). As this increase affects the constituents known to be furnished by the liver cells, it may be supposed that the bile undergoes a certain amount of concentration while in the bladder in consequence of the absorption of water.

Cholagogues.—Numerous experiments have been made upon the effect of various drugs upon the secretion of bile. These experiments have shown that substances which cause a destruction of red corpuscles increase the flow of bile. Direct injection of dissolved hemoglobin into the circulation has the same effect. The increase in the secretion in such cases is said to be transient. The substance that has the most marked and prolonged effect upon the secretion of bile is bile itself. Bile fed to an animal or injected into the circulation accelerates the secretion of bile, and the same effect may be obtained by using solutions of the bile acids alone. Since the so-called bile acids have a distinct hemolytic action it might be supposed at first that their effect as cholagogues is due to this action on the red corpuscles; but their effect is so much greater than that of other hemolytic agents that we must believe that they exert a specific stimulating action upon the liver cells. In addition to the bile salts it has been shown that the secretin (see under pancreatic secretion) formed in the duodenum by the action of acids has a distinct cholagogue action. Each gush of chyme from the stomach into the duodenum may, therefore, through the absorption of the secretin produced, provide a chemical stimulus that increases the flow of bile. There may be other as yet undetermined chemical stimuli in the portal blood, for according to some observers the liver forms but little bile when the portal circulation is excluded.

Secretion of the Kidney.—None of the secretions of the body has been studied with more care than that of the kidney. The especial interest which this secretion possesses for pharmacology and internal medicine as well as for physiology accounts in large part for the attention it has received. In addition it has seemed to offer the best opportunity for testing one of the fundamental questions of secretion, namely, the extent to which the physical processes of filtration, diffusion, and osmosis participate in the act of secretion. Most of the discussion on this point has been along the lines of the two main theories of urinary secretion which have been under discussion now for many years. One theory, proposed first substantially by Bowman and afterward supported vigorously in a modified form by Heidenhain, holds that the water and salts of the urine are actively secreted by the epithelium of the capsule surrounding the glomerulus, while the urea and the other specific organic constituents of the urine are secreted together with some water by the epithelium of the convoluted tubules. The other theory we owe to Ludwig. According to him all the constituents of the urine are formed by filtration through the glomerulus. The two layers of epithelium through which this filtration occurs, the capillary or vascular, and the glomerular epithelium, act simply as a membrane through which the constituents of the urine are filtered off from the blood by the excess of pressure in the blood capillaries. The urine so formed is very dilute, and as it passes along the convoluted tubules it becomes concentrated by absorption. In both theories a difference of function is supposed between the capsule and the convoluted tubule. It will be convenient to discuss the functions of these two parts separately.

Function of the Glomerulus.—The arrangement of the glomerulus and the capsule presents a structure peculiar to the kidney and suggestive of a special purpose. The glomerulus is a knot of capillary vessels which do not form a plexus but rather a rete mirabile with a single afferent and a smaller efferent vessel. For physical reasons the blood in passing through the glomerulus suffers a diminution in velocity, on account of the sudden increase in the width of the stream bed, and yet maintains a high hydrostatic pressure on account of the resistance offered by the narrow efferent vessel and the capillary plexus with which it connects. Moreover, there are no lymph spaces round the glomerulus. The epithelium of the blood capillaries is directly adherent to the epithelium of the capsule into which the glomerulus is inserted, so that the cavity of the capillaries is separated from that of the uriniferous tubules by a double layer of endothelial cells. The arrangement suggests a filtering mechanism, and Ludwig's theory supposes that it acts in this way for all of the constituents of the urine. Bowman's theory supposes that only the water and salts are formed here, and Heidenhain, moreover, has given reasons for believing that the water is not formed by mechanical processes, but by an active secretory process on the part of the glomerular epithelium. If attention is paid only to the water and salts it is evident that if Ludwig's theory is correct the pressure tending to force them through the epithelium may be expressed by the formula $P - p$, in which P represents the pressure in the glomerular capillaries and p the pressure of the urine in the capsular end of the tubule. According to this theory, the amount of urine formed should vary directly with P and inversely with p. It is obvious that the factor P may be increased by raising arterial pressure in the renal arteries or by obstructing the flow in the renal veins, and, according to theory, each change should cause an increased flow of urine. Experiments of this kind have been made. It has been found that raising arterial pressure in the kidney arteries does increase the flow of urine, and *vice versa*. However, it must be borne in mind that this relationship holds only when the pressure in the glomerular capillaries varies in the same direction as in the renal arteries. All experimental variations which may be safely assumed to raise the pressure in the glomerular capillaries are fol-

lowed by a greater flow of urine. The reverse experiment, however, of raising P by blocking the venous outflow fails entirely to support the theory. When the renal veins are compressed the capillary pressure in the glomeruli must be increased, and if the veins are blocked entirely, we may suppose that the capillary pressure is raised to the level of that of the renal arteries. In such experiments, however, the flow of urine is diminished instead of being increased, and indeed may be stopped altogether when the veins are completely blocked. The adherents of the Ludwig theory have attempted to explain this unfavorable result by assuming that the swollen interlobular veins press upon and block the uriniferous tubules.

According to the antagonistic theory of Heidenhain, blocking the veins suppresses the secretory activity of the glomerular epithelium by depriving it of oxygen and the chance for removal of CO_2, and thus producing local asphyxia. The latter explanation seems the simpler of the two, and it is very strongly supported by the opposite experiment of clamping the renal artery. When this is done the blood flow through the kidney ceases and the secretion of urine also stops as would be expected. But when after a few minutes' closure the artery is unclamped the secretion is not restored with the return of the circulation. On the contrary, a long time (as much as an hour or more) may elapse before the secretion begins. This fact is quite in harmony with the Heidenhain theory, since complete removal of their blood supply might well result in a long-continued injury to the delicate epithelial cells. On the mechanical theory, however, we should expect the contrary. Injury to the cells should be followed by greater permeability and an increased filtration, as is found to be the case with the production of lymph. These two experiments, blocking the renal artery and the renal vein, seem at present to discredit the filtration theory and to support the secretion theory. If we accept this latter theory it may be asked how it agrees with the experiments mentioned above upon the variations in capillary pressure brought about otherwise than by obstructing the venous outflow. Heidenhain has emphasized the fact that all of these experiments involve not only a variation in capillary pressure, but also in the blood flow, and that it is open to us to suppose that the effect upon the secretion of urine is dependent upon the rate of flow rather than upon the capillary pressure. If we adopt this explanation we are led again to the secretion hypothesis, since mere rate of flow should not influence filtration, but should affect secretion, since it would alter the composition of the blood flowing through the glomeruli and also the supply of oxygen and carbon dioxide. An important fact, which seems at first sight to show the influence of pressure, is that when general arterial pressure falls below a certain point, about forty millimeters of mercury, the secretion of urine ceases altogether. Such a condition may be brought about by surgical shock, by hemorrhage, or by section of the spinal cord in the cervical or thoracic region. But here again the great vascular dilatation causing this fall of pressure is associated with a feeble circulation, and the effect upon the kidney secretion may well be due to this latter factor.

In addition to varying the factor P in the formula given above, it is possible also to increase the factor p. Normally the pressure of the urine in the capsule must be very low owing to the fact that the secretion drains away as rapidly as it is formed. If the ureter is occluded, however, the pressure of the urine will increase, and the filtration pressure $P - p$ will diminish. When this experiment is performed and the pressure in the ureter is measured by a manometer, it is found to rise to fifty or sixty millimeters of mercury and then to remain stationary. This fact might be explained by supposing that when $p = P$ the secretion stops on account of the failure of the filtration pressure. Little weight, however, can be given to this argument, since it is quite possible that under these conditions the urine may still continue to form, but is reabsorbed under the high tension reached. The experiment simply serves to show the secretion pressure of the urine, and the fact that this pressure rises as high as fifty to sixty millimeters mercury, while the fact that the capillary pressure is probably somewhat lower would rather serve as an argument against the filtration theory. Exact figures, however, regarding the capillary pressure in the kidney cannot be obtained, so that the experiment on the whole gives us no satisfactory information regarding the theory of secretion. Dreser has used a different argument to prove that the production of the water involves the performance of work on the part of the epithelial cells. He points out that in some conditions, *e.g.* after drinking beer, the urine may be very dilute, as shown by the fact that its freezing-point may be only 0.18° C. or 0.16° C. below that of pure water, that is, $\Delta = -0.18°$ C. or $-0.16°$ C. Since blood serum has $\Delta = -0.56°$ C. the difference in concentration between the blood and the urine in such a case of extreme dilution shows an osmotic pressure in favor of the blood equivalent to $\Delta = -0.4°$ C. Measured in mechanical units this would indicate an osmotic pressure of 49.08 meters of water tending to drive the water from the uriniferous tubules into the blood, whereas the filtration pressure driving the water in the other direction could not at a maximum exceed 2.72 meters of water. Evidently if this argument is just, the elimination of the water takes place against a strong opposing osmotic pressure, and the energy necessary for its secretion can be referred only to the activity of the epithelial cells.

Function of the Convoluted Tubules.—By convoluted tubule is meant that portion of the uriniferous tubule which extends from the capsule to the straight or collecting tubes. Its epithelium varies, but is distinguished in general from the flat, thin epithelium of the capsule by a larger amount of granular protoplasm. According to the Ludwig theory, this portion of the tubule functions as an absorption membrane and serves thus to concentrate the dilute urine filtered through the glomerulus. The fact that the urine is often more concentrated than the blood proves that this absorption, if it occurs, is not due to simple hydrodiffusion, and later adherents of this theory have been obliged to abandon the simple physical theory proposed by Ludwig and to suppose that the absorption effected by these cells is a physiological process dependent upon their living structure and properties. The Bowman-Heidenhain theory, on the contrary, assumes that these cells are secretory in function and serve for the excretion of the urea, uric acid, etc. With regard to the absorption theory it may be said that positive evidence is lacking, and it is difficult to present briefly the facts that are quoted from time to time in its favor. On the other hand, there is much probable evidence that the secretory hypothesis is nearer to the truth. This evidence may be summarized briefly as follows: 1. It is stated that if the ureters are ligated in birds the urates will be found deposited in the uriniferous tubules, but never at the capsular end. 2. Heidenhain has given proof that the convoluted tubules are capable of excreting indigo-carmine after this substance is injected into the blood. His experiment consisted essentially in injecting the material into the blood after dividing the cord so as to reduce the rapidity of secretion. After a certain interval the kidney was removed and irrigated with alcohol to precipitate the indigo-carmine *in situ* in the organ. Microscopic examination showed that after this treatment the granules of the indigo-carmine are found in the convoluted tubules, but not in the capsules round the glomeruli. 3. Several observers (Van der Stricht, Disse, Trambasti, Gurwitsch)

have described microscopic appearances in the cells lining the tubules indicative of an active secretion. They picture the formation of vesicles in the cells and appearances which indicate the discharge of these vesicles into the cavity of the tubules. 4. Nussbaum made use of the fact that in the frog the glomeruli are supplied by branches of the renal artery, while the other tubes are supplied by the renal portal vein. He stated that if the renal artery is ligated the glomeruli are deprived completely of blood, and that as a result the flow of urine ceases. If under these conditions urea is injected into the circulation it is excreted together with some water, thus proving the secretory activity of the tubules with regard to urea. Later experiments by Adami and by Beddard have thrown doubt upon this otherwise crucial experiment. Adami claims that ligature of the renal arteries does not shut off completely the glomerular circulation, while Beddard, although he corroborates Nussbaum in the point that complete occlusion of the renal arteries suspends entirely the secretion of urine, finds that under these conditions injection of urea into the circulation is not followed by a secretion. 5. Dreser has shown that the acidity of the urine is due to an action of the epithelium of the tubules. If an acid indicator, such as acid fuchsin, is injected into the dorsal lymph sac of a frog, and an hour or so later the kidneys are examined, it will be found that the convoluted tubules are colored red, while the capsular end is colorless, indicating that the secretion at that point has an alkaline reaction. The experiment shows that the acid phosphate of the urine is produced in the convoluted tubules. Similar microchemical reactions are described by Leschke which seem to show that urea, uric acid, and even sodium chloride when in excess of the normal concentration in the blood are eliminated by a secretory activity of the tubular epithelium. 6. Study of the gaseous exchanges of the kidney when stimulated by diuretics show that during or immediately after the secretion there is an increased absorption of oxygen and an increased elimination of carbon dioxide. This increase implies greater functional activity of the kidney cells such as would be expected from secretory activity. On the whole it must be admitted that the weight of evidence is in favor of the Bowman-Heidenhain theory of secretion, and it remains for future investigations to explain more definitely what is meant by the obscure term, secretory activity.

Influence of the Nervous System on the Secretion of Urine.—Although Berkley states that terminal fibrils of the nerves distributed to the kidney may be traced to the epithelial cells of the convoluted tubules, the physiological evidence at present is opposed to the existence of secretory nerve fibers. The kidney receives a rich nervous supply by way of the sympathetic, but experiments indicate that these fibers are vasomotor in function. Both vasoconstrictor and vasodilator fibers have been described, and inasmuch as the secretion of urine varies directly with the rapidity and volume of the blood flow, it follows that these vasomotor fibers must exercise normally an important regulatory influence upon the amount of secretion.

Action of Diuretics.—An important side of the theories of secretion of urine is their application to the action of diuretics. Water, various soluble substances, such as salts, urea, and dextrose, and certain special drugs, such as caffein or digitalis, exert a diuretic action on the kidneys. Much experimental work has been done to ascertain whether the action of these substances can be explained mechanically by their influence on the blood flow or the blood pressure in the kidney capillaries, or whether it is necessary to fall back upon a specific stimulatng effect exerted by them upon the epithelial cells of the tubules. Adherents of the original Ludwig theory are forced to explain their action by the effect they produce upon the pressure in the kidney capillaries, and indeed it has been shown with reference to the saline diuretics that their effect upon the secretion is in proportion to the osmotic pressure they exert. It has been suggested, therefore, that the action of these diuretics lies in the fact that they attract water from the tissues into the blood and thus cause a condition of hydremic plethora. But whether the elimination of this excess of water is due to filtration or to an active secretion by the glomerular epithelium simply revives the discussion that has been presented briefly above. Most observers find that the vascular changes in the kidney, particularly after the administration of caffein and digitalis, do not explain satisfactorily the phenomenon of diuresis, and although it is necessary to admit that the diuretics, or some of them, act in part by the changes which they cause in the circulation in the kidney, those who adopt the Bowman-Heidenhain theory assume usually that these substances exert also a direct stimulating action on the secretory cells.

Secretion of the Sebaceous Glands.—Practically nothing is known of the mechanism of secretion of these glands beyond the results furnished by histological examination. It is believed that the secretion is formed not by a liquid discharge from the cells, but by the casting off of the cells themselves. The cells upon the basement membrane multiply, and the daughter cells are displaced toward the lumen of the gland. Gradually these latter cells disintegrate, and their débris forms the thick, oily secretion.

Secretion of the Sweat Glands.—The secretion of sweat is important, partly because it helps to regulate the water contents of the body, but mainly because it is an effective means of controlling the body temperature. In accordance with these regulative functions we find that the formation of sweat is governed by the central nervous system, by means of which a reflex adaptation of the process to the needs of the body is made possible. Definite experimental proof of the existence of sweat nerves was obtained first by Goltz. He showed that electrical stimulation of the peripheral end of the divided sciatic in dogs or cats causes the formation of visible drops of sweat on the balls of the feet. This result has since been confirmed for other parts of the body, and it has been shown that the sweat nerve fibers take much the same course anatomically as the vasomotor fibers. They take origin in the cord or the medulla, pass over to the sympathetic ganglia where they end round the sympathetic nerve cells. Thence their course is continued by a sympathetic neurone, so that they reach their destination probably as non-medullated fibers. Their course for different regions of the body is known with a fair degree of exactness. All the evidence that we have indicates that the sweat glands, like the salivary glands, do not secrete normally except under the influence of these secretory fibers. Ordinary profuse sweating due to a high external temperature must be explained as a reflex act. The high temperature stimulates sensory nerves in the skin, and the impulses thus generated are transmitted to the cord and returned to the sweat glands by the efferent sweat fibers. Attempts have been made to ascertain whether the general activity of these sweat fibers is controlled like that of the vasoconstrictors by a medullary nerve center. The work done is not conclusive, but it seems to indicate that the reflex centers for the system are found in different regions of the brain and cord. In all probability the nuclei of origin of the sweat fibers for each skin area constitute the sweat center for that region. These nuclei or centers may be stimulated reflexly by incoming impulses from the skin or from the higher nerve centers, or they may be acted upon by changes in the composition of the blood as is shown by the effect of dyspnea and certain drugs. Atropine and pilocarpine exert their well-known antag-

onistic influence in the sweat secretion, the latter causing a flow of sweat and the former inhibiting it. As in the case of other glands, the action of these drugs is supposed to be peripheral, pilocarpine stimulating the endings of the sweat fibers, and atropine paralyzing them. Nicotine also in proper doses suspends the secretion of sweat, and it is probable that this alkaloid acts upon the connection between the spinal or preganglionic neurone and the sympathetic or postganglionic neurone.

Secretion of the Mammary Glands.—The development of these glands in connection with the processes of gestation and their functional activity for a variable period after the act of parturition, are the points of greatest physiological interest. It seems evident that the causal connection between the changes in the uterus and in the mammary gland must be established either through the central nervous system or through the blood. During the development of the fetus sensory stimuli may be developed in the reproductive organs of the mother which act reflexly upon the mammary gland and stimulate its growth and secretion; or, on the other hand, the changes in the reproductive organs or in the fetus may result in the formation of an internal secretion, which being discharged into the blood, acts upon the tissue of the gland either directly or through the nervous system. The crucial experiment of destroying the nerve supply of the gland in a pregnant animal has given somewhat unsatisfactory results, but it seems to show that the development and functional activity of the gland proceed as under normal conditions, although the quantity of milk produced is less. By exclusion, therefore, we should infer that the bond of connection is furnished by the blood rather than by the nervous system and this conclusion is strengthened by direct evidence of one kind or another. Thus Starling and Lane-Claypon have shown that extracts of the body of a fetal rabbit when injected into a virgin rabbit cause an accelerated development of the mammary glands. They assume that a hormone is formed in the fetal tissues which is absorbed into the mother's blood and serves to cause or promote the growth of the mammary glands. Since at birth after the expulsion of the fetus the gland begins active secretion they attribute a twofold function to this hormone. On the one hand the stimulation to development of the gland tissue and on the other the inhibition of the metabolic processes concerned in the actual formation of the milk. Steinach gives evidence to show that in the early stages of its development at least the growth of the gland is influenced by, or is dependent upon an internal secretion furnished by the interstitial tissue of the ovaries. He asserts for example that if ovaries are transplanted under the skin of a young castrated male mammæ and nipples will develop in the latter. But perhaps the most conclusive proof that the cycle of functional activity in the mammary gland is controlled by chemical stimuli in the blood is furnished by recorded cases of twin monsters, the Blazek sisters, for example, having a common circulation but separate nervous systems. It was found in the case of these sisters (Basch) that pregnancy and parturition in one was followed by a secretion of the mammary glands in both. This evidence indicates that the bond of connection is furnished by the blood rather than by the nervous system, and we may adopt provisionally the hypothesis of an internal secretion. Assuming that this hypothesis is correct, it still remains possible, of course, that the activity of the gland in lactation may be regulated by extrinsic nerves. Some facts speak for this possibility. It is known, for instance, that in women during lactation the flow of milk is influenced by emotional conditions, and, on the other hand, histologists have described nerve terminations round the gland cells which look like secretory nerve fibers. The physiological evidence for secretory fibers is, however, quite meager. Mironow in experiments upon goats has stated that stimulation of sensory nerves causes a diminution in the secretion, but that when the nervous connections of the gland are destroyed this reflex cannot be obtained. Röhrig finds that section of the inferior branch of the external spermatic increases the secretion, while stimulation of the same nerve causes a diminished secretion. These experiments might be regarded as indicating the existence of inhibitory fibers to the gland, but it is equally probable, that they may be explained in a more indirect way. Ott and Scott have shown that extracts of some glands, especially of the posterior lobe of the hypophysis and of the corpus luteum, have a marked stimulating (galactagogue) effect upon the mammary glands and on the other hand recent work indicates that emotions and strong sensations are characterized by their effect upon the autonomic nervous system which innervates the ductless glands. It may well be, therefore, that the known influence of the central nervous system on the secretion of milk may be exercised not directly through true secretory fibers, but indirectly through variations in the blood supply to the gland or through the intermediate influence of the secretions of the ductless glands.

Internal Secretions.

The term internal secretion seems to have been employed first by Claude Bernard, but the essential idea conveyed by it, namely, a secretion discharged into the blood or lymph, had long been entertained in connection with the so-called ductless glands, such as the thyroid. About 1889 the term and the idea implied by it were emphasized by Brown-Séquard in connection with work upon testicular extracts. This author suggested that not only the glands but all tissues may have internal secretions of greater or less importance in the general nutrition of the body. This extension of the original conception was not justified by subsequent experiments and to-day we must limit the use of the term to the distinctly glandular bodies. Experience has shown, however, that not only the ductless glands but some at least of the typical glands with well-defined ducts may produce internal secretions. It has become customary to group the glands or tissues furnishing internal secretions under the general designation of the *endocrine* system (ἔνδον, within, and κρίνω, I separate). The active substance or substances in these secretions so far as known are not enzymes, as is the rule with the external secretions, but bodies of a simpler and more stable structure which act as definite chemical stimuli. For such substances Bayliss and Starling have proposed the general designation of *hormones* (ὁρμάω, I excite).

Internal Secretion of the Thyroid Tissues.—Under the term thyroid tissue we may include the thyroid bodies, the accessory thyroids which have a similar, indeed identical structure, and the parathyroids whose structure is peculiar, but whose function seems to be related to that of the thyroids. The history of the discovery of the functions of the thyroids, so far as we know them, is most interesting and illustrates admirably how experimental physiology may cooperate with experimental and clinical work in medicine and surgery. The early work indicated that removal of the thyroids is followed quickly by marked symptoms of disturbed metabolism, cachexia, muscular tremors and spasms which soon end in death. Later work has shown that a rapidly fatal result is obtained only when the operation removes all of the thyroid tissues, and that the characteristic symptoms and their duration before a fatal termination depend somewhat upon the species of animal used and its age. In human beings it is known that atrophy or loss of function in the thyroids proper leads to cretinism and myxedema, and that these distressing conditions may be removed completely by feeding thyroid tissue to the patient. In

the lower animals the precise results of removal of the thyroids proper and of the parathyroids are not yet entirely known, but the results differ undoubtedly in the two cases. Speaking generally it may be said that removal or diminution in function of the thyroids in the adult is attended by a condition of malnutrition which is not immediately fatal but leads to a chronic cachexia and perverted metabolism such as is exemplified by myxedema in man. Removal of these glands or suppression of their function in early life is also followed by a perverted metabolism which exhibits itself especially in a retarded growth of the skeleton and of the brain, as is the case, for example in the well-known condition of cretinism. The parathyroids are usually four in number and while removal of some of them may cause no obvious disturbance, complete extirpation in the dog at least and probably also in man, is followed quickly by death which is preceded by a characteristic muscular tetany. The tetany may be obviated by the administration of calcium salts (Macallum and Voeghlin) or of acids (Wilson) but a fatal termination follows nevertheless. Evidently the two tissues have in some respects different functions, although normally their activities may be interrelated in some way. The abundant literature bearing on this subject contains a mass of facts which cannot well be condensed or summarized here. It will suffice perhaps to state briefly the usually accepted conclusions in regard to the functions of these bodies. It is assumed that the thyroids furnish an internal secretion containing a hormone which as yet has not been isolated successfully. Many have supposed that this secretion consists of, or is contained in the colloid material formed in the vesicles of the gland, and from this material Baumann prepared an organic iodine containing compound, iodothyrin, which he supposed constitutes the characteristic element of the secretion; but this conclusion has not been substantiated satisfactorily by subsequent work. Whatever may be the nature of the hormone it exerts a stimulating influence on body metabolism. When the amount of this secretion falls below normal, a condition that may be designated conveniently as *hypothyroidism*, metabolism is decreased and perverted, as in the case of myxedema and cretinism, and in such conditions the deficient hormone may be supplied by grafting the gland from another animal of the same species, or, more simply and more successfully by simply feeding thyroid tissue. On the other hand, when the amount of the secretion is above normal as may result from an increase in the size or the activity of the gland, or from excessive feeding of thyroid tissue or extracts, we have a condition of *hyperthyroidism* in which the metabolisms of the body are increased and possibly also perverted since under these circumstances there is a heightened irritability of the heart and central nervous system. It is commonly believed that the symptoms of exophthalmic goiter owe their existence in part at least to a condition of hyperthyroidism. In regard to the parathyroids not much that is definite is known beyond the fundamental fact that complete parathyroidectomy is usually quickly fatal and that muscular tremors and spasms constitute the most striking visible result of the operation. While it is open to us to assume that this tissue like the thyroid proper forms an internal secretion whose hormone takes some specific part in controlling metabolism, it is perhaps more commonly assumed that the rôle of the parathyroids consists in neutralizing toxic substances formed in the metabolism of the body. As some evidence in this direction it is stated that in a parathyroidectomized animal the tetany may be made to disappear by bleeding and infusing this animal. This result would seem to indicate that the toxic substance or condition responsible for the tetany was contained in the circulating blood.

The Adrenal Bodies.—Brown-Séquard was the first to show that removal of these bodies in dogs is followed by the death of the animal within a day or two. Subsequent observers have confirmed this fundamental fact, and have shown that the symptoms preceding death are great muscular weakness, a loss of vascular tone, and a feeble heart beat. On the clinical side these results agree well with the observation that in Addison's disease, which is accompanied by a lesion of the adrenals, there is also marked asthenia with feeble heart beat and loss of vascular tone. As in the case of the thyroids physiological investigations of recent years tend to show that the adrenals produce an internal secretion of importance in metabolism, particularly the metabolism of the muscular tissues. Extracts of the medulla of the gland injected into the circulation of a normal animal cause a marked slowing and strengthening of the heart beat and a rise of blood pressure. The heart effect, so far at least as the slowing of the beat is concerned, is due to an action of the extract on the inhibitory center of the vagus, since it disappears on section of these nerves or after the administration of atropine. After section of the vagi injection of the extracts causes a quickening of the heart rate and a great rise of blood pressure and it is said that a similar augmentation of the heart beat may be caused, when the vagi are intact, provided the dose is reduced greatly. The effect on blood pressure seems to be due to a direct action on the musculature of the small arteries and veins or upon the endings of the vasoconstrictor nerve fibers in these vessels, thereby causing a contraction and an increase in peripheral resistance. The evidence at hand indicates that the active hormone in the secretion (epinephrin) acts in general upon the endings of the sympathetic autonomics (Langley). Where these endings normally cause contraction as in the case of vasoconstrictor fibers there the epinephrin also causes contraction, but where the nerve fibers affected normally exhibit inhibitory activity, as in the case of the endings of the splanchnic nerves in the musculature of the intestine, there also the epinephrin when injected into the blood causes inhibition or relaxation. The effect of injections of adrenal extracts upon blood pressure is only temporary; in a few moments the pressure returns to normal, showing that the active substance is quickly neutralized or destroyed within the body. This active substance in the medulla of the glands is normally secreted into the adrenal veins, since blood collected from these veins and injected into a normal animal gives the effects described above. There is also direct evidence that the secretion of this substance is under the control of secretory nerve fibers which reach the gland through the splanchnic nerves. These fibers may be stimulated directly or reflexly, but perhaps the most interesting fact in regard to them is that they are brought into activity by emotional excitement of any kind (Cannon *et al.*). The quickened heart-beat and higher blood pressure associated with rage or fear may be explained by this mechanism. It should be stated also that the secretion of the adrenal glands as well as its extracts exercises other effects upon body metabolism, particularly in the matter of the sugar regulation. Adrenal extracts increase the amount of sugar in the blood, and it has been suggested that this result is due to a stimulating effect upon the process of glycogenolysis in the liver whereby more glycogen is converted to sugar and passed into the blood. A number of investigators have attempted to isolate the active substance and these efforts have been rewarded with unusual success. The active hormone has been isolated in pure form; its chemical structure has been ascertained and it has even been prepared synthetically. The hormone has the molecular composition given by the formula ($C_9H_{13}NO_3$) and chemically is described as a dioxyphenyl-ethylol-methylamin. In medical literature it is designated by a variety of names: epinephrin, adrenalin, adrenin, etc., and under a number of trade names some of its derivative compounds are on the market for thera-

peutic use, particularly as a hemostatic. The conclusion commonly drawn from the above facts is that the adrenals secrete continually into the blood a substance that is necessary to the maintenance of normal muscular tonicity, particularly in the circulatory organs. When it is completely absent, as in

Groups of similar cells are found in the ganglia of the sympathetic chain or in irregular masses along the abdominal aorta below the adrenal glands. Since these cells probably have a function similar to that of the medullary cells of the adrenal gland they are grouped together under the general term, chromaffin

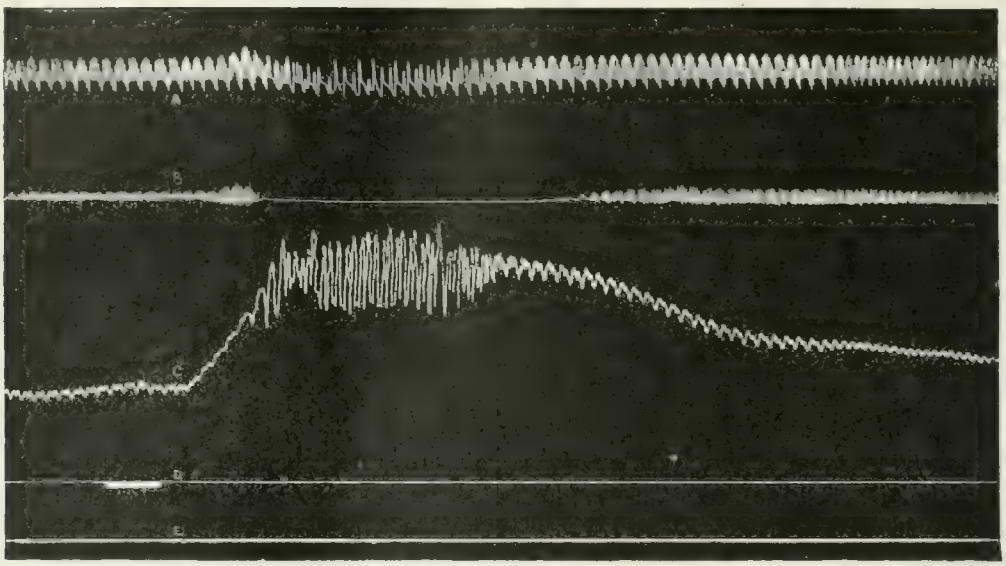

FIG. 4482.—Curve to show the Effect of Intravenous Injections of Extract of the Adrenal, when the Vagi are Intact. The time of the injection and the duration are represented by the white space on line *D*; the effect on blood pressure and pulse rate is represented by line *C*; the effect on the contractions of the ventricle and the auricle are represented respectively by lines *A* and *B; E* gives the time in half seconds. (Schaefer.)

removal or disease of the adrenals, there is a marked loss of muscular tone. The fatal result may possibly be attributed directly to the effect on the circulation, the feeble heart beat, and the loss of vascular tone, giving a condition analogous to that caused by vascular shock. This explanation of the normal function of the adrenal glands is applicable only to the

system. The above suggestion in regard to their normal function is not wholly satisfactory. It assumes that there is a constant secretion of the hormone into the circulation, but as a matter of fact some authors deny that epinephrin occurs constantly in the blood in amounts adequate to give an effect upon arterial tone. However this may be, it is perhaps evident that

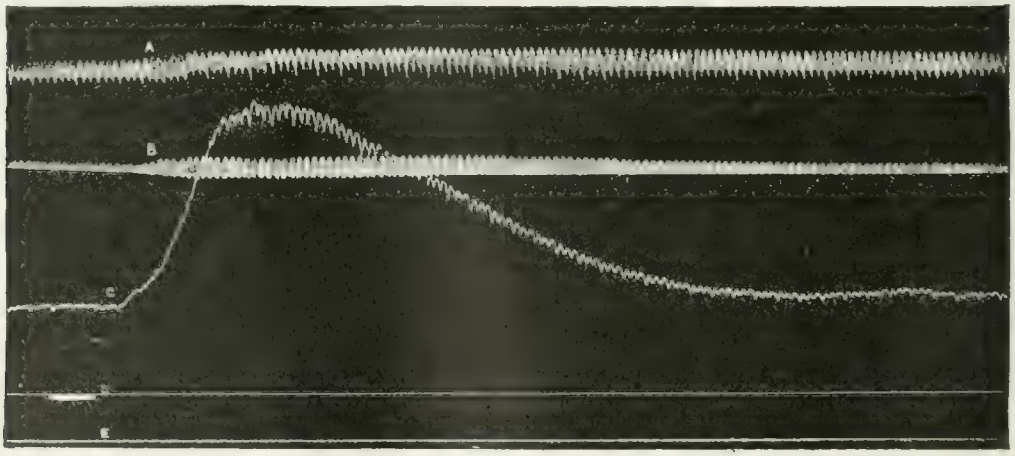

FIG. 4483.—Curve to show the Effect of Intravenous Injections of Extract of the Adrenals when both Vagi are Cut. The designation of the curves is the same as in the preceding figure. (Schaefer.)

medullary portion of the gland. There is much evidence that the hormone, epinephrin or adrenin, is secreted only by the medullary cells or similar cells found elsewhere. The cells in question give a characteristic color reaction with chromates and hence are sometimes designated as chromaffin cells.

the probable wide effect of epinephrin on the tissues innervated by the sympathetic autonomics, and upon the glycogenetic function is not taken account of in this theory, so that if correct so far as it goes, it does not explain the entire functional significance of the secretion. As regards the cortical portion of the

adrenal gland our knowledge regarding its functions is less complete but highly interesting. In some of the fishes this portion of the gland is anatomically distinct from the medullary portion and is designated as the *interrenal body*. Its extirpation in these animals is followed by a condition of progressive muscular weakness ending in death (Biedl). This result indicates that the cortex has some function essential to life, and it is probable that this function is mediated through an internal secretion containing a hormone

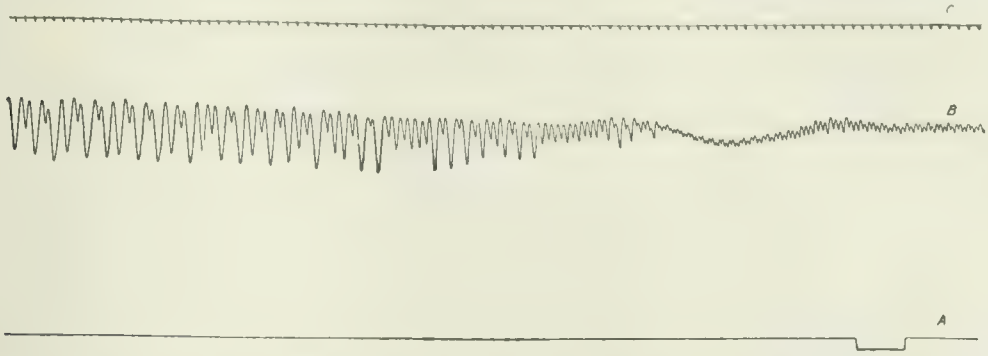

FIG. 4484.—Curve showing the Effect upon Blood Pressure and Heart Beat of an Injection of an Extract of the Infundibular Body when the Vagi are Intact. The point of injection is shown upon line *A*; *B* is the blood-pressure record and *C* the time record in seconds. (Howell.)

different from the epinephrin. Some observers (Crowe and Wislocki) are inclined to believe that the rapidly fatal result of complete extirpation of the adrenal glands in the mammal is due to the loss of cortical rather than of medullary tissue. But the nature of the secretion furnished by the cortex and its normal functional value are matters of speculation only at present. Attention has been called to a special relation to the sexual glands. The various phases of sexual life seem to be accompanied by histological changes in the cortical cells, but this relationship is

The Pituitary Body.—The pituitary body so called consists in reality of two quite distinct structures: a large anterior lobe of glandular structure and a smaller posterior lobe adherent to the infundibulum of the third ventricle of the brain. The latter lobe consists of two parts, the *pars nervosa* composed chiefly of neuroglia tissue, and the *pars intermedia*, a thin layer of epithelial or glandular cells which invests the periphery and neck of this lobe (Herring). Embryologically it has been found that the anterior lobe and the pars intermedia of the posterior lobe

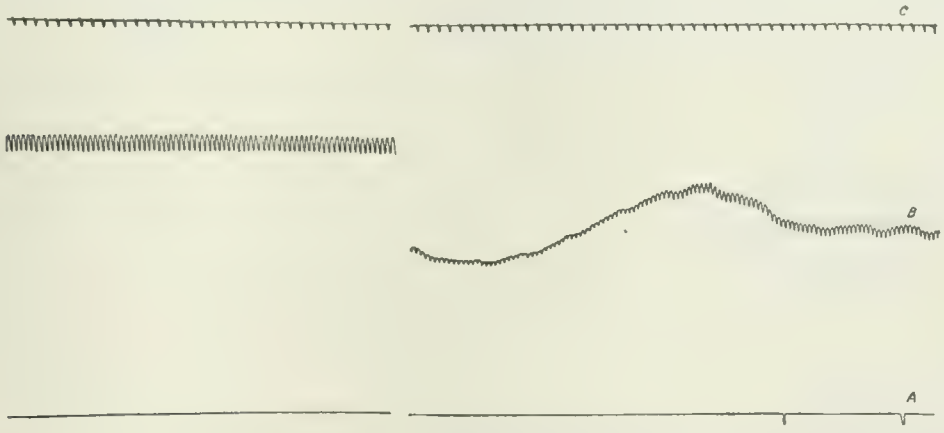

FIG. 4485. —Curve showing the Initial and Final Effect of an Injection of Extract of the Infundibular Body when the Vagi are Cut The designation of the curves is the same as in the preceding figure. (Howell.)

indefinite and if significant throws no special light on the function of the tissue. Attempts to use adrenal extracts therapeutically in cases of Addison's disease, that is, to substitute injections of the extracts in place of the normal secretion, have given negative or uncertain results. This failure may be due to the fact mentioned above, namely, that the effect of injections is quite transient. According to Battelli, continuous injections of adrenal extracts fail to prolong life to any noticeable extent in animals whose adrenals have been removed experimentally, and Christiani and

arise from the ectoderm of the mouth cavity. Whatever secretory activity the organ may possess is resident probably in these structures. The nervous part of the posterior lobe arises from the third ventricle of the brain and in the adult at least it is probable that this tissue has no glandular activity. Experimental work upon the physiology of the pituitary body has proceeded mainly along two lines, namely, the effects of injecting extracts of the gland into the living animal, and the effects of partial or complete hypophysectomy. As regards the first method it has been

found that injections of extracts of the anterior lobe give negative results. Injections of extracts of the posterior lobe on the contrary are followed by well-marked effects on the heart and blood-vessels, the kidneys, the mammary glands, etc. The heart rate is slowed and the blood pressure is raised (Howell-Schäfer and Vincent) somewhat as in the case of epinephrin, although the effect is less intense but longer lasting than with the latter substance. In the kidney a diuresis is produced (Schäfer) and in the mammary glands, when in functional activity, there is an increased secretion of milk (Ott and Scott). It is stated also (Weed and Cushing) that these extracts stimulate the flow of cerebrospinal liquid. The inference from these experiments is that the posterior lobe, presumably the pars intermedia only, forms an internal secretion containing one or more hormones which have a widely extended action upon glandular and plain muscular tissue. Its effect upon the latter tissue is more general than in the case of epinephrin, it seems to stimulate contraction in all or most of the involuntary muscles in the body, *e.g.* the intestines, bladder, and uterus as well as the blood-vessels. Whereas the epinephrin, it will be remembered, stimulates the endings of the sympathetic autonomics and causes contraction (vasoconstriction) or relaxation (intestines) according as the nerve fibers are motor or inhibitory. The general stimulating effect of the posterior lobe secretion makes it probable that its action is directly upon the muscle itself. On the histological side characteristic hyaline or colloid bodies occur in the posterior lobe and there is some evidence that this constitutes the secretion. It has been suggested that this material, formed in the pars intermedia, traverses the nervous part of the lobe and enters finally the third ventricle where it is dissolved in the cerebrospinal liquid and then penetrates into the general circulation by passing into the veins. In addition to its effect on the glandular and muscular tissues the experiments on extirpation make it probable that this secretion affects also the general metabolism, especially the carbohydrate metabolism. Removal of the pituitary body is an operation offering considerable surgical difficulty and the results of the first work reported were confusing and unsatisfactory. Better operative methods have given, however, more consistent results (Paulesco-Cushing). Removal of the entire gland causes the death of the animal in a few days with symptoms of a fall in temperature, diarrhea, and emaciation. Removal of the anterior lobe alone gives a similar fatal result, while removal of the posterior lobe alone is not fatal, but is attended by certain characteristic changes in body metabolism. There is a tendency to obesity and an increased tolerance to carbohydrate foods. If the operation is performed on a young animal the normal development of the reproductive glands is retarded or arrested, the animal exhibiting a condition of sexual infantilism. On the clinical side lesions of the hypophysis have been associated with the conditions of gigantism and acromegaly and it is assumed that these conditions are indications of a hypersecretion of the anterior lobe. These brief statements indicate clearly enough that the functions of the hypophysis are complex and difficult to interpret. The organ as a whole is essential to life, but the anterior and the posterior (pars intermedia) lobes have different functions. The anterior lobe seems to furnish a secretion that has some specific influence on the growth of the skeleton and in addition plays a rôle of vital importance in metabolism, the nature of which is unknown. The posterior lobe gives a secretion that has a stimulating effect on plain muscle and on some of the glands, that takes part in the general metabolism of the carbohydrates and is correlated in some way with the internal secretions from some other of the ductless glands (adrenal cortex thymus) in controlling or regulating the development of the sexual organs.

Internal Secretion of the Pancreas.—Few discoveries in physiology have been more interesting and significant than that made by von Mehring and Minkowski regarding the internal secretion of the pancreas. Briefly stated, they found that complete removal of the pancreas brings on a condition of serious glycosuria known now as pancreatic diabetes. Acetone and β-oxybutyric acid are also present in the urine, and, as in the diabetes mellitus of man, the animal shows polyuria and an abnormal thirst and hunger. These symptoms are followed by muscular weakness, emaciation, and in a few weeks by death. If the pancreas is removed incompletely the glycosuria may be serious, or slight and transient, or absent altogether, according to the amount of the gland extirpated. If so little as one-fourth or one-fifth of the gland is left in the body the glycosuria may not show itself, and since the portion so left may have no connection with the intestine, this fact as well as others shows that the mere suppression of the pancreatic juice has nothing directly to do with the diabetes that results from complete removal of the gland. In pancreatic diabetes the glycogen disappears from the liver. The blood shows an increase in its sugar contents from 0.15 per cent. to 0.3 or 0.5 per cent., and the urine may continue to contain sugar in quantity when carbohydrate food is withheld completely. On the basis of these and simi-

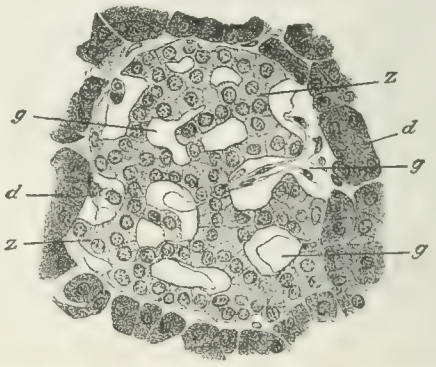

Fig. 4486.—Section through an Island of Langerhans. *d*, The gland cells of the surrounding pancreatic tissue; *g*, blood capillaries; *z*, the columns of cells composing the island. (Kölliker.)

lar results it is believed that the pancreas forms an internal secretion which is given off to the blood. This internal secretion is supposed to play an essential part in the metabolism of the carbohydrates. It has been difficult, however, to find the true explanation of its action. According to one group of workers the hormone furnished by the pancreas plays an essential part in the process known as glycolysis, that is to say in the series of changes by which sugar is broken down and finally oxidized to water and carbon dioxide. Various specific suggestions have been made in regard to the part taken by the pancreatic hormone in this process, but inasmuch as the steps in the metabolism of sugar in the body are still very much in dispute, speculations as to the part taken by the pancreas have been naturally also of an unsatisfactory character. Other observers have adopted an entirely different view, holding that the pancreatic secretion normally regulates the output of sugar from the liver and other sugar-producing tissues. In its absence this output is increased and raises the sugar percentage in the blood to such an extent as to cause glycosuria. We must admit at present that the way in which the internal secretion of the pancreas affects the sugar consumption of the body is not known satisfactorily, although there is no doubt that in some way it is absolutely necessary in the process. Considerable experimental and histological evidence has ac-

cumulated tending to show that the cells concerned in this important function of the pancreas are not the pancreatic cells proper, but the so-called islands of Langerhans. In man these islands are scattered through the pancreas and form round or oval bodies that may reach a diameter of as much as one millimeter. The cells are polygonal and their protoplasm is pale and finely granular, while the nuclei show a thick chromatin network which stains deeply. In each island there is a capillary network resembling somewhat the glomeruli of the kidney.

According to Ssbolew, ligation of the pancreatic duct is followed by a complete atrophy of the pancreatic cells proper, but does not affect to any marked extent the islands of Langerhans. Since under these conditions no glycosuria occurs, while removal of the whole organ including the islands is followed by pancreatic diabetes, the obvious conclusion to be drawn is that it is the removal of the islands that causes the pancreatic diabetes, and that therefore it is these cells that form the normal internal secretion of the pancreas. This conclusion is further corroborated by pathological results upon the lesions of the pancreas in human beings in connection with diabetes mellitus. A number of observers (Opie, Ssbolew, Herzog, *et al.*) find that in diabetes mellitus the islands are markedly affected. They show signs either of hyaline degeneration or of atrophy, and indeed may in severe cases be absent altogether. It must be added, however, that all these conclusions have been contradicted by other observers. Some writers contend that the islands of Langerhans are simply one stage in the development of the ordinary alveolar or acinar cells of the pancreas and therefore have probably no specific function. The most complete study of the subject (Bensley) seems, however, to demonstrate that the islands are permanent organs differing probably in function from the pancreatic cells proper. So also cases of diabetes have been reported in which the islands showed no detectible histological changes. The matter of the relation of these islets to the internal secretion of the pancreas must be considered at present as an open question.

The Reproductive Glands.—The general interest in the subject of internal secretions in recent years was aroused largely by the work of Brown-Séquard upon the effect of testicular extracts (1889–92). The results of his experiments seemed to indicate that these extracts possess a marked stimulating or dynamogenic action upon the neuromuscular apparatus. The effect was said to be pronounced not only upon sexual power but upon general muscular and mental vigor. Pohl claims to have obtained from such extracts a definite substance, spermin, to which he assigned the formula $C_5H_{14}N_2$, and which he believes has a general tonic effect upon body metabolism. Similarly Zoth and Pregel report that these extracts increase the power of doing muscular work when measured quantitatively by means of an ergograph. These and other experiments give us some reason to believe that the testes may form an internal secretion of importance in regulating and stimulating the metabolisms of the body and some similar evidence has been obtained in the case of the ovaries. Most recent work seems to agree upon the fact that the internal secretions furnished by the ovary and testis are not formed in the reproductive cells proper, the egg and the spermatozoon, but in what are known as the interstitial cells of Leydig which lie outside the seminal tubules in the testis. These interstitial cells have an undoubted influence upon the development of sexual characteristics and the normal sexual appetite. When a young male is castrated completely the secondary male characteristics and sexual appetite do not develop with growth, but mere atrophy of the sexual elements, such as may occur after ligation of the cord, does not destroy sexual desire or the development of the secondary sexual organs. Steinach reports many interesting experiments which convince him that the development of secondary sexual characteristics and the phenomenon of puberty in general are dependent on the internal secretion of the interstitial cells. No satisfactory work has been done at present upon the nature of this secretion or of the hormones that it is supposed to furnish. Accepting its existence as probable it must be remembered that there is some kind of reciprocal influence in this respect among a number of the ductless glands. The adrenal cortex, the thymus and the posterior lobe of the pituitary gland all are concerned in some way with the growth and activity of the reproductive organs. However important the internal secretion of the interstitial cells may be it can scarcely be asserted that it is essential to life or even to health. The evidence furnished by castrated and spayed animals seems to be conclusive on that point. If such a secretion is formed, its action is not absolutely necessary to normal metabolism as is shown by the fact that castrated animals live in apparently good health.

The Thymus.—It was formerly supposed that this gland reaches its maximum development at birth and thence forward undergoes a gradual involution and loss of function, but recent work tends to show that the gland retains its full size and presumably also its functional activity until puberty at least, and moreover that remnants of the thymus tissue may remain throughout life with the possibility of a hyperactivity under pathological conditions. The fact that normally the gland undergoes atrophy or involution after the period of puberty would suggest that its activity is associated with the metabolism of growth. This activity is exerted presumably through an internal secretion, but as a matter of fact there is really no direct evidence of the existence of such a secretion. Thymectomy on quite young dogs may prove fatal (Klose and Vogt). The animals show a tendency to excessive fat formation and later develop a cachectic condition owing to a general malnutrition which exhibits itself particularly perhaps in the bones. Other observers have noted also that removal of the gland in young dogs brings on a condition resembling rickets. Castration seems to cause a persistence or retarded atrophy of the gland (Henderson) while on the contrary removal of the thymus hastens the maturation of the reproductive glands (Paton). Gudernatsch reports some striking experiments upon tadpoles in which he found that feeding the animals with thymus tissue caused abnormal growth and a retarded metamorphosis, while thyroid tissue gave, on the contrary, minimal growth and rapid metamorphosis. While it is not yet possible to base any satisfactory theory of function of the gland on these and other known facts it seems almost certain that this gland has some direct connection with the little understood metabolism of growth, particularly perhaps of the skeleton and possibly also an inhibitory influence, direct or indirect, on the development of the reproductive organs.

The Pineal Body.—This small organ develops as an outgrowth from the roof of the third ventricle and in early life exhibits a glandular-like structure which is lost after puberty. By analogy it has been assumed that it may belong to the system of ductless glands and possess therefore a specific internal secretion. As with the other glands experiments have been made by the method of injecting extracts or by the method of surgical removal. Injection of extracts shows the presence of a depressor substance causing a fall of general blood pressure but it can hardly be asserted that this effect is specific. Removal of the gland in the hands of some observers has given serious results which were probably incidental to the operation rather than the result of a loss of pineal function, since Dandy reports a number of cases of complete removal in dogs in which no results of any kind could

be determined although the animals were observed for over a year after the operation. In view of this negative finding it is perhaps doubtful whether any physiological significance at all can be attributed to this structure. WILLIAM H. HOWELL.

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Starling: Recent Advances in the Physiology of Digestion.

Cannon: Bodily Changes in Pain, Hunger, Fear, and Rage, 1915.

Segmentation of the Body.—Segmentation of the body, or metamerism, is an expression used to convey the idea that the body is composed of a series of segments, also called *metameres*, or *somites*, that are arranged in a series along the principal axis, and in each one of which the principal organs are repeated. Familiar examples of metamerism are furnished by the earthworms and centipedes. A better example is a typical marine annelid like Polygordius or Nereis, in which each somite, beside the integument, ventral nerve cord, main blood-vessels, and gut, which are continuous through the length of the body, has its own body cavity separated by a partition from its neighbors fore and aft, a pair of limbs (parapodia), a pair of nephridia, a pair of gonads, and several pairs of lateral blood-vessels and nerves, the same arrangement being found in each somite except the terminal ones.

In the vertebrates there is an indication of a similar metamerism. Thus in all vertebrates the vertebræ, the ribs, and the spinal nerves are arranged metamerically, and in the fishes the trunk muscles are divided by transverse tendinous plates into myomeres, which are likewise metamerical in arrangement. This metamerism of the musculature is present to a less degree in the amphibia, but in the higher vertebrates, including man, it has almost disappeared in the adult, as the result, doubtless, of adaptive modifications. But in the embryo metamerism is very evident, even in the highest forms, and has its foundation in the primitive segmentation of the mesoderm, forming the so-called mesodermal somites. The divisions of the body being thus outlined at an early stage the spinal nerves, lateral blood-vessels, vertebræ, ribs, and the primitive nephredial tubules are developed in definite relation to them.

The body of a vertebrate may be divided into three main regions—head, trunk (extending from the first cervical vertebra to the anus), and the tail. The segmentation of the trunk and tail is very evident in the embryo, if not in the adult, and the number of segments may be counted. Thus in man there are thirty-seven or thirty-eight originally, of which four or five are caudal segments that disappear during the second month of fetal life.

The segmentation of the trunk region in man and other vertebrates has been the subject of an extensive investigation by van Rynberk, both from the physiological (1912) and the anatomical (1910) standpoint. At an early embryonic stage nerve fibers grow out from the spinal cord and become attached to the adjacent mesodermal somites. The latter give rise each to a part of the skeleton, *sclerotom*, to a segment of the corium, *dermatomere*, and to a muscle segment, *myomere*. The dermatomeres soon fuse and with the epidermis form a continuous covering to the body; and the myomeres in the higher vertebrates undergo extensive modifications of form and position. Both would become unrecognizable were it not for the fact that the nervous connections remain unaltered. Thus for each segment of the trunk there is a pair of segmental nerves and their branches, which form a unit, the *hodoneuromere* (from the Greek ὁδος, a path). By tracing the hodoneuromeres to their peripheral connections, it is possible to outline the segments of the skin and of the musculature. Likewise by tracing the fibers from each spinal nerve centrally into the cord it is possible to delimit its segments or *polioneuromeres*.

The segmentation of the head is not so clear, even in the embryo, and has been a subject for earnest investigation and discussion for a long time. While it is evident that the head is a segmented structure, the actual number of segments and the organs appertaining to each one can be determined only after very minute comparative study of the development of the whole complex of muscles, nerves, ganglia, sense organs, and other structures composing the head, and it is not surprising, therefore, that there should be considerable difference of opinion. Thus Rabl denies that the head contains any segments in front of the ear that can be regarded as homologous with the trunk segments. This opinion is contrary to that of Minot and Hertwig, who regard the whole head as composed of homologous segments. But Hertwig estimates the number as nine, while Minot makes it thirteen.

The segmentation of the body in vertebrates has been held to indicate the descent of this group from the annelids. Comparative anatomy shows, however, that the most primitive known allies of the vertebrates present no likeness to the annelids, but, on the contrary, resemble in some respects the echinoderms, or rather their larvæ; therefore the annelid theory of the origin of the vertebrates seems of very doubtful validity. It is more probable that the metamerism of the body arose independently in the primitive forms of the two groups in adaptation to a similar mode of life. ROBERT PAYNE BIGELOW.

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Segmentation of the Ovum.—The segmentation, or cleavage, of the ovum is the first stage in the development of an embryo from an egg. It is the process by which the ovum, a single cell, becomes converted into a multicellular organism. In this and the subsequent stages the division of the cytoplasm is preceded by mitotic division of the nucleus, in which the chromosomes are divided longitudinally and the two halves go to opposite poles of the spindle. Thus the two daughter cells receive amounts of chromatin which are alike quantitatively and probably qualitatively. This stage begins with the first cell division after fertilization (or after the last maturation division in case of parthenogenesis, *q.v.*) and it is ended when the cells assume an epithelial character. But of course cell division continues during later stages, in fact throughout life in some tissues, as in the epidermis (see *Ovum*, *Gastrula*, and *Area embryonalis*).

The course of cleavage differs greatly in different groups of animals. Eggs having comparatively little

deutoplasm, or yolk, divide completely into two, four, eight, sixteen, . . . etc., cells. The cleavage is then said to be *total*, and the egg is described as *holoblastic*. The cells derived from the division of the ovum are called *blastomeres*. The blastomeres may be very nearly of the same size or some may be much smaller than the others. In the first case the cleavage is said

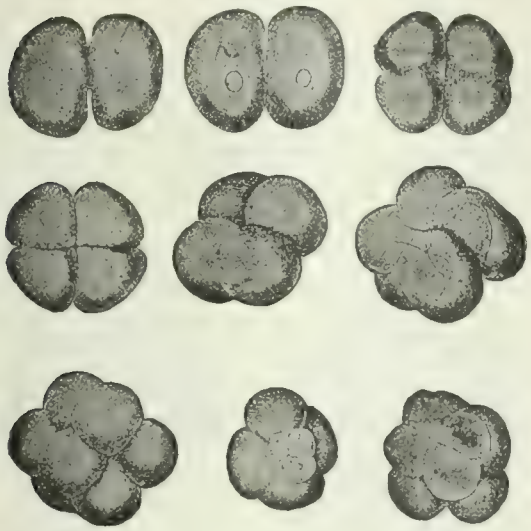

Fig. 4487.—Cleavage of the Egg of an Irregular Sea Urchin, Echinocardium. *A*, First cleavage furrow; *B*, two-cell stage; *C*, beginning of second furrow; *D*, *E*, four-cell stage; *F*, third cleavage, two cells have divided and two are in process of division; *G*, eight-cell stage complete; *H*, sixteen-cell stage, seen from animal pole; *I*, same from vegetal pole. Magnified. (After Fleischmann.)

to be *equal*, in the second it is *unequal*. When the blastomeres are not of the same size, the smaller ones are called *micromeres* and the larger ones *macromeres;* and usually they differ in the parts they play in the development of the embryo. Equal cleavage is found in the eggs of sponges, celenterates, echinoderms (Fig. 4487), truncates, amphioxus, and mammals (Figs. 4488 and 4489), and in some annelids, crustacea, and molluscs. Unequal cleavage is typical of the

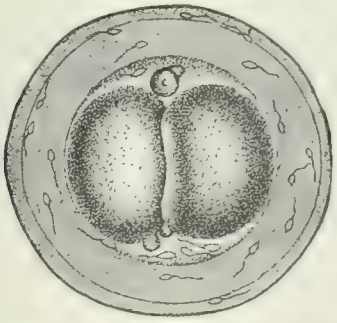

Fig. 4488.—Egg of a Rabbit of Twenty-four Hours; the first cleavage has been completed. (After Coste.)

annelids, molluscs (Fig. 4491), lampreys, ganoid fishes, and amphibia (Fig. 4490).

Other animals produce eggs that contain a very large proportion of deutoplasm. In such cases only a part of the egg undergoes segmentation, the rest of the yolk dividing incompletely and being finally absorbed as food by the growing embryo. This form of cleavage is called *partial*, and the egg is described as *meroblastic*.

Meroblastic eggs may be *centrolecithal*, having the yolk chiefly at the center, or *telolecithal*, having it

Fig. 4489.—Egg of a Bat, Vespertilio Murina, in the Four-cell Stage. (After Van Beneden and Julin.)

concentrated toward the vegetal pole (see *Ovum*). Centrolecithal eggs have a *superficial* cleavage, the blastomeres forming a layer of cells, the *blastoderm*, surrounding the unsegmented yolk. This form of cleav-

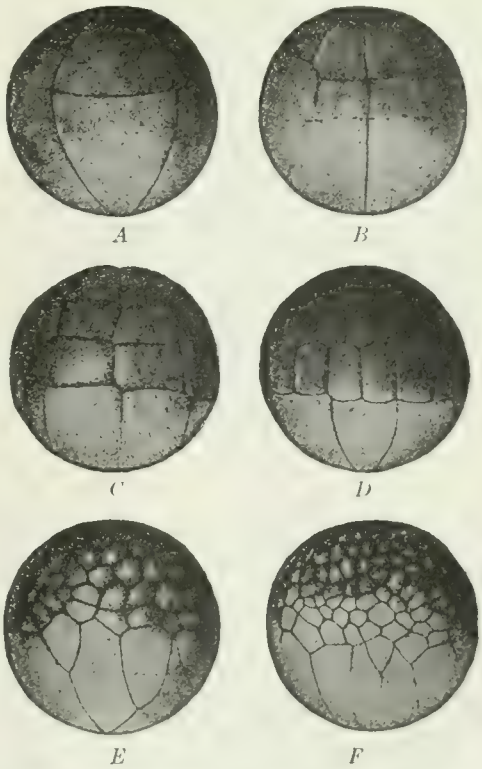

Fig. 4490.—Segmentation of the Frog's Egg and Formation of Blastopore. *A*, Eight-cell stage; *B*, beginning of sixteen-cell stage; *C*, thirty-two cell stage; *D*, forty-eight cell stage (unusually regular); *E*, *F*, later stages. Magnified. (From Morgan.)

age is characteristic of the arthropods. Telolecithal eggs have a *discoidal* cleavage, the blastoderm forming a disc at the animal pole of the egg. This is the form of cleavage to be found in the eggs of cephalopods

(Fig. 4492)), sharks and rays, bony fishes, reptiles, birds (Fig. 4493), and monotremes.

The position of the planes of cleavage depends somewhat upon the type of the egg. In centrolecithal eggs the cleavage nucleus takes a position near the center of the egg previous to division. Then follows a number of nuclear divisions without division of the cytoplasm. The resulting nuclei migrate to the surface of

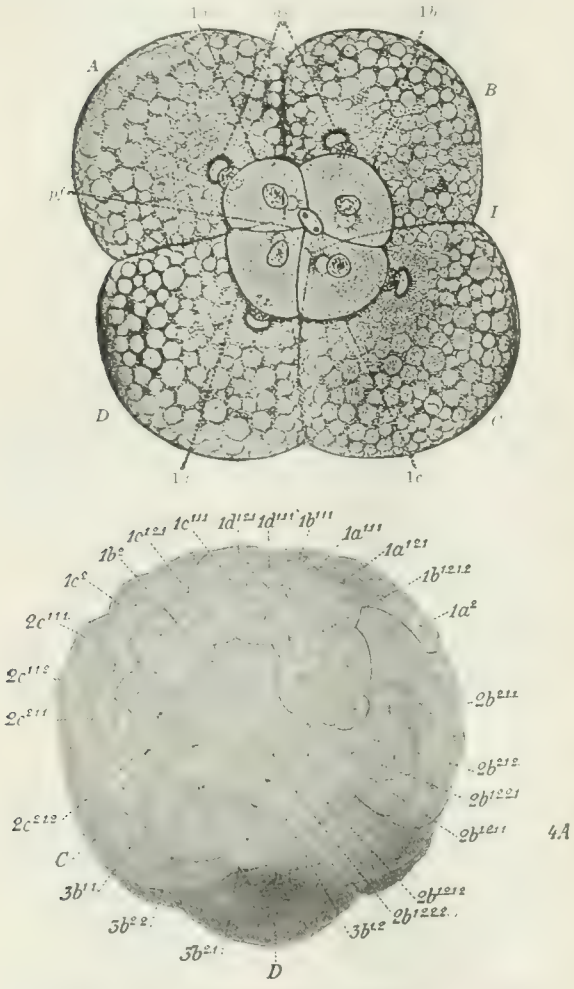

FIG. 4491.—Two Stages in the Development of Crepidula. Upper figure, four-cell stage viewed from above; lower figure one hundred and nine-cell stage, viewed from the side. *I* and *II*, first and second cleavage furrows: *A*, *B*, *C*, *D*, macromeres; 1*a*, 1*b*, 1*c*, 1*d*, micromeres; *as*, aster. Highly magnified. (From Conklin.)

the egg, and the mass of cytoplasm gathered around each nucleus becomes separated from its neighbors by cleavage furrows starting from the exterior.

In alecithal and telolecithal eggs the first two planes of cleavage are always at right angles to one another and cross at the animal pole of the egg (Fig. 4487, *A*, *E*). In many cases the structure of the egg is such that the first plane must coincide with a predetermined radius. In other cases the path of entrance of the spermatozoon determines the radius of the first cleavage, while in still other eggs this appears to be wholly indeterminate. In the subsequent stages there are developed three types of cleavage—radial, spiral, and bilateral. As examples of the radial type we may take the eggs of sea urchins and of frogs, both holoblastic eggs, the one having equal cleavage, the other unequal. Any one provided with a good microscope can easily observe the cleavage of the eggs of sea urchins or of starfish. The eggs are obtained by cutting up the ovaries of a ripe female. If these are placed in a dish of clean sea water and a small piece of the testis of a ripe male is cut into small pieces and mixed with the eggs, fertilization will take place, and then it requires only a little patient watching of eggs placed from time to time under the microscope for one to observe all stages up to the formation of the larva. Freshly laid and fertilized frog's eggs may be obtained by careful search of the ponds in early spring. By packing the eggs with ice, development may be delayed until the laboratory is reached. After the eggs have been placed in fresh water at the normal temperature, the cleavage will proceed and may be followed easily with a hand lens or a microscope.

The first indication of cleavage is the appearance of a slight furrow at the animal pole—the position of the polar body in the echinoderm's or the center of the black half in the frog's egg. This occurs in the frog's

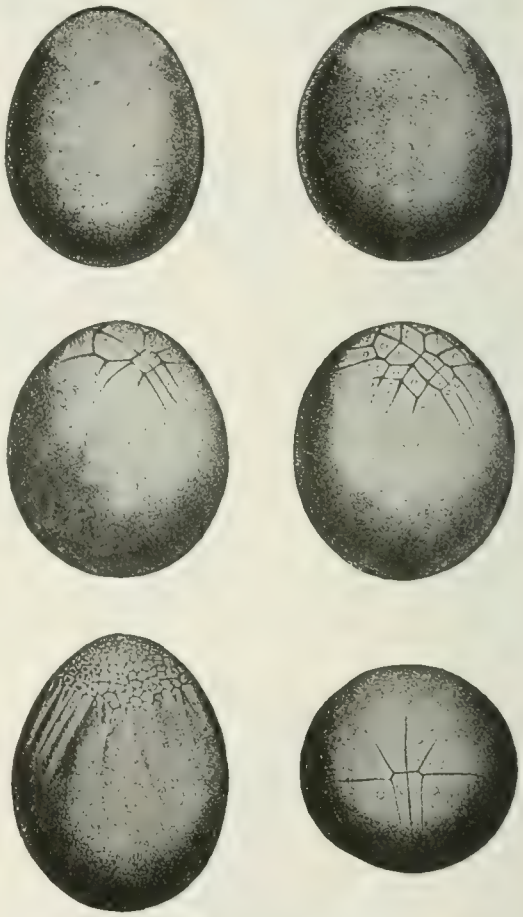

FIG. 4492.—The Discoidal Cleavage of the Egg of a Squid. *A*, Unsegmented egg and polar bodies; *B*, first cleavage furrow; *C*, *D*, *E*, later stages; *F*, eight-cell stage viewed from the animal pole and showing the marked bilateral symmetry of the cleavage furrows ×30. (After Watasé.)

egg between two and a half and three hours after fertilization. This furrow quickly deepens and extends around the egg to the other side (Fig. 4487, *A* and *B*). Sections of an egg made just before and during this stage show that the nucleus had divided previously by a typical mitosis, and that the plane of cleavage is at right angles to the spindle, so that each blastomere contains one of the daughter nuclei. During the division the blastomeres become more or

less rounded. But when it is completed they flatten against one another, so that the line of division becomes indistinct, and the egg rests for a time. At the end of the resting period, about three-quarters of an hour after the appearance of the first furrow in the frog, the blastomeres round up again and the second furrow makes its appearance at right angles to the first at the upper, animal, pole of the egg (Fig. 4487, *C–E*). This furrow extends around the egg like the first, dividing each blastomere into two. The egg is now in the four-cell stage. After another period of

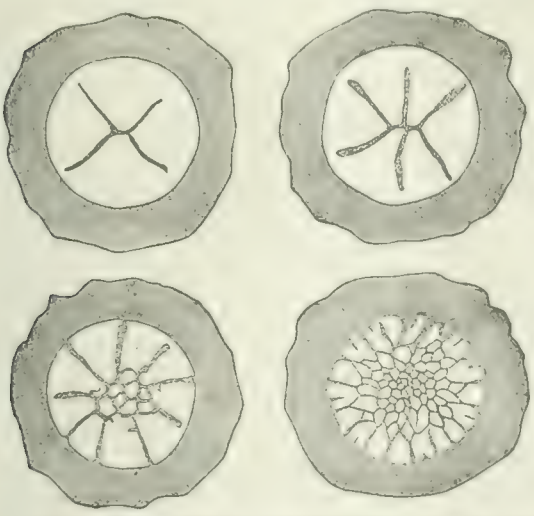

Fig. 4493.—Four Stages of the Segmentation of the Hen's Egg. Only the germinal disc, seen from above, and part of the surrounding yellow yolk are represented. (After Coste.)

rest, the third cleavage furrow appears in a horizontal plane at right angles to both the first and the second. In the echinoderm egg this is very nearly at the equator of the egg, but in the frog it is somewhat above the equator, so that in the eight-cell stage we find four black micromeres and four white macromeres. Compare *F* and *G*, Fig. 4487, with *A*, Fig. 4490. The fourth cleavage in the frog occurs from one-half to three-quarters of an hour later. When this is regular each blastomere is divided into two in a plane at right angles to the preceding one. The planes of division form two great circles bisecting the angles between the first two. But in the frog the eggs are seldom so regular as this and the following cleavages are quite irregular (Fig. 4490).

The spiral form of cleavage is characteristic of the worms and molluscs (Fig. 4491). In these groups the third cleavage plane is not a continuous horizontal circle, but is tilted in each blastomere, to the left usually, looking at the egg from the side. Thus the blastomeres of the two quartets in the eight-cell stage do not lie directly one above the other, but they break joints. The lines of division in the next cleavage are tilted in the opposite direction, and are thus at right angles to the preceding ones. This alternation of spirals may continue for several generations of cells. In these forms the blastomeres are frequently unequal to a marked degree, and the rhythm of cleavage may vary in the blastomeres of different sizes, with the result that there is developed a very complex type of cleavage.

In the bilateral form of cleavage there is but one plane of symmetry, usually coinciding with the first cleavage furrow. The blastomeres are arranged in a bilaterally symmetrical pattern on the two sides of this plane. This form of cleavage is found in both holoblastic and meroblastic eggs, namely, those of tunicates and cephalopods (Fig. 4492).

The cleavage of the bird's egg is not easy to observe, for it takes place before the egg is laid, but cleavage stages have been observed in eggs taken from the oviduct of the hen and the pigeon (Harper, 1904), and the cleavage appears to be of an irregular radial type. As in other meroblastic eggs, the earlier cleavage furrows are incomplete, so that the blastomeres are not separated from the undivided yolk. It is only after several radial furrows have formed that concentric ones appear, dividing the blastomeres into a central group of superficially complete ones surrounded by a circle of larger blastomeres still connected with the yolk at the surface (Fig. 4493); and it is still later when a horizontal division occurs, separating the central blastomeres from the yolk beneath.

The segmentation of the ovum differs also among the various groups of animals in being either *determinate* or *indeterminate* in character. Typically determinate types of cleavage are found in the eggs of worms and molluscs. In these forms the cleavage is often very complex, and at first glance appears very irregular, but careful study shows that each cell division follows a law that is perfectly definite within the species. Thus the history of each cell may be traced from the first cleavage to the formation of the organs. Conklin, for example, has constructed a remarkable genealogical tree showing the history of each cell in the eggs of Crepidula, the common slipper shell, to the one-hundred-and-nine-cell stage (Fig. 4491), and from the groups of cells present at that stage he was able to observe the development of various important organs.

In the echinoderms and vertebrates, on the other hand, the cleavage soon becomes irregular and no one has succeeded, so far, in tracing the history of the blastomeres. So, for the present, the cleavage of these forms must be regarded as indeterminate. The cleavage of the human ovum is unknown, but its character may be inferred from what has been observed in other mammals. The cleavage of the monotremes is discoidal, forming a blastoderm upon one side of the yolk (see article *Blastoderm*, Fig. 661). In the eggs of marsupials the small amount of yolk is extruded during the early stages of cleavage, which results in the formation of equal blastomeres that finally form a blastocyst surrounding the yolk (Hartman, 1916). The eggs of placental mammals contain practically no yolk. The cleavage is total, equal, and irregular (Figs. 4488 and 4489), resulting in the formation of a solid mass of cells known as a *morula*. This soon acquires a cavity and becomes a blastocyst. In the rat this stage is reached during the fifth day after insemination (Huber, 1915).

Robert Payne Bigelow.

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Semen.—As ejected, semen presents a whitish-yellow milky appearance. It is a viscous, sticky fluid, containing white non-transparent lumps.

The milky appearance is caused by the presence of spermatozoa. It contains proteins, is heavier than water, is neutral or alkaline in reaction, and possesses a peculiar odor. It becomes gelatinous soon after ejection and later reassumes a fluid nature. White flakes or shreds separate on dilution with water. It contains 9.7 per cent. solids with 0.9 per cent. inorganic and 8.8 per cent. organic substance. Protein is present to the extent of 2.3 per cent. and bodies soluble in ether to the extent of 0.17 per cent. The proteins present consist of nucleoproteins, mucin, and albumin. The inorganic constituents consist mainly of calcium phosphate and sodium chloride with potassium present in smaller amounts. Ejected semen differs from that in the vas deferens by possessing a peculiar odor. The odor is conferred upon the semen by the admixture of the secretions of the prostate. The secretion of the prostate is alkaline in reaction and presents a milky appearance. It contains small amounts of proteins, particularly nucleoproteins, a substance similar to fibrinogen, and one similar to if not identical with mucin, together with inorganic salts of which sodium chloride predominates. In addition an enzyme, *vesiculase*, is present which probably is concerned in the production of the process resembling coagulation occurring in ejected semen. Lecithin, chlorine, and a base C_2H_5N in combination with phosphoric acid are also present. The phosphorus compound has been called Böttcher's spermine crystals and it is probable that the peculiar odor of semen is due in part at least to decomposition products of this crystalline substance. On slowly evaporating the semen or upon preservation in alcohol crystals are deposited which are identical with the phosphorus compound mentioned above. The base C_2H_5N has been called spermine. These crystals, contrary to some statements, are different from the Charcot-Leyden crystals found in the blood and in the lymphatic glands in leucemia.

Chemically the spermatozoa are divisible into two parts the head and the tail. In the head nucleic acid is especially abundant. The tail contains proteins and is also rich in lecithin, cholesterol, and fat. These substances are present to a very limited extent only in the head. In fishes the nucleic acid is combined in part with protamines and in part with histones.

Frank P. Underhill.

Semmola, Mariano.—Born at Naples, Italy, Jan. 31, 1831. He studied medicine, first in his native city, and afterward at Paris, where his principal instructors were Claude Bernard, Trousseau, and P. Rayer. In 1853 he began the practice of his profession in his native city, and in 1856 he was chosen Attending Physician at the large Hospital for Incurables in Naples. In 1865 he received the appointment of Professor of Pharmacology and Therapeutics at the University. In 1886 the Government made him a member of the Royal Commission to which was confided the duty of providing suitable sanitary regulations for the Kingdom of Italy; and later, in the same year, he was made a senator, in recognition of the services which he had rendered to his country. He died April 5, 1896.

Semmola made a number of valuable contributions in the department of experimental therapeutics. Of his published writings the following deserve to receive special mention: "Terapia empirica e terapia scientifica," Bologna, 1869; "Del metodo sperimentale nella materia medica, etc.," Naples, 1865; reports on the employment of iodoform in cases of tuberculosis, on cardiac syphilis, on the treatment of lead-poisoning by means of the electric current, etc.; lectures on experimental pharmacology and clinical therapeutics, published in 1887; a monograph entitled: "Bacteriology in its Relations to the Experimental Method;" and the article on "Diseases of the Liver" in the Twentieth Century Practice of Medicine. A. H. B.

Senega, U. S. P. (*Senegæ Radix* B. P.).—The dried root of *Polygala senega* L. (fam. *Polygalaceæ*). The senega plant is a smooth, perennial herb, its habit well displayed in the accompanying illustration. Flowers small, pinkish white, in terminal spikes; calyx irregular, of three small green, and two (lateral) large, petaloid sepals, the latter concave and enclosing the corolla; corolla consisting of three partly united petals, of which the lower is concave and ornamented with a crest of papillæ; stamens eight, diadelphous (1 + 4); ovary transversely two-celled; style single. Senega has a wide range in the United States, from western New England and the Middle and Western States southward. It is now mostly collected in Minnesota and Manitoba. The variety *latifolia* is a larger form with broader leaves.

The plant takes its common name, "Seneca snakeroot," from the Seneca Indians, by whom it is reported to have been used as a remedy for snake-bites.

The root is mostly seven to fifteen centimeters (three to six inches) long and four to six millimeters (one-sixth to one-third inch) thick, exclusive of the large, knotty, many-headed crown, occasionally reaching several times this size; tortuous, tapering, and bearing several similar horizontal branches, and few rootlets, and for a variable distance below the crown a more or less sharp keel, varying greatly in prominence, and usually taking a spiral direction, often nearly absent; externally yellow brown to dark gray brown, longitudinally wrinkled; fracture rather tough, but short and sharp, the bark thick, yellow or brownish, of a waxy or resinous, faintly fine-radiate appearance, enclosing a yellowish-white wood, from which a larger or smaller radial segment is usually wanting; odor slight, disagreeable; taste sweetish, then acrid.

Various adulterants of senega have been reported, consisting chiefly of the roots of other species of *Polygala* of the southern United States, but any other than the genuine root is now scarcely seen in commerce.

Constituents.—The important constituents of senega are the two saponin-like glucosides *senegin* and *polygalic acid*, from one to two per cent. of the former and about five per cent. of the latter. There are also present from six to nine per cent. of fixed oil, some glucose, resin, gum, and very variable amounts of methyl salicylate and methyl valerianate, which latter give to the drug its characteristic odor. Starch is wanting. Senegin resembles in properties and action the saponin of soap-bark, while polygalic acid resembles quillajic acid, but they are weaker, respectively, than these substances.

Action and Use.—Senega possesses in medium degree the characteristic physiological properties of the saponin-containing group of drugs. In the nares it is sternutatory, in the mouth acrid and somewhat sialagogue. In small doses it is stomachic and laxative; in larger ones emetic or purgative. It is a nauseating yet stimulant expectorant, and this constitutes the basis of its principal use. It has been extensively employed in chronic bronchitis and other diseases accompanied by cough. As an ingredient of cough preparations it has probably its most extensive use, but is much less valued than formerly. As an emmenagogue and diuretic it is obsolete.

The dose of senega is about gr. xv. (1.0). The official preparations are the fluid extract and from it the twenty-per-cent. syrup. The compound syrup of squill contains eight per cent. of fluid extract of senega. Henry H. Rusby.

Senna, U. S. P., B. P. (*Folia Sennæ*, P. G.).—The dried leaflets of *Cassia acutifolia* Delile (*Alexandria*

Senna), or of *Cassia angustifolia* Vahl (*India Senna*); fam. *Leguminosæ*.

In the United States, German, and French pharmacopœias, the general title covers both the principal varieties; in the British, the Alexandrian (*Senna Alexandrina*) and Tinnivelly (*Senna Indica*) sennas are distinguished by name; they are always entirely distinct in the market.

1. *C. acutifolia* Delile is a small shrub about a meter (a yard) high. Its pod is broad, flat, coriaceous, slightly curved, rounded, and oblique at the ends, containing about half a dozen seeds. This species has a wide and unknown range in Central Africa, is abundant in Nubia, Kordofan, Sennaar, etc., and is said to be found in Timbuctoo. The leaflets are gathered twice a year by native tribes and carried to Alexandria, where they are very carefully freed from sticks, stems, stones, and other impurities, and the broken and defective leaves separated, the different portions of leaf, even to the siftings, being marketed separately.

2. *C. angustifolia* Vahl. is also a small shrub, a good deal like the preceding, but it has larger flowers and larger, more numerously paired leaflets. Its pod is narrower and straighter than that of *C. acutifolia*, and contains about eight seeds. It is a native of Arabia, and in the wild state supplies an inferior, carelessly collected variety of senna (Arabian). It is also said to be found in Somaliland. This is the species cultivated in the south of India (where it is not indigenous) as the source of Tinnivelly senna. The leaves, under cultivation, are increased in size and improved in quality.

Although the Alexandrian variety brings a higher price and is generally held in higher esteem, there seem no good grounds for the idea that it is essentially different in its action from the other.

Description.—*Alexandria senna* consists of leaflets with extremely short, stout petioles, about 2.5 centimeters (one inch) long and one centimeter (two-fifth inch) broad, inequilaterally lanceolate or lance-ovate, acutely cuspidate, entire, subcoriaceous, brittle, pale green or slightly yellowish or grayish green, sparsely and obscurely hairy, more so underneath, the hairs appressed; odor peculiar, tea-like; taste mucilaginous, tea-like, bitterish.

It is frequently contaminated with the one-nerved, thick, wrinkled, glaucous, equilateral Argel leaves.

India senna leaves average nearly twice as long, though but little broader, are more abruptly pointed, usually more yellowish, and the hairiness is even more obscure.

Constituents.—As to its active constituents, senna is closely related to rhubarb, cascara sagrada, and some other laxative and cathartic drugs. Like them, its active principles appear to be the anthraquinones emodin, iso-emodin, and chrysophanic acid, all of which have been considered elsewhere, with which exist rhamnetin, a large amount of gum, a little tannin, and ordinary leaf constituents. Cathartic acid, formerly regarded as the active constituent, is apparently a mixed body, and fairly represents the properties of the drug. However, the administration of anything else than the entire drug, or a preparation of it, appears inadvisable.

Action and Use.—This is one of the most satisfactory and generally useful of simple cathartics, usually emptying the bowels thoroughly in ten or twelve hours, with but little depression or other untoward effects, excepting a variable amount of griping; it acts principally upon the small intestine, and the amount of effect produced can generally be pretty accurately regulated, by the dose, from the mildest laxative to a brisk cathartic. It is in universal domestic use, and is the foundation of numerous proprietary laxatives. By combination with salines its activity is considerably augmented; in small doses it does not readily lose its efficiency. It appears to be partially excreted in the milk, when taken by nursing women.

Administration.—A few senna leaves chewed every day are a favorite habitual laxative with many people, who find them to act efficiently, without griping and without producing after-sluggishness of the bowels. One or two dozen leaves usually display some effect. In large doses of ʒiss.–ʒii. (6.0–8.0) or more, as required for thorough action, it is apt to produce colic, unless modified by aromatics or salines. A strong alcoholic extract is inert; a watery extract, made from the residue after exhausting by alcohol, is active and much pleasanter than one made without this previous treatment. Infusion with hot water extracts the active principles and makes a good form for administration, but prolonged boiling destroys it, as do also mineral acids and alkalies. Bitters are said to increase its action.

The official preparations are numerous and good. The fluid extract (*Fluidextractum Sennæ* U. S. P.), made with weak alcohol, represents the leaves weight for weight. It is not often given alone, but is eligible for mixture with other medicines. The compound infusion, black draught (*Infusum Sennæ Compositum*, U. S. P.), consists of: senna, six grams; manna, twelve grams; sulphate of magnesium, twelve grams; fennel, bruised, two grams; boiling water, 800 c.c. Pour the boiling water upon the senna and fennel, macerate until cold, strain with expression, dissolve in the Epsom salt and manna, again strain, and add enough cold water to make the infusion measure 1,000 c.c. The syrup has a strength of twenty-five per cent. of senna, and contains a little oil of coriander to flavor. The confection contains ten per cent. each of senna and tamarind, sixteen per cent. of cassia fistula, seven per cent. of prune, twelve per cent. of fig, and a little oil of coriander to flavor. It is a blackish extract-like mass of a sweetish taste, and is an appropriate remedy for chronic constipation, being especially useful for children, who take it readily. The compound syrup of sarsaparilla contains 1.5 per cent. of the fluid extract of senna. The compound liquorice powder has already been considered under *Glycyrrhiza*.

Allied Products.—The leaves of a number of other species of the section of *Cassia* to which the official species belong, possess similar properties, though much weaker, and have been at one time or another proposed as substitutes, especially those of *C. obovata* Collad., widely diffused through the tropics of both hemispheres. No others, however, appear in commerce at the present day. Henry H. Rusby.

Senn, Nicholas.—Born in the Canton de St. Gall, Switzerland, Oct. 31, 1844. He came to this country with his parents in 1852. He received the degree of Doctor of Medicine from the Chicago Medical College in 1868. After practicing for several years in Wisconsin, first in Ashford and then in Milwaukee, he visited Europe and attended the medical course in the University of Munich, receiving the doctor's degree from that institution in 1878. Upon his return to this country he settled in Chicago and accepted the Chair of Principles of Surgery and Surgical Pathology in Rush Medical College. A few years later he was made Professor of the Practice of Surgery and of Clinical Surgery in the same institution. He died January 2, 1908.

Dr. Senn was not only a surgeon of exceptional skill and originality, he was also a forceful and very clear writer. Besides several journal articles and the extremely interesting and valuable contributions which he made to the first edition of this Handbook, he published the following larger works: "On Experimental Surgery," "On Intestinal Surgery," and the beautifully illustrated "Surgical Bacteriology."

A. H. B.

Sepsis.—A genus of flies. The larvæ of the dung fly, *S. violacea*, sometimes occur in the human intestine. A. S. P.

Septicemia.—See *Pyemia.*

Serine, or α = amino—β-hydroxy-propionic acid. $CH_2.OH.CH.NH_2.COOH$.—Serine is present in most proteins in small amounts only but may be obtained from the decomposition of silk glue in large quantities. F. P. U.

Serpentaria.—Virginia or Texas Snakeroot.—The dried rhizome and roots of *Aristolochia serpentaria* L. (True Virginia Snakeroot or Serpentaria) or of *A. reticulata* Nutt. (Texas Snakeroot or Serpentaria) (fam. *Aristolochiaceæ*). These are perennial herbs, a foot or so high, from knotty, horizontal, aromatic rhizomes; stems slender, flexuose, branching at the base; leaves of various shapes between ovate and narrowly lanceolate, with heart- or halberd-shaped base, petiolate, entire; flowers lateral, on slender, straggling, crooked peduncles in the axils of bracts near the surface of the ground, about an inch long, consisting of a dull-purple, single perianth (calyx), whose curved tube has a wasp-like constriction near the middle, and a very oblique, spreading, three-lobed border; stamens six, short, connected with the style in three pairs; ovary three-celled, many-ovuled, inferior. The first named is a native of the eastern United States, especially of Pennsylvania, Virginia, and Kentucky, where much of the drug is collected. The second named, of Texas and the adjacent region, is somewhat larger and coarser

Description.—*Virginia Serpentaria.*—Rhizome of oblique growth, one to three cetimeters (two-fifths to about one inch) long and one to two millimeters (one-twenty-fifth to one-twelfth inch) thick, crooked and somewhat branched, bearing on the upper surface approximate, short stem bases, and underneath a dense tress of long, thin, branched roots, which are straightish, except as they are bent and doubled by pressure; dull yellowish brown, internally whitish, the wood-rays of the rhizome longest in the lower side; fracture of both rhizome and roots weak; odor strong, aromatic, and camphoraceous; taste warm, aromatic, bitter.

Texas serpentaria is larger, coarser, of a more gray color, and the roots are fewer.

Constituents.—Serpentaria owes its aromatic properties to a volatile oil, existing to the extent of from one-half to one per cent., of which *borneol* is the important constituent. Associated with this is five or six per cent. of resin, the greater portion of it soluble in petroleum ether. Tannin, starch, gum, and sugars also occur. The bitter principle is not well known, but is believed to be, in part at least, a very small amount of the alkaloid *aristolochine*, extracted by Hesse from *A. argentina* Griseb. The amaroid *clematitin* ($C_9H_{10}O_6$), obtained from *A. clematitis* L., is believed to be identical with a constituent of serpentaria which has been called *aristolochin*, also *serpentarin*, and which is poisonous; but the relationship of these to the alkaloid named above is not known. Hesse also describes *aristinic*, *aristidinic*, and *aristolic acids* from *A. argentina*, and these are believed also to be present in serpentaria.

Action and Use.—Although aristolochin has been found, as stated above, to be poisonous when pure, it is present in the drug in such small amount that the latter is not poisonous in any ordinary doses. Neither has serpentaria any specific properties, although such have been ignorantly ascribed to it. Its action is merely that of an excellent aromatic bitter and its antiperiodic and antirheumatic reputation is doubtless due entirely to its indirect effects as a general tonic. The dose of serpentaria is gr. xv.–lx. (1.0–4.0); of the official fluid extract, ♏xv.–lx. (1.0–4.0). The Pharmacopœia provides also a ten-per-cent. tincture, of which the ordinary dose is fl. ʒi.–iv. (4.0–16.0). Like other bitter stomachics, serpentaria is far better taken in small doses, of the weaker preparations, a short time before eating.

The genus contains a large number of species, many of which have been similarly used in their own homes. Some of them are far more active than serpentaria, large doses acting as emeticocathartic poisons. Henry H. Rusby.

Serum Diagnosis.—Serum diagnosis is the examination of the blood serum for the purpose of aiding in diagnosis. The term as generally used is taken to mean those methods of investigation which belong to the realm of immunology and not those which are chemical or physical in the ordinary sense. Practically it is limited to the identification of specific antibodies in the serum. If such antibodies are found to be present it is concluded that the patient from whom the serum was obtained is suffering, or has suffered from infection with the organism capable of producing those antibodies. The antibodies generally sought for are agglutinins, precipitins, opsonins, bacteriolysins, hemolysins, and certain specific amboceptors. The Wassermann and Widal reactions are the methods of serum diagnosis which are most commonly used and relied upon. The number of such methods is very great but not all of them have proven of sufficient value to be generally adopted. Description and discussion of these tests will be found in the various articles describing the antibodies or diseases in question and it is necessary here only to mention certain general considerations which apply to the methods of serum diagnosis as a whole.

It must be remembered that the best known of them all, the Wassermann reaction, is not a specific test and is therefore subject to certain errors in addition to those which beset the performance of other methods in serum diagnosis. The results of all of these methods must be considered together with the history and physical examination of the patient before a diagnosis can be reached. Moreover the technique of the tests is often complicated and always particular so that slight errors may completely destroy the value of the reaction. Results obtained by inexperienced workers are often of doubtful value and the reagents used may be a frequent source of trouble. In spite of all this, serum examinations have proved of inestimable value to the physician in the diagnosis of disease. The agglutination reactions for typhoid and paratyphoid infections, the complement deviation tests for syphilis, gonorrhea, and other infections, and the determination of the opsonic index have helped very materially to increase the percentage of correct diagnoses. Similar methods have been valuable in veterinary medicine. Precipitin tests for the recognition of human blood are used in medicolegal work and hemolytic and agglutination tests are made use of in determining the suitability of blood for transfusion. Both should be included in any consideration of serum diagnosis though they are not diagnostic of disease conditions. Ralph G. Stillman.

Serum Therapy.—Behring's discovery of diphtheria antitoxin formed the basis for a method of treatment which has been tried in many of the infectious diseases and has in some instances proved to be exceedingly efficacious. Serum therapy is the use for treatment, either prophylactic or curative, of the blood serum of an animal which has been rendered actively immune to the disease in question. It is thus the production of a passive immunity. The curative

treatment of diphtheria and the prophylactic treatment of tetanus have been the most successful applications of this method of therapeutics but sera have been produced for a large number of infectious diseases both in man and in lower animals. The discussion of each serum will be found in the article under the title of the disease. One of the important things to be remembered in the use of blood serum is that one is injecting into the patient an alien protein and that in the presence of sensitization dangerous symptoms may develop. The danger of such an outcome has been reduced in some instances by the treatment of the serum so as to separate the fraction which contains the antibody so that the bulk is diminished and with it the amount of foreign protein injected.

In addition to the above which may be called *immune* serum therapy there is also a *normal* serum and an *autoserum* therapy. The injection of normal serum or of whole blood has been used in the treatment of hemorrhagic conditions with more or less success depending upon the cause of the hemorrhages. In the hemorrhagic disease of the new-born the results are sometimes marvelous. Normal serum has also been used in the treatment of the toxicoses of pregnancy and in some of the diseases of the skin. Autoserum therapy is the injection into a patient of his own blood serum. It has been used quite extensively in the treatment of skin diseases and of serous effusions whether tuberculous or not. The intraspinous injection of salvarsanized or mercurialized autoserum in the treatment of syphilis of the central nervous system has been the greatest advance in the therapy of this condition which has been made in recent years.

RALPH G. STILLMAN.

Servetus, Miguel.—Born in 1511 at Tudela, in Navarre, a province of Spain. In 1536 he went to Paris, and studied medicine under Johann Günther, Jacques Dubois, and Jean Fernel. Servetus succeeded Vesalius as assistant to Günther, who extolled his general culture, noted his skill in dissection, and ranked him second to none in knowledge of Galen. During the following two or three years he practised medicine at Avignon and also at Charlieu. In September, 1540, he resumed his medical studies at the University of Montpellier, and possibly received from that institution the degree of Doctor of Medicine. Pierre Paulmier, archbishop of Vienne (about twenty miles from Lyons), invited Servetus to be his confidential physician, and the latter accepted. It was during his residence in Vienne (1541–53) that Servetus began a correspondence with Calvin which led to his being burned to death, at the stake at Champel, near Geneva, Switzerland, by the order of the Court, after a formal trial, and with Calvin's approval. This occurred Oct. 27, 1553. The astounding religious bigotry of that period is revealed by the further fact that the civil tribunal at Vienne had also ordered that Servetus be fined and burned alive.

In 1903 there was erected at Champel, on the spot where Servetus met with his dreadful fate, a simple monument which is suitably inscribed and which is intended to serve, as in some manner, a reparation for the great wrong done him. Servetus displayed a keener interest in theological speculations than in the pursuit of medical knowledge, and as early as in 1531 he published a work entitled "De Trinitatis erroribus"—a work which attracted considerable attention, and doubtless was looked upon by Calvin and by the Church of Rome as sacrilegious.

Of the medical writings published by Servetus the following deserves to receive special mention: "Syruporum universa ratio," etc., Paris, 1537 (several subsequent editions). The statement which has led some to believe that Servetus (and not Harvey) was the discoverer of the circulation of the blood, is to be found in one of the former's theological writings—"De Trinitatis erroribus libri septem." A. H. B.

Sevum.—SUET, Mutton suet, mutton tallow. The part of the animal taken for suet is the same that yields the hardest and best lard, or beef tallow, namely, the thick mass of fat lying along the loins and surrounding the kidneys. The whole tissue is suet; the fat melted out and purified is tallow.

The preparation of suet is exceedingly simple, although not always carefully performed. It consists in first cleaning the suet from connective tissue, vessels, blood, etc., then cutting it in small pieces and washing in cold water, or allowing it to soak for a few hours in water; then it is boiled with a little water until the tissue is broken up, strained, and poured away to cool; the last portion of water is then removed by prolonged, moderate heat, which should not be allowed to rise above the boiling-point of water. In the laboratory the steam kettles offer the most perfect means of "trying out" lard and tallow.

Mutton suet has no medicinal properties not common also to the other animal fats, excepting greater hardness, a higher melting-point, and perhaps superior keeping qualities to most of them. It consists of the usual glycerin fats, *stearin*, *palmitin*, *olein*, etc., with the former in excess, and the latter at a minimum. The pharmacopœial description is as follows:

A white, solid fat, nearly inodorous, and having a bland taste when fresh, but becoming rancid on prolonged exposure to the air.

Insoluble in water or cold alcohol; soluble in forty-four parts of boiling alcohol, in about sixty parts of ether, and slowly in two parts of benzin. From its solution in the latter, kept in a stoppered flask, it slowly separates in a crystalline form on standing.

An alcoholic solution of suet is neutral or has only a slightly acid reaction to litmus paper moistened with alcohol.

Suet melts between 45° and 50° C. (113° and 122° F.), and congeals between 37° and 40° C. (98.6° and 104° F.).

Suet forms about one-fourth of mercurial ointment and one-half of tar ointment. It is also an extensively used domestic cerate.

ALLIED SUBSTANCES.—Numerous fats of domestic and wild animals are in common household estimation for one purpose or another, with very little real difference from each other except in odor and hardness. Goose, chicken, and skunk oils are extensively used in country families all over New England. Something more distinctive, and having peculiar claims to attention, are the preparations of grease obtained from the wool of sheep, for which see *Adeps Lanæ*.

W. P. BOLLES.

Sewerage and Sewage Disposal.—A system of sewerage is the network of pipes, conduits, etc., constructed for the purpose of collecting and carrying away from a city, town, or village, the wastes of human life other than that portion of the wastes which are known collectively under the term garbage. The wastes entering the sewers may come from houses, stores, stables, factories, etc., and, if the sewerage system is constructed upon the so-called combined plan, the sewers will also carry street wash. If the system is constructed upon the so-called separate plan, street wash will be excluded, to be cared for by means of drains built for that purpose. The volume of sewage flowing in the sewers of a town or city of a given population depends mainly upon three things: (1) The consumption of water; (2) the tightness of the sewers, that is, their ability to prevent the entrance of ground water; and (3) whether the sewers are on the so-called separate or on the combined system. In England and upon the Continent, where the consumption of water does not average much more than thirty gallons per capita per day, the average volume of sewage produced by a given population

must necessarily be less than in America, where the consumption of water in our largest cities and towns varies from seventy-five to 200 gallons per capita per day. Upon the tightness of the joints of the pipes of the sewer system rests a great deal of responsibility in regard to the volume of liquid entering these sewers. By careful construction of the sewers and in some soils much ground water may be excluded, but faulty construction in porous soils will often allow the entrance of a volume of ground water sometimes fully as great or greater than the volume of true sewage. In the combined system of sewage the volume of sewage flowing in the sewers is very much augmented at times of storm by the addition of street wash. In the separate system of sewerage, drains for the removal of ground water are often laid below the sewers.

After collection in sewers some satisfactory method for the disposal of sewage is necessary. Formerly it was considered sufficient to empty this sewage into some body of water or flowing stream, which would either dilute it sufficiently to prevent visible nuisance, or carry it away from the vicinity of the town or city producing it. This method can still be carried out without offence by fortunately located cities and in sparsely settled countries with large rivers, lakes, and streams. As a country becomes more thickly settled, however, it is not sufficient simply to pass the sewage from its source to a point where it will not cause a nuisance to those producing it, but it must also be cared for in such a way as to prevent it from becoming a nuisance or a source of danger to other communities. On this account and coincidently with the great increase of urban life in civilized countries during the past thirty-five years, the question of sewage disposal has become a most pressing one. In England as early as 1876, so general had become the nuisance caused by sewage entering streams that the Rivers Pollution Prevention Act was passed—a law providing that no rivers or streams should be polluted by the admission of crude sewage. In the thirty-nine years elapsing since that time there has been a constant agitation in England upon the subject, with an idea to bettering the condition of the rivers and streams, but even now the Act is very imperfectly carried out.

Practically the first agitation of this question in America was in the State of Massachusetts. The report of the State Board of Health for 1876 contained an article by the then secretary of the Board, in regard to sewage disposal systems in England and on the Continent, and the same volume contained a report by an engineer of an examination in regard to the condition, on account of sewage pollution, of certain rivers and streams of Massachusetts. Since that date important investigations upon sewage disposal and purification have been made in England, Germany, and America, and as a result of these investigations the science of sewage purification has become well established. Descriptions of the most important methods are given here. It is well to state, however, that little mention can be made of methods of dry disposal of wastes. These methods do not properly come under the head of sewage disposal, but they are methods in vogue in towns, dwellings, public buildings, etc., by means of which the wastes are collected in such manner as to render them more or less valuable for fertilizing purposes; that is, either without having been diluted or mixed with water, or only to a very slight extent. Besides the common middens, privies, etc., many patent processes for the accomplishment of the same result are in vogue in different places, and many processes by which by some means the solid matter of these wastes is, even when mixed with water, separated more or less efficiently from it before the main body of liquid enters the sewers. Before the invention of the water closet, in 1810, the disposal of domestic wastes was always carried out by means of some method of dry disposal; since that date, however, and the introduction of public water supplies, sewerage systems have become an absolute necessity in thickly settled communities.

The demands made upon modern engineering in complex and difficult sewerage construction are very great, and methods are constantly improving. Sewerage works are increasing enormously in number, in the area covered by a single system and in the volume of sewage collected at a single point. The volume of sewage thus collected for disposal by a single city or metropolitan district now often reaches into the hundreds of millions of gallons daily.

There are seven methods of sewage disposal:

1. Dilution by discharge into bodies of water.
2. The "dry method" or pail system.
3. Irrigation or sewage farming.
4. Screening and sedimentation.
5. Tank treatment, including the use of chemical precipitants or without precipitants in septic tanks, Imhoff tanks, etc.
6. Filtration or biological purification.
7. Aeration in combination with growths—"activated sludge."

1. *Direct Disposal into Bodies of Water, or Disposal by Dilution.*—Fortunately located cities and towns can satisfactorily discharge their sewage unpurified into large bodies of water. Where such communities are in close proximity to the seacoast or upon a large river, the discharge of unpurified sewage into tidal waters or swift currents is still resorted to successfully. The method is practically without expense after the sewerage system is once complete, other than that, in some instances, of pumping. It is efficient if the tidal or other currents are strong and the sewage is prevented in this manner from reaching adjoining shores, and if the volume of water into which the sewage is discharged is large compared with the volume of entering sewage. In some instances, however, even at such locations, some attempt at partial purification is made by collecting the sewage in basins and allowing sedimentation to occur before the discharge of the supernatant liquid; this sedimentation often being aided by the use of chemical precipitants. In other places disinfection by means of calcium hypochlorite, commonly known as bleach, is practised. This is especially true of outlets sewage from which may pollute areas where shellfish are taken.

Beginning in 1852 the straggling sewers of the city of London were given more definite form, a system of intercepting and main sewers being designed by Sir Joseph Bazalgette, and the sewage of this city collected and carried by means of sewers to Barking Creek and Crossness, twelve miles below London bridge. This enormous work was made necessary by the polluted condition of the Thames River. Before this date the sewage was discharged through many sewers directly into the Thames, as the river passed through the city. The greater part of the new works emptying at Barking Creek were completed in 1864, and in 1865 works on the opposite side of the river at Crossness were also completed. Ten years after the opening of these works it became necessary, on account of sewage carried up the river from these outfalls, to build large settling tanks in which the sewage was collected and chemicals were added for the purpose of precipitating the solid matter before discharging the clarified sewage into the tidal estuary. The solid matter resulting from this precipitation is taken out to sea in sludge boats, and the sewage is discharged between high and the middle of ebb-tide. During 1909 the average volume of sewage discharged daily amounted to 283,000,000 gallons and 50,000 tons of sludge were carried to sea in sludge boats each week. Twenty-five thousand tons of protosulphate of iron and 6,000 tons of lime were used during the year.

Boston, Mass., together with the cities and towns surrounding it and composing a metropolitan district, with a population of 1,500,000 and having an area of 187 square miles, collects its sewage into three main systems, all of which discharge into strong tidal currents in the outer parts of Boston harbor. With two of these systems the discharge is continuous, while in the other the sewage is collected in large storage tanks and allowed to pass out on the ebb-tide. Two of these points of discharge have been in operation for many years, and, notwithstanding the volume of the sewage, amounting at the present time to about 120,000,000 gallons daily, so efficient is the disposal because of dilution, sedimentation, and the rapid carrying away by swift tidal currents, that well-patronized summer resorts exist within short distances of the points of discharge.

The sewage of Greater New York all empties into New York Harbor by means of many sewers, and is so diluted and dissipated by the swift and deep tidal currents that it is well cared for. During the past ten years, however, many investigations have been made looking to a more satisfactory and sanitary disposal of this large volume of sewage. As a result of these investigations the Metropolitan Sewerage Commission has proposed the collection of all this sewage by intercepting sewers and main sewers extending to an artificial island in the outer part of New York Bay and its treatment in tanks to remove matters in suspension before being allowed to disperse in the tidal waters. The sewage of Buffalo enters the Niagara River between Lakes Erie and Ontario. The sewage of St. Louis enters the Mississippi River, as does now the main portion of the sewage of Chicago through the Chicago drainage canal and the Illinois River, and in each instance, on account of the large volume of water flowing in the river, the disposal from some points of view is adequate.

Many engineering data have been collected, especially by the Massachusetts State Board of Health which show that where disposal by dilution in streams is practised, objectionable conditions so far as visible nuisance is concerned are unlikely to result where the flow of the stream receiving the sewage exceeds six cubic feet per second per 1,000 persons discharging sewage. Sewage disposed of by dilution should never be great enough in volume to exhaust the dissolved oxygen of the water into which it enters. Only by so limiting the discharge of organic matters as to prevent such exhaustion, is nuisance prevented. Very thorough studies of this subject have shown that clean water can receive an addition of two to four per cent. of its volume of normal sewage without the disappearance of dissolved oxygen.

2. *The "Dry Method" or Pail System.*—This system is limited to buildings not having modern plumbing. It is the disposal of excreta in the familiar earth closet or into a pail or receptacle of suitable size and construction and covered after each addition with dry earth or ashes. The pails are changed frequently and their contents removed and disposed of as manure or buried. It is a primitive system but prevents the waste of the fertilizing value of excreta. Its chief objections are its inconvenience as compared with modern systems of water carriage and the fact that more or less odor is practically inevitable. It is fast becoming obsolete except in isolated dwellings.

3. *Sewage Farms.*—Berlin, Germany, passes its sewage to immense sewage farms, which have been in operation for many years, and are 39,000 acres in extent; Paris, a portion of its sewage to farms at Gennevilliers and other places, where it is adequately cared for. Many other cities and towns, both in Great Britain and upon the Continent, follow the same method of disposal satisfactorily. This method can be carried out successfully, however, and at a profit from the farm only where the sewage is comparatively rich in organic matter, that is, where the volume of water is small compared with the population producing the sewage. It is with considerable difficulty even then that these farms can be made to return a profit above the cost of operation. It goes without saying that American sewage cannot be disposed of satisfactorily in this manner, being altogether too dilute; and any attempt so to utilize it means generally the use of only that portion valuable for irrigation, with the direct discharge of the remainder, unpurified by filtration through the soil, into the most convenient body of water. Sewage irrigation or farming, however, was the first attempt properly to purify sewage upon land, but having, sometimes at least for its main object the utilization of the sewage rather than its purification; a profit from the farm being deemed of more importance than purification.

The capital sum expended upon the Berlin farm up-to-date is about $12,000,000 and the receipts from farm produce are greater than the operating expenses. Interest at 3.5 per cent. on the capital sum expended offsets this, however, and causes an actual cost of about $10 per million gallons of sewage treated. The same story is true of the Paris farms. At Wolverhampton, Eng., is one of the best managed English sewage farms. The sewage of about 110,000 people, amounting to more than 3,000,000 gallons per day, is applied to a farm of 600 acres, and the cost of operation is about $30,000 per year greater than the profit from the sale of farm produce. The only regions where sewage farming can perhaps be carried on with a profit, are those of low rainfall and hence the sewage is valuable as a liquid, that is, for real irrigating purposes. In the minds of many, the belief remains, however, that sewage has great manurial value. This was, and is, of course, true of the matter collected from dry closets, but with the introduction of public water supplies and the use of modern plumbing, etc., the valuable constituents are so diluted with enormous volumes of water that its economical recovery is an almost hopeless task. One thousand gallons of average American sewage contain not over eight cents' worth of fatty and fertilizing matters. Of this, about one-half is represented by the ammonia in solution. There are about 2,400 pounds of sedimentable matter in 1,000,000 gallons of such sewage and the nitrogen, fatty matters, etc., in this 2,400 pounds of sludge are worth from $15 to $18. In order to reclaim this, however, the sludge must be dried, pressed and subjected to some process for separating the grease from the fertilizing constituents. Only by this separation can the grease become an article of commerce and the sludge of real agricultural value. This fact is well established by long experience and many investigators. Only at a few places as yet is such separation attempted. Many unsuccessful plants have been abandoned and only a few show any promise of achieving success. Sludge has value, however, and as the recovery processes are improved, and as nitrogen advances in price, sewage sludge properly treated will become of greater agricultural value and use than at the present time. In this connection, Maurice Fitzmaurice, C. E., Chief Engineer to the London County Council, makes the following statement: "Several enthusiasts on the subject of the useful utilization of sewage have begged for gallon samples of it at the (London) outfalls, and one even took away a barrelful but I have never heard from any of them, and the amount of sewage which they have taken away has made no appreciable diminution in the 280,000,000 gallons a day which are still at the disposal of anyone who will take it."

4. *Screening and Sedimentation.*—For the proper purification of sewage by filtration, the removal of the matters in suspension is desirable in order that these matters may not clog the filter. This removal is accomplished by means of screens or tanks, or both. At certain municipalities, the sewage can be adequately disposed of by dilution after screening only;

at others, screening and sedimentation are desirable, while at others screening, tank treatment and filtration are necessary. The suspended matters when removed are known as sludge. Screening plants have reached a high state of development in England and Germany. They consist generally either of bar screens or wire cloth. Bar screens are the more common and the screening plant very often consists of several such screens, the first one collecting the coarser matters only while the final screen is constructed of bars only one-eighth or one-quarter inch apart. These screens are cleaned by rakes or brushes moving automatically, the power often being furnished by the flow of sewage through a turbine water-wheel. Screens of this type when efficiently operated remove from one to one and one-half tons of sludge from each 1,000,000 gallons of sewage screened.

After screening, sewage is generally passed through sedimentation tanks. These tanks are, if properly constructed, of such size that the sewage will be about four hours in passing through. With this period for sedimentation it is often possible to effect a removal of fifty per cent. of the matters in suspension.

Sedimentation with the Use of Chemical Precipitants.—At a few disposal works in America and at many in England, France, and Germany, a greater removal of the matters in suspension than can be obtained by the use of screens and sedimentation basins, is desirable, and chemical precipitants such as lime, aluminum sulphate, and ferrous sulphate are used. When such a precipitant as aluminum sulphate is used in an alkaline liquid, or made alkaline by the use of lime, a gelatinous precipitate forms which collects and carries down matters in suspension in the sewage together with a large percentage of the bacteria present. At the Lawrence Experiment Station during five years, Lawrence sewage received sulphate of alumina in the proportion of 1,000 pounds per million gallons followed by four hours' sedimentation with an average removal of about seventy-five per cent. of the total organic matters and sixty-eight per cent. of the bacteria. At many places abroad where modern trickling filters, to be described later, are installed, the use of chemical precipitants is general, as the sewage clarified in this way can be satisfactorily purified by these filters at a much higher rate than when only screened and settled. At many places, moreover, as at Worcester, Mass., Providence, R. I., and London, Eng., practically all the sewage treated with chemicals receives no further purification.

The liquid sludge produced generally amounts in volume to from 0.5 to 1.5 per cent. of the volume of sewage treated and contains at least ninety-five per cent. of water. Much of this water is often removed and the solid matters concentrated by filter-press treatment, the filter press being a machine in which the sludge, having first been bagged, is placed to undergo compression for the removal of water, while the solid matters are retained by the cloth bagging in which the sludge is placed. At the present day chemical precipitation is generally resorted to as a treatment of sewage preliminary to filtration. Where modern trickling filters, to be described later, are installed, it is of great advantage both for efficiency of filtration and economy of disposal area to free the sewage of suspended matters before filtration. This is so on account of the much greater rate at which these filters can be operated with clarified than with unclarified sewage. The English Royal Commission on Sewage Disposal estimated in 1908 that the average cost of chemical precipitation treatment, including loan charges, is about $17 per million gallons.

At Worcester, Mass., is a well-constructed and well-managed chemical precipitation plant. Worcester is a city of about 150,000 people. The chemical precipitation plant was constructed largely in 1891, although additions have since been made to it as the growth of the city and the volume of sewage to be disposed of have required. At the Worcester plant there are sixteen precipitation tanks about 100 feet long, 66.7 feet wide and 7 feet deep. The sewage on its way to the tanks passes through screens and is there mixed with chemicals. From these screens it passes through a mixing channel to the first precipitation tank and then continuously through a series of tanks, the period of sedimentation being about seven hours. About 13,500,000 gallons of sewage are treated daily. At this plant about five tons of lime are used daily or about 900 pounds per million gallons of sewage, and by this chemical treatment about seventy per cent. of the suspended organic matters in the sewage are precipitated and removed. The precipitated sludge is in volume about 0.5 per cent. of the total volume of sewage treated. The cost of the process at Worcester amounted to $40,000 during 1914 or about twenty-three cents per capita. This cost includes handling of sludge and sludge pressing, and is about $8 per million gallons of sewage treated. The disposal works to date have cost $784,000. Interest on this sum at four per cent. per annum amounts to $31,000 which added to the operating cost for chemical treatment each year, namely, $40,000, gives a sum of $71,000, making the total cost of disposal by this method at Worcester approximately $15 per million gallons.

A series of experiments upon the removal of organic matter from sewage by means of chemical precipitation was made at the Lawrence experiment station, continuing from 1890 until 1898, and the results showed that generally about fifty per cent. of the total organic matter could be removed from the Lawrence sewage by this treatment, and a considerably greater percentage of the matters in suspension only. As good results were obtained with the normal alkaline sewage of Lawrence when using 1,000 pounds of chemicals per million gallons as when using a greater amount, and, of the various precipitants tried, sulphate of alumina gave on the whole the best results. The chemicals used in precipitation are of low cost per pound, but when a large volume of sewage is to be treated, this expense amounts to a serious sum.

5. *Tank Treatment.—Cameron Septic Tank.—Lawrence Tank.—Hampton Tank.—Imhoff Tank.*—What is known as the septic tank process of sewage treatment was first proposed by Donald Cameron of Exeter, England, and at that place the first tank of this kind was installed. The septic tank, briefly, is simply a brick or concrete tank, covered, through which sewage is passed slowly allowing time for sedimentation and for the action of those bacteria which disintegrate and hydrolize, and in this way change or destroy solid organic matter causing it to pass into solution or escape into the air in gaseous forms. On a following page a statement is made regarding the difference between fresh and stale sewage. To carry on further those bacterial actions which cause the change of organic matter in suspension to matter in solution, is the function of the septic tank.

As stated, the first septic tank was that at Exeter, England. It was sixty-four feet long, eighteen feet wide, had an average depth of a little more than seven feet, was built under ground and was covered. At first it was stated that this method of treatment would cause about eighty per cent. of the organic matter in suspension in the sewage retained in the tank, to pass into solution or to escape in gaseous forms. This was a very much exaggerated claim and only a few tanks have been successful to this degree. At the present time septic tanks have been in operation for many years in England, Germany, and America, and modern experience is that even under the best conditions not more than from twenty-five to thirty per cent. of the suspended organic matter retained in them is hydro-

lyzed. Large tanks of this sort in operation at Hanley and Birmingham, England, are even less efficient. At many sewage disposal plants, however, such tanks are of undoubted value for the treatment of sewage preliminary to filtration.

Observations and experiments at Lawrence and elsewhere, having determined that the more concentrated the sewage entering septic tanks the greater the per cent. of destruction or change of solid organic matter, gave rise to the idea that where exceedingly large volumes of sewage are to be treated, this sewage could be passed through ordinary settling tanks so constructed that the sludge settling to the bottom of these tanks could be flushed into septic or digestive tanks and this sludge alone be submitted to tank action instead of attempting to treat in such tanks the entire volume of sewage coming to a disposal area. At the Lawrence Experiment Station a two-story tank, so called, was put into operation in 1899 to receive the sludge obtained by settling the regular Lawrence sewage for four hours, and from November 15 of that year this tank was operated in such a way that fifteen days' digestion of the sludge was allowed. This tank was successful in concentrating and destroying a very large per cent. of the organic matter entering.

Following the operation of this Lawrence tank, Dr. Travis started at Hampton, England, a somewhat similar tank and several years afterward a German modification known as the Imhoff tank was put into operation by Dr. Imhoff at Essen, Germany. Both the Imhoff and Hampton tanks are based upon the principle of the Lawrence tank of 1899, namely, the retention of the sludge only for digestion while the main body of sewage passes through the tank quickly.

Dr. Travis states: "The conception of the bacterial tank is the result of a close study of the numerous experiments conducted at Lawrence under the State Board of Health of Massachusetts. This being so, an acknowledgment of the source from whence the ideas were derived and a recital of the conclusions having special reference thereto, are as a matter of common honesty as well as of courtesy, equally desirable."

The Imhoff tank which the Imperial Patent Court of Germany has declared to be the same in principle as the Lawrence tank just described, consists generally of two lower cylinders with conical bottoms connecting with an upper rectangular tank with a V-shaped bottom. As the sewage passes through the upper tank at a fairly slow rate the matters in suspension in the sewage settle and slide along the lower sloping walls of the tank and are deposited in the cylindrical sludge digestion chambers. These tanks are usually at least thirty feet deep. In the conical digestion chambers putrefaction occurs but the gas evolved is prevented by the V-shaped bottom of the upper chamber tank from passing up through the sewage in this rectangular compartment, and by this same construction particles of the sludge lifted by the gas evolved are also prevented from entering this compartment. The sludge held in these digestion chambers for several months becomes concentrated to a high degree and by the long-continued anaerobic action is rendered often entirely odorless. Owing to the long-continued digestion it is granular in character and more easily handled than the sludge from the ordinary septic tanks.

6. *Biological Purification of Sewage.*—With the exception of sewage farming, the processes of sewage treatment so far described in this article have to do almost entirely with the clarification of sewage; that is, the removal of the matters in suspension. Sewage, however, contains much organic matter in solution and this is the matter which first undergoes bacterial and chemical change and causes a nuisance when sewage is not quickly, adequately, and properly purified. Continual agitation on the question of the prevention of the pollution of streams made a broad demand for a thorough understanding of proper and efficient purification, and scientific studies of the subject were begun by the Massachusetts State Board of Health practically thirty years ago. It had been observed that the passage of sewage through soil not only caused the removal of the suspended matters but that the matters in solution were also so changed that they did not appear in the effluent except in unrecognized forms. Knowledge of germ life and the science of bacteriology fortunately had its beginning at about this period and it was proved that the changes occurring in the sewage passing through the soil were caused by bacterial life in the soil. These first investigations were made by Schloessing and Muntz in France and Warrington and Frankland in England. Their experiments were upon a laboratory scale, and without attempting to show that bacterial life was present they did demonstrate that if germicides were added to the filter or to the sewage, purification did not occur. They also observed that their small tube filter containing earth, marble, and other media not only purified the sewage but that the filters remained fairly clean and organic matter accumulated very slowly within them. These investigations were meager and not long continued. Toward the end of 1887, however, the State Board of Health of Massachusetts established an experiment station for investigations upon the subject and soon published the results of the most important scientific studies ever made upon sewage purification. During the past twenty years work along the same lines has been done in England, Germany, and France, practically all of this work being based upon the Lawrence data. Experience with sewage farming or sewage irrigation having made clear the fact that sewage disposal in this manner could not be made financially successful except under unusual conditions, the investigations at the Lawrence Experiment Station were centered upon evolving a process of purification by means of which the largest possible volume of sewage could be efficiently purified upon the smallest possible area and at a minimum cost. The main studies at Lawrence were at first upon bacterial methods of purification; that is, upon purification caused by oxidation of the organic matters in sewage by means of those bacteria which establish themselves, sooner or later, in sewage filters of all kinds.

In the purification of sewage by bacterial action, the process is as follows: The bacteria in the sewage in the presence of oxygen first attack the carbonaceous matter, carbonic acid being formed; nitrogen and hydrogen are set free and unite to form ammonia, this in turn uniting with the carbonic acid forming ammonium carbonate which goes into solution. The next step is the oxidation of the nitrogen of the free ammonia to nitrous and then to nitric acid by the nitrifying bacteria working in the presence of the oxygen. The nitric acid then unites with a base such as sodium and potassium present in the sewage or in the filter material and sodium and potassium nitrates are formed. These are, in the small amounts present, innocuous mineral salts and appear in solution in the filter effluent.

In this work of the bacteria much of the organic matter is also changed to gaseous forms, and gases are set free. If filtration through properly prepared filter beds is carried on slowly enough, all the organic matter in the sewage applied to these beds can be changed either to gaseous forms, such as carbonic acid, ammonia, free nitrogen and hydrogen which escape into the air, or to mineralized bodies, which appear in solution in the effluents of the filters. Such thorough purification as this, however, is not generally necessary, nor is it practicable in many instances, except where the volumes of sewage to be dealt with are comparatively small and where land is cheap.

Intermittent Filtration.—Next to sewage irrigation or farming, in which mere driblets of sewage are generally applied to each acre under cultivation—at Berlin the volume is from 500 to 5,000 gallons—the best results and the best purification can be obtained by filtration through properly prepared filter beds of sand or similar material. In order that good work may be done in such beds they must be constructed of sand coarse enough to allow sewage to enter easily, and the sewage must be applied in such a manner, at such intervals and in such volumes, that it will pass through the entire area of the filter in a fairly uniform manner, and meet an abundance of oxygen within the filter.

Physical Characteristics of Sand Used for Filtration.—At the Lawrence experiment station a method for determining the efficiency of sands in sewage filtration was elaborated from practical experience. By this method the sand is sifted through sieves, these sieves being so calibrated that the approximate size of the sand grains passing through can be easily determined. It was found that the quantitative and qualitative efficiency of sands used in filtration depends to a considerable extent upon the finer particles present. Owing to this, a certain arbitrary standard was adopted, called the "effective size," this being the diameter in millimeters of the finest ten per cent. by weight of the sand grains. Following this standard, if a sand is stated to have an effective size of 0.25 millimeter, the meaning is that ten per cent. by weight of the sand consists of grains with an average diameter less than this figure. The determination of the volume of water which a certain depth of sand of a known grade, well underdrained, will hold by capillarity is easily made. The knowledge of these two facts gives adequate data to enable one to foretell the volume of sewage which can be held by a well-underdrained sand filter of a given depth, or, in other words, its time of passage through such a filter when successive applications are made; this having a direct bearing upon the volume that can be purified satisfactorily and successfully upon a given area.

An average sand has about thirty-five per cent. of open space; that is, when this sand is dried and packed as closely as natural, the space between the grains filled with air amounts to about thirty-five per cent. of the total volume of the sand. This percentage of open space differs but little with coarse and fine sand. When a coarse sand, well underdrained, has water applied to it for a considerable period, it will hold but a small portion of this water by capillarity, while each finer grade will hold more and more, until a grade is reached that will hold itself practically saturated to within a few inches of its surface; that is, the open or air space present when the sand is dry will be filled with water.

Rate of Filtration through Sand Filters.—A sand as fine as this last grade, which will in fact resemble clay, is practically useless in sand filtration of sewage. Any sand, ten per cent. by weight of the grains of which have a smaller diameter than 0.05 millimeter, is of small value for sand filtration, especially in a cold climate where freezing occurs in winter, although areas constructed of a grade of sand as fine as this can be used if trenched with coarse sand, and if the sewage is applied to these trenches. All grades of coarse sand are valuable for filtration purposes, none being too coarse to effect good results, if the underdrains of the area are placed at sufficient depths and a proper distance apart. A rate of filtration equal to 75,000 gallons per acre per day can easily be maintained upon coarse sand filters with sewage of average strength. On two filters of the same grade of coarse sand the rate that can be maintained depends very largely upon the strength of the sewage; that is, upon the amount of organic matter present in each unit volume of water going to make up the volume of sewage. Many weak sewages from towns having a considerable length of pipes laid but with comparatively few connections, or systems into which ground water enters in considerable volume, can be filtered through sand with satisfactory purification results at rates at least twice as great as the figure given above—that is, if the filters are properly cared for.

Care of Sand Filters.—The care of sand filters is, of course, one of the main points in maintaining permanency of operation. It goes without saying that as much as possible of the matters in suspension in the sewage should be removed by screens, tanks, etc., before the sewage is applied to the filters, even then in order that the surface of the beds may not become clogged, much of the matter reaching them in suspension in the sewage either has to be raked up and removed from time to time, or else systematically ploughed under. With a fresh sewage—that is, a sewage where the mixture of filth and organic matter of all kinds with the waste water of the town has just occurred and little time has been given for mechanical, chemical, and bacterial actions to take place in the sewers—we have a liquid containing organic matter in quite a different form from the same matter in the sewage when opportunity has been given for these various actions to take place. A fresh sewage generally contains free oxygen, nitrogen in the form of nitrates and nitrites, the proportion of organic matters in suspension to those in solution is comparatively large, and the matters in suspension are in comparatively coarse particles. When sewage reaches a filter area in this condition, the matters in suspension are easily screened or settled out. If then they are mixed with loam or sand—that is, composted—they cause little or no offense, and even when placed in a heap without mixture with soil or loam, the organic matter generally decomposes so slowly that little, if any, nuisance occurs. As fresh sewage flows along in the sewers and mechanical, chemical, and bacterial forces have a chance to act upon it, the organic matter present undergoes a decided change. The chemical and bacterial change is practically the breaking up of the organic matter into simpler forms, and the mechanical change is the disintegration of the matters in suspension into finer particles. Sewage in this condition—that is, with much of its suspended organic matter either changed to solube forms or finely disintegrated—is designated as stale sewage, and, when it flows upon a filter bed, much more organic matter is carried into the pores of the filter than when the sewage reaches the bed in a fresh state. Upon the surface of beds receiving such sewage, little matter accumulates that can be removed by raking, but the disappearance of this matter by bacterial oxidation can be very much aided if the surface of the bed is loosened from time to time by raking, harrowing, or ploughing.

Method of Operation of Sand Filters.—In order to purify sewage satisfactorily upon sand filters, an abundance of air in the pores of the filter is a necessity. To assure the presence of this air, the application of sewage must be intermittent—that is, it must be applied from time to time and in limited volumes. If we should apply sewage continuously to a sand filter, keeping the surface of the sand covered with sewage, the entire open space in the filter would become filled with liquid, air would be excluded, and those organisms which oxidize the organic matter by working in the presence of air would be either destroyed or rendered unable to work successfully. This fact has often been proved, and is what occurs when attempts are made to purify sewage by passing it in any but very limited amounts through soil or clay—materials useless in sewage purification. Instead of oxidation in such beds, if they are overworked, we have reducing actions occurring, oxygen is taken from the oxides in the soil or clay or sand, and the base of these oxides passes into solution. Putrefaction of the organic matter of the sewage also occurs,

with the production of odors, and an effluent often less pure than the applied sewage is the result. In order to prevent this the volume of sewage applied to any intermittent sand filter must be such that under no conditions will the sewage entering the filter exhaust the air present, or keep the surface of the filter covered for too long a period. The volume of sewage which can be applied to filters of coarse or fairly fine sand with good results varies comparatively little, but the method of application should vary considerably if good results are to be obtained. That is to say, with a filter of fine sand the sewage should be applied in large doses as it enters the filter slowly, and when once it has passed below the surface of the sand a considerable period should elapse before another application is made, in order that air may enter the upper portion of the filter. With a filter of coarse sand, into which the sewage enters readily, more frequent applications of a smaller volume of sewage is the preferable manner of operation, in order that the sewage may not pass through the filter too quickly. Much air may be made to enter the filter by this manner of flooding, as the sewage disappears quickly from the surface of the coarse sand. This difference of action of different sands can be modified very much, however, by different distribution of the underdrains. By such equalization as can be obtained in this way a filter of coarse sand may be worked practically in the same manner as a filter of finer sand, and *vice versa*.

The following table shows first the average results for one year obtained when filtering sewage through two different experimental filters that had been in operation for twenty-seven years at the Lawrence experiment station when these results were obtained. One of these filters (A) is constructed of coarse mortar sand and the other (B) of fine river silt trenched with a coarser sand, the coarse filter being operated at a rate three times as great as the fine filter, or approximately 60,000 and 20,000 gallons per acre daily, respectively. In the same table are given the results from a third filter (C) of coarse sand, operated at a rate of 300,000 gallons per acre daily, the sewage applied to this filter being of such strength, however, that 300,000 gallons contained no more organic matter than the 60,000 gallons applied to Filter A:

Table I.—Parts per 100,000.

	Sewage (A and B)	Filter A.	Filter B.	Filter C.
Ammonia –				
Free	3.8200	0.5502	0.0660	0.0404
Albuminoid				
Total	0.8000	0.0697	0.0166	0.0306
In solution	0.3800			
In suspension	0.4200			
Chlorine	8.4800	8.3600	7.8900	2.8200
Nitrogen as –				
Nitrates	0.0000	2.7100	2.9300	1.2500
Nitrites	0.0000	0.0118	0.0009	0.0044
Oxygen consumed	3.9000	0.4500	0.1100	0.3400
Bacteria per cubic centimeter	4,760,000	28,800	58	15,800

In calculating the percentage of purification obtained by filtration the common method is to show the

Percentage Purification.

	Albuminoid ammonia	Bacteria per cubic centimeter.
Filter A	91.3	99.4
Filter B	97.9	99.9
Filter C	96.2	99.7

removal or oxidation of organic matter as shown by the determinations of albuminoid ammonia in the sewage applied to and the effluents from the filters, and this is given in this instance in the table. True purification in sand filtration is by nitrification, and it will be noticed that the nitrogen appearing in the nitrates in the effluents of Filters A and B in the accompanying table, accounts for a large part of that present in the sewage in the free and albuminoid ammonia.

Sand Filter Areas.—Massachusetts has more sand filter areas for the purification of the sewage of cities and towns than any other State in the country. These filters are in successful operation, and undoubtedly produce better results in the New England climate than could be obtained the year round by any other method of filtration. At the end of the year 1914 there were thirty-three cities and towns in the State, besides many large institutions, purifying their sewage upon sand areas. It is well to describe one of these areas, with the results which are being obtained from it.

Sewerage and Sewage Filtration at Marlborough, Mass.—Marlborough is a Massachusetts city of about 15,000 people. The sewerage system was constructed in 1891, and was designed to take house sewage only. All the sewage is collected in a system of pipe sewers and conveyed by gravity through a main pipe sewer to settling tanks and filter beds about three and one-half miles away from the city. In constructing the sewers considerable ground water was encountered, and a large amount of this water leaks into these sewers. In this city, in distinction from others, no underdrains were laid beneath the sewers to care for the ground water. The average amount of sewage reaching the beds daily is about 750,000 gallons, the amount varying very much at different times of the year. Accurate measurements have shown that the volume during wet months, such as in the early spring, is several times that flowing in the dry months of the late summer and early fall. The sewage at the filtration area enters settling tanks, four in number and with a combined capacity of 275,000 gallons. The material which accumulates in these tanks is usually removed about once each fortnight and is discharged upon special sludge beds, where it is allowed to dry, and is then raked up and carried away, some of this material being used by the farmers in the vicinity as a fertilizer. The sewage in the tanks passes upward through horizontal screens having a one-inch mesh, before its discharge into the carriers leading to the filter beds. There are thirty-one of these beds having a combined area of about twenty-one acres. The beds were originally underdrained by lines of pipe about fifty feet apart, with a depth of from five to eight feet beneath the surface. On account of these drains receiving a large amount of ground water, it was found that their capacity was insufficient to remove both ground water and effluent, and additional underdrains were put into place.

The sand in the beds varies but has an average effective size of about 0.14 millimeter. The sewage is discharged upon these beds near the corners, and the general method has been to turn all the sewage on to one, two, or three beds, according to the quantity flowing, and allowing it to flow upon these beds for twenty-four hours. In wet weather, of course, the flow has to be more widely distributed over the entire area. The sewage is applied to the beds in rotation, and once in about five weeks the surface of each of the beds is raked to remove the surface deposit, and then harrowed and allowed to remain out of operation for a short time; the solid matter which accumulates on the surface being removed before the surface is harrowed. In the fall the beds are ploughed and the surface is left in ridges and furrows, so that the ice forming upon the beds rests on the ridges and protects the sand from freezing, the sewage running in the furrows beneath this ice. The beds receive no atten-

tion in the winter in regard to surface management, but in the spring they are raked and then ploughed, harrowed, and graded, and remain level throughout the summer. The average rate of filtration at this area approximates 36,000 gallons per acre daily. The following table gives a fairly average analysis of the sewage applied to and the effluent from this area:

TABLE III.—PARTS PER 100,000.

	Sewage.	Effluent.
Residue on evaporation—		
Total	83.45	42.02
Loss on ignition	44.18	
Ammonia—		
Free	6.4100	0.4694
Albuminoid—		
Total	1.5500	0.0328
In solution	0.7500	
In suspension	0.8000	
Chlorine	12.0600	8.06
Nitrogen as—		
Nitrates		1.8648
Nitrites		0.0057
Oxygen consumed	9.02	0.3900

the organic matter in sewage, and thus make it possible either to dispose of sewage by discharge into bodies of water; that is, by dilution, or to filter the clarified sewage, at high rates upon sand or other filters. It is only in fortunate localities, however, that sand filters can be constructed at a low cost. In New England in most places sandy areas are available. Throughout a large section of this country, however, areas of sand are not to be found, and sewage filters must be built on different lines. This is also the condition of affairs in England. Because of this, elaborate studies and experiments have been made upon other means of purifying sewage than by sand filtration; all these methods having, of course, as their main feature the possibility of purifying large volumes of sewage upon relatively small areas. Sand filters are comparatively inexpensive of construction, costing in New England not more than from a few hundred to four or five thousand dollars per acre, according to the locality in which they are built and other conditions.

Of the first attempts upon filtering sewage at high rates, the passage of this sewage through aerated gravel or broken stone filters, with nitrification aided by a current of air forced into the filters, appeared to be the most interesting and practical. Such

FIG. 4494.—A Massachusetts Filtration Area.

The average purification by these beds is about ninety-four per cent.; that is, ninety-four per cent. of the organic matter in the applied sewage does not appear in the effluent from the filters. This area has cost to date about $82,000 and the yearly cost of operation is about $1,500.

Filters of Coarse Material.—Rapid Rates of Filtration.—Sedimentation, chemical precipitation, and straining are not, of course, in the true sense complete sewage purification. They are preliminary methods taken to remove and concentrate a certain amount of filters were operated at the Lawrence experiment station as early as 1892, and at experimental plants in other places soon after this date. At Lawrence average rates of 500,000 gallons per acre per day were obtained by this method, and good nitrification occurred the sewage being applied to these filters in small doses at frequent intervals. The effluents of the filters, however, contained much organic matter in suspension and in solution, and the purification obtained was at that time considered only preliminary to sand filtration, or, in other words, it was simply a

method for increasing the rate at which sand filters could be satisfactorily operated.

Contact Filters.—Contact filters are sewage filters constructed of any coarse material such as coke, cinders, slag, broken stone, gravel, broken bricks, etc., the filtering material being placed in water-tight enclosures or tanks. The method of operating these filters is to close the gate at the outlet of their underdrains, gradually fill the open space of the filter with sewage, applied at the surface, allow a period of standing full, then drain, rest for a more or less prolonged period, and again fill. In this manner the entire depth of the filter is brought into contact with the sewage applied each day; that is to say, the entire open space of the filter is filled with sewage daily or even several times daily, and a high rate of filtration obtained. It is evident that filters constructed of these materials and operated in the way outlined cannot produce the results given by good sand filters; in other words, they are not good strainers, and the sewage passes through them too quickly for prolonged bacterial action to occur. Nevertheless, very organic matter is strained out from the applied sewage by being caught on this rough material, to remain in the filter and to become oxidized and nitrified when the filter is empty. Experiments with this class of filters were first made in England.

Long-continued investigations in regard to contact filtration have been made at the Lawrence experiment station. Filters of different materials have been in operation, different methods of flooding have been followed, and double contact has been compared with single contact. These studies have shown that the best results can be obtained with filters constructed of rough material, such as cinders and coke, that in such filters, when well operated, fair nitrification occurs, and that fairly stable effluents are obtained. With filters of broken stone much poorer results are obtained. The rate of operation of these filters should not average more than 600,000 to 700,000 gallons per acre daily. There is a tendency for the open space in the filter to become clogged more or less with the matters removed from the sewage, thus decreasing the rate of operation, and the prevention of this is the most serious

Fig. 4495.—Manchester, England, Contact Filter.

satisfactory purification results can be obtained by their use, especially if the system of beds is so constructed that double contact of the sewage is given—that is, a system of beds in two sets, all sewage passing through two filters.

In operating these filters the method of filling may be continuous or intermittent; that is to say, the sewage may be allowed to pass into the filter continuously until the entire open space is filled from the underdrains to the surface, or the sewage may be run in at frequent intervals. The latter method introduces more air into the pores of the filter than the continuous method, and better purification ensues. When the effluent flows from the filter, air is drawn into the filter again and fills the open space. It is evident that, if the action of the bacteria upon the sewage in the filter is to be that of oxidation, the sewage should be withdrawn some time before the exhaustion of this oxygen occurs. When the filter is emptied, the oxygen drawn in causes a partial oxidation of the organic matter left within the filtering material, nitrification ensues, and we have a filter really working all the time, although flooded but a portion of the time. If the filter is constructed of rough material, such as cinders, coke, slag, etc., much problem presented in the satisfactory and permanent operation of contact filters. In fact, it is quite generally recognized at the present time, that, if filters of rough material are to be used successfully in this way for any long period, a larger portion of the matters in suspension in the sewage must be removed as a preliminary to filtration. In the life of filters of this nature, but constructed of smooth material, this preliminary treatment is not so essential, as the material in the filter can be so graded and the underdrains left so open that much of this matter will pass from the top to the bottom of the filter and flow out from the underdrains. Such filters of smooth material, however, do not, as has been said, give as good results as the filters of rough material.

Contact filters have been adopted and constructed in many places, especially in England. At Manchester, England, a plant for the purification of 40,000,000 gallons of sewage per day upon contact filters has been built, the sewage first being treated in septic tanks. These filters are seventy-six acres in area; 150 men are constantly employed upon the plant and the cost approximates $9 per million gallons of sewage treated. At Sheffield, England, the sewage of 450,000 people is cared for by settling tanks and thirty acres of con-

tact filters. The cost of this plant complete was $1,500,000.

Two coke contact filters in operation at Lawrence for a period of eight years at an average rate of 573,000 gallons per acre daily produced the following average effluent.

PARTS PER 100,000.

	Filter No. 175.	Filter No. 176.
Color	0 61	0.73
Ammonia—		
Free	1 1470	1.4904
Albuminoid—		
Total	0.2168	0.2221
In solution	0.1565	0.1621
Chlorine	11.85	11.48
Nitrogen as—		
Nitrates	2.03	0.76
Nitrites	0.0283	0.0159
Oxygen consumed	1.51	1.61
Bacteria per cubic centimeter	461,500	408,200

from eight to ten feet in depth of filtering material, can be operated, at rates approximating two or more million gallons per acre daily, and produce a highly nitrified effluent. Much of the organic matter in suspension in the sewage when it enters these filters passes away in suspension in their effluents, but in a very different and less offensive condition from that in which it exists when applied to the filters. That is, if the filter is well constructed and properly operated, a large portion of this matter adheres for a considerable period to the filtering material throughout the entire depth of the filter, and its more easily decomposed constituents are either passed into solution, or disappear as gas, while the remainder is changed to a more stable form. Effluents of successful filters of this class contain organic matter in such a stable form that they are little subject to putrefaction even under adverse conditions, and often improve in character after issuing from the filter. Their steady improvement is assured if they run into a considerable body of water containing free oxygen. Filters of this class were first put into operation at the Lawrence experiment station in 1899, and have since been studied quite extensively there. Large municipal filters of

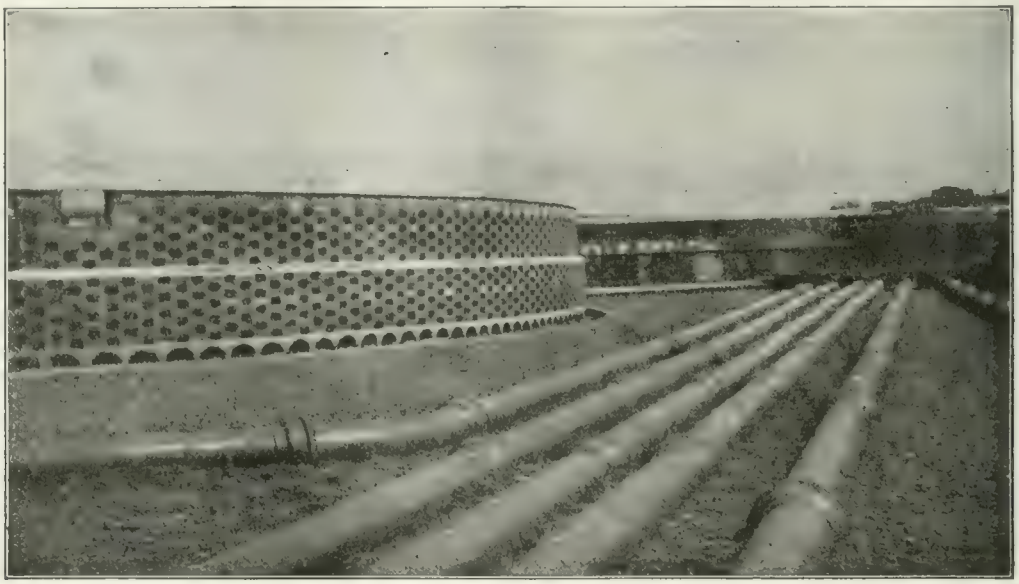

FIG. 4496.—Circular Trickling Filters.

Trickling or Sprinkling Filters.—In the continuation of studies upon rapid methods suitable for the purification of sewage, filters of coarse material have been constructed, through which sewage passes in a practically continuous stream. The coarseness of the material used in these filters is so great, however, and the rate of application of the sewage to them so regulated, that the surface of the filter is always practically free from sewage, and a large portion of the open space in the filtering material is always filled with air. Such filters may be constructed either of rough material such as coke, slag or cinders, or of smooth material, such as coarse gravel or broken stone. The sewage applied passes in thin streams or layers over the filtering material, and is in contact with air from its entrance at the surface of the filter until it passes away in the underdrains. With a filter of coarse material, operated under conditions which assure an abundance of air within it, wonderful activity of the oxidizing and nitrifying bacteria is induced, and the production of nitrates is exceedingly rapid. Filters constructed in this manner, containing this kind have been constructed in America, at Baltimore, Md., Columbus, O., Reading, Pa., and at Fitchburg and Brockton, Mass.

England and Germany have many extensive and fine sprinkling filter plants. During the past ten or fifteen years this method of purifying sewage has grown greatly in favor in these countries. It is thought, all things considered, to be the most economical method of filtration that can be practised with the production of satisfactory results. At practically all of the English and German cities where this method is in use the sewage is either settled and treated with chemical precipitants or passed through septic tanks or in some instances, a combination of these preliminary treatments.

The largest purification plant of this kind in the world is at Birmingham, England, where the sewage of rather more than 1,000,000 people is purified by being passed through grit chambers, sedimentation and septic tanks and sprinkling filters. At all the English and German plants, the sewage is applied either through sprinkling nozzles or by means of automatic

distributors. These distributors are generally constructed on the Barker-wheel plan, the jets of sewage causing the distributor to revolve. Hence, filters upon which sewage is distributed in this way are almost invariably circular in construction. When the sewage is passed to the filters by sprinkling nozzles, these nozzles are attached to pipes generally laid just below the surface of the filtering material and the head or pressure of sewage in the tanks causes the spray from the nozzles to be widely distributed. Distributing devices of a different kind are those run by electric power, as those at Hanley, England. This distributing device is as follows: On the side of each rectangular filter a track is laid and also a channel or trough into which sewage is delivered; stretching over each filter bed is a heavy iron distributor, a bridge-like structure operated by means of an endless wire rope coming from a power house. This endless rope, turning a wheel, causes the distributor to move from one end of the filter to the other. Its movement is reversed by an automatic device in the power house and the distributor moves across the filter bed in a reverse direction. The sewage is siphoned from the channels or troughs along each filter into the pipe in the distributor. From this pipe it is delivered through many small openings in the bottom upon dash plates which sprinkle it over the filter surface.

Fig. 4497.—Fitchburg, Mass., Trickling Filter.

7. *Aeration in Combination with Growths, "Activated Sludge."*—A new and promising process of sewage purification is that of aeration in the presence of algal growths. Many investigators have sought to purify sewage by direct chemical oxidation by air currents and have failed. At the Lawrence Experiment Station, it was discovered in 1912 that aeration in the presence of certain growths caused a satisfactory purification of sewage. The work was first carried on upon a small scale in gallon bottles. It was found by these experiments that aeration of the sewage for twenty-four hours in bottles containing growths caused the sewage to become stable and to contain nitrates equal to 1.5 parts in 100,000. The bottles were emptied and refilled daily, leaving simple growths and sewage slime attached to the sides and bottoms of the bottles. This work was carried on through several months successfully. Further experiments were made upon a larger scale in tanks containing a few layers of slate in order to promote algal growths. These were also successful and aeration and the circulation by air currents of the sewage through and over these growths, purified the sewage, removing not only matters in suspension but colloidal matters. Bacterial oxidation also occurred and as with the bottle experiments, stable and well-clarified effluents were obtained. In the fall of 1912, this work was repeated by English workers and designated by them the "activated sludge" process. At the present time, it is being tried on a considerable scale at many places in America and in England, and in one city, namely, Milwaukee, Wis., a plant of this kind is being constructed capable of treating several million gallons of sewage daily. The process is very promising as a method preliminary to filtration, or it may be so successful under certain conditions as to render further purification of the sewage unnecessary.

Résumé.—In the preceding pages six well-known methods of sewage disposal or purification have been described and one method, that of aeration with the aid of growths, which is still in its experimental stage. They include all methods by which sewage is purified by natural forces, that is, by bacteria and air, and which promise such developments in the future as to adequately solve all sewage purification problems. To summarize the methods:

1. Disposal by dilution.
2. The dry method.
3. Irrigation or sewage farming.
4. Screening and sedimentation.
5. Tank treatment including the use of chemical precipitants or without precipitants in septic tanks, Imhoff tanks, etc.
6. Filtration or biological purification.
7. Aeration in combination with growths—"activated sludge."

Disposal by dilution is extensively practised and entirely satisfactory at such places as those mentioned in this article. The *dry method* or pail system is practically obsolete and used only in a few localities. *Irrigation* or *sewage farming* has been widely practised for many years, is successful in many places especially with a concentrated English or European sewage and is especially applicable to regions of little rainfall as in such regions the sewage is really valuable for irrigation purposes apart from its fertilizing constituents. *Screening and sedimentation* are of value when only the matters in suspension in sewage need to be removed or as a preliminary treatment before further purification. *Chemical precipitation* and *tank treatment* in tanks of the Imhoff type are both widely practised in sewage disposal. Chemical precipitation not only by itself but as a preliminary treatment is very extensively used abroad to prepare sewage for rapid filtration through trickling filters and is practised on a large scale at a few American municipalities.

Filtration or Biological Purification.—Under this heading can be classed sand filters, contact filters, and trickling filters. Sand filters have been long used and are always entirely successful if the beds are properly constructed and properly operated. Contact filters are of value in many places but are of seeondary importance to trickling filters. These latter treat at the present time the sewage of more people than any other method of purification.

Purification by *aeration* aided by growths or "activated sludge" as has been stated, is as yet in an experimental stage. H. W. Clark.

Sex.—In the life history of nearly every multicellular organism there is a time when a new germ (oöspermium, or *zygote*) is formed by the union of two cells (*gametes*). In some of the protozoa and the lowest of plants the two gametes appear to be alike. Such organisms are said to be *isogamous*. But, as remarked by Coulter (1914), it is probable that their gametes differ chemically, otherwise they would not be mutually attractive.

The great majority of animals and plants are *heterogamous*, producing gametes that are evidently of two kinds. The larger, less mobile of the two cells, is the *macrogamete*, egg, or ovum (*q.v.*), and the smaller more active one is the *microgamete*, spermatozoon (*q.v.*) or its equivalent. The ability to produce a macro- or microgamete constitutes the essential distinction of *sex*. The individual which produces the latter is said to be of the *male* sex, the individual pro-

ducing the former is said to be of the *female* sex. In most of the higher plants and in a few of the lower animals both sexes are included in a single individual, which is then said to be *hermaphrodite*. The union of dissimilar gametes is the essential feature of sexual reproduction (see *Impregnation*). In many of the unicellular animals, Protozoa, there is a temporary union, or *conjugation*, of similar gametes, during which there is an interchange of part of the nuclear substance. In other Protozoa the gametes are of different size and the union is complete and permanent. Thus in these lowly forms we see foreshadowed the sexual process of the higher organisms. Moreover in the isogamous plants the gametes are hardly to be distinguished from asexual spores, and throughout the vegetable kingdom spore formation and sexual reproduction are intimately related; whereas in the animal kingdom the evolution of sex has proceeded along different lines.

If our definition of sex be correct, it follows that the quality of sex cannot be an attribute of the gametes, but only of the parent organism, except in so far as the sex of the offspring may be determined by some characteristic of one or both of the gametes. This view is borne out by what is known of the history of the germ cells, which has been shown elsewhere to be identical in all essential features in the two sexes (see *Maturation*). The differences between the gametes of the male and those of the female are confined chiefly to the cytoplasmic structures, and are associated with a physiological division of labor; the cytoplasm of the egg being more or less laden with food yolk and unprovided with locomotor apparatus, while the spermatozoon has practically all of its cytoplasm modified into a locomotor apparatus, by means of which it may actively seek the egg.

We may follow Ellis in dividing the characteristics that distinguish the sexes into primary, secondary, and tertiary. The primary characteristics are those associated with the organs concerned in the production and union of the gametes. And these organs may be divided again into the essential and the accessory reproductive organs. The former are the gonads, called ovary and testis in female and male animals respectively. In low forms, like the jelly-fishes, there are no other reproductive organs. But we need to go very little higher in the scale to find developed accessory organs that assist in the discharge and union of the gametes. Such are the oviducts, the vasa deferentia, and the appendages of these organs. Morphologically these tubes may be modified nephridea, or they may be newly developed structures. In all strictly terrestial animals and in many of the higher groups of aquatic forms fertilization takes place within the oviduct. This is associated with a marked structural differentiation of the sexes. The male is usually provided with a special organ for the introduction of the spermatozoa. This may be a prolongation of the sexual orifice, forming a penis, or, as in the elasmobranch fishes and higher crustacea, it may be in part a modified limb. In the female, on the other hand, the oviduct is either provided with glands to secrete a protective covering for the egg, or is modified to shelter the developing embryo, or even, as in the placental mammals, to nourish it during its fetal life.

The secondary sexual characters are those that clearly distinguish the sexes without being directly concerned in the reproductive function. Among these characters we may distinguish clasping organs, weapons, ornamentation, voice, and appliances for the shelter or nutrition of the offspring. In a large number of animals, especially among the crustacea and insects, there are to be found special modifications of one or more limbs of the males which serve to hold the female in firm embrace during coitus. Many males are provided with weapons, as tusks, horns, spurs, or the like, which are employed in fighting with other males for the possession of the females. Often the males alone are provided with such weapons, and when they are possessed by both sexes, they may differ in the two sexes. Thus the cow has long, pointed horns adapted for defense against carnivorous enemies, while the bull has shorter, thicker horns, probably more useful for fighting with rivals.

In some cases structures that probably arose as weapons are now developed as ornaments. The most notable examples of this are the antlers of the deer family. In most cases, however, the ornamentation has arisen independently of the weapons, and consists of the most varied forms of coloring and modification of structure. Ornamental secondary sexual characters are found widely distributed among the insects, amphibia, reptiles, birds, and mammals. They are especially conspicuous among the birds. They are usually possessed by the adult males only, and reach their highest state of perfection during the mating season. After this season the deer shed their antlers, and many male birds, like the bobolink, exchange their bright plumes for the sober protective coloring of the female. This exuberance of growth and coloring in the males, together with the song of male birds, and other instances of greater activity, like the superior eagerness of the male in courtship, are taken by Geddes and Thomson as evidence for their conception of maleness as a preponderance of catabolic activity. But they leave out of consideration the fact that these conditions are not always characteristic of the male sex. In the species of phalarope—birds not uncommon on our shores—the female is the more brightly colored, the more pugnacious, and more ardent in courtship; in short, she has all characteristics usually found in a male, except that she lays eggs. The male, on the other hand, is relatively dull colored, is courted by the female, incubates the eggs, and takes entire care of the young.

The characters that we are considering are called ornamental, not because they appear beautiful to us—often they are quite the contrary—but because, according to Darwin's theory of sexual selection, they are supposed to have been developed through the choice, conscious or unconscious, of the courted sex (see *Evolution*).

In man we find ornamental secondary sexual characters in both sexes, which would seem to indicate that the courting is not all done by one sex. The chief of these characters in men is the beard. While women have longer hair on top of the head, and this is associated typically with an entire absence of visible hair on other parts of the body, except in the axillæ and on the pubes. The layer of subcutaneous fat that develops in young women upon reaching maturity, and gives them the characteristic rounded contours of that period, may have become a fixed character of the species by the action of natural selection, owing to its value as a provision for the nutrition of prospective offspring; but, at any rate, it now forms one of the chief ornaments of women.

Sexual differences in the voice or in the method of using it are common, as every one knows, in amphibia, birds, and mammals. Witness the piping of the frogs, the song of birds, and the deep voice of men. Usually the modification of the voice is found in the males, and first appears, as in man, at the beginning of maturity. In fact, it is a general rule that when the male possesses special weapons, ornaments, or peculiarities of voice, these characteristics are not developed until about the time of the first ripening of the spermatozoa, and the immature males resemble the females. For this reason it has been inferred that the female, at least so far as these characters are concerned, represents a more primitive type than the adult male.

Devices for sheltering eggs or young are developed after different patterns in various groups of the animal kingdom, and they are usually confined to the females. Thus in most species of crustacea the female

is provided with some means of carrying the eggs until they hatch. The female marsupials have a fold of the skin forming a pouch, in which the imperfectly developed young are placed at birth and are carried there until they are able to run about. The most characteristic organs of the mammalia and the ones from which the group has received its name, the mammæ, or milk glands, are possessed by the females of all species from monotremes to man. While functional only in the females, these organs are present in a rudimentary condition in the males also. Their importance as a means of rearing the young is so great that it has been questioned as to whether they should not be regarded as primary rather than secondary sexual organs. That they are essentially secondary, however, is shown by the practices of civilized women, who have largely relegated them to the position of ornaments—to the detriment of the best races of the human species.

In addition to the well-marked secondary sexual characters that distinguish males and females, there are other usually slight differences that Ellis classifies as tertiary sexual characters. We know very little in regard to these differences in the sexes of the other animals, but, thanks to Ellis, we have in his book, "Man and Woman" (1894), a very interesting and complete summary of these characters, anatomical, physiological, and psychical, in men and women. It would be impossible to summarize even his summary in the limits of this article. We can notice only a few of his conclusions and must refer the reader to the book for more.

Among the anatomical differences women show a greater youthfulness of physical type, as is common among females generally; but they show another anatomical peculiarity not found in other female mammals, and that is an enlargement of the pelvis. This, in the higher races of men, might be regarded as a secondary sexual character. A study of the brain and of the intellectual process in men and women gives the impression that the observed intellectual differences may be as much due to differences of training as to any innate differences between the sexes. In their senses women appear to be less discriminating, but more irritable, and in their emotions they show a greater affectability. Ellis thinks that women are more variable than men, but that this is true for all characters is denied by Pearson.

It is a general rule that in most species the two sexes are approximately equal in number of individuals, but in a few forms in which parthenogenesis is common there may be a large preponderance of females. From the records of 59,350,000 births in European countries Oesterlen (1874) calculated that the normal proportion of boys to girls is 106.3 to 100, and in the single countries the proportion of boys varied only between 105.2 and 107.2.

The following statistics of the numerical proportion of the sexes in other animals were collected by Darwin ("Descent of Man," Amer. ed., vol. i., pp. 293–307):

	Number of cases	Proportion of males to 100 females.
English race-horses	25,560	99.7
Greyhounds	6,878	110.1
English and Scotch sheep.	59,650	97.7
Cattle.....	982	94.4
Fowls (pure Cochins)	1,001	94.7
Lepidoptera, various species	1,695	122.7

These figures are all taken from records of births except in the case of the sheep, in which the sex was recorded at the time of castration, and in the case of the lepidoptera, in which the sex of the imagos was recorded after emergence from the chrysalis. In the pigeons, which have two young in a brood, there is usually one of each sex, but occasionally both will be males, more rarely both females.

The question as to the factors that determine whether any given individual shall be a male or a female has excited the greatest interest since early times, and it is probable that there is no subject within the domain of biology on which so much nonsense has been written. According to Beard, it has been estimated that there are over five hundred theories, or rather hypotheses, of sex. It is manifestly impossible to review any considerable number of these hypotheses within the limits of the present article, and we will confine our attention to a few that deserve special attention because they are either very recent or are founded on experimental evidence.

Waldeyer (1903) divides the hypotheses into three groups which he calls progamous, syngamous, and epigamous. 1. According to the progamous theories the sex of the future individual is determined before the fertilization of the egg from which it is to develop. (*a*) According to some authors the differentiation takes place in the spermatozoon, (*b*) while others think that it is in the unfertilized egg that this occurs. 2. The syngamous theories hold that the sex of the embryo is determined at the time of fertilization, while (3) the supporters of the epigamous theories hold that the zygote and the embryo in its early stages are sexually indifferent, and that the sex is determined by external factors acting upon the embryo during its development.

A flood of light was thrown upon the question of the determination of sex when the late Miss Nettie M. Stevens (1905), following a suggestion of McClung (1902), showed that in a beetle, *Tenebrio molitor*, whose larva is the common meal-worm, there are two kinds of spermatozoa, one containing ten large chromosomes and one containing nine large and one small one. The eggs are all alike and contain ten large chromosomes. If the two kinds of spermatozoa are equally active there will result two kinds of fertilized eggs, one with twenty large chromosomes, which is the number found in the somatic cells of the female, and one with nineteen large ones and one small one, the number found also in the somatic cells of the male. Sex is, therefore, determined at the time of fertilization and is due to the difference in structure of the spermatozoa.

This result was quickly confirmed by E. B. Wilson (1905 and later). The chromosomes that are concerned in the determination of sex have been given various names: accessory, idiochromosome, and now most frequently sex-chromosome. They are recognized by this peculiar behavior during spermatogenesis (see articles *Chromosome* and *Maturation*), and they have been observed in a large number of animals, including man, and in some plants. In many animals, Wilson's Type A, there are two idiochromosomes in the female and only one in the male. Usually in the first maturation division the single idiochromosome goes undivided to one daughter cell, so that there are formed two kinds of spermatozoa in equal numbers. Spermatozoa containing an idiochromosome are female producing, those with none are male producing. In other animals, Type B, there are two idiochromosomes in the male, frequently differing in size. The larger of the two, corresponding in behavior to the single one in Type A is called by Wilson the X-chromosome, its mate is the Y-chromosome. In general it may be said that in the great majority of animals the somatic cells and oögonia of the female contain paired X-chromosomes, whereas the somatic cells and spermatogonia of the male contain a single X-chromosome or a group of X-chromosomes that act like a single one. The Y-chromosome, normally present in males of Type B and in their male-producing sperm appears to have no significance in the determination of sex.

In a few cases the reverse condition occurs, the male having the greater number of chromosomes; the female, less. This has been proved to be true in a few moths by cytological evidence, and is inferred from breeding experiments on other moths and butterflies and on birds, but Guyer (1916) finds on cytological evidence that this is true of the fowl.

Further evidence for the relation between chromosomes and sex is furnished by the brilliant researches of T. H. Morgan and his associates. This evidence is in two lines: first, studies on the spermatogenesis in species that produce one sex only from fertilized eggs; second, studies in relation to the inheritance of sex-linked characters.

In the Phylloxera of the hickory fertilized eggs produce females only. Morgan found that in spermatogenesis two kinds of spermatocytes are produced, but one of these degenerates, leaving only the female producing sperm. In this species sexual males and females are produced from parthogenetic eggs and the difference in sex was found to be associated with differences in the process of maturation, which result in the small male-producing eggs having one less chromosome than the large female-producing ones.

It has long been known that in the honeybee males are produced from unfertilized eggs, while females are hatched from eggs that have been fertilized. All the eggs give off two polar bodies in maturation, but the male produces only one kind of sperm. Thus the fertilized egg contains twice the number of chromosomes present in the one that develops without fertilization.

A sharp line must be drawn between "secondary sexual" characters and "sex-linked" characters. The secondary sexual characters are normally constant for one sex only. The inheritance of sex-linked characters is well illustrated by a certain kind of color-blindness. A color-blind man married to a normal woman produces normal children but half his grandsons will be color-blind. If the wife is color-blind and the husband normal, the children are normal, but color-blindness may appear in the granddaughters as well as the grandsons. The explanation is that color-blindness is a recessive character transmitted by a factor present on the X-chromosome (see *Heredity*). This explanation has been verified by the extensive work of Morgan and others on the easily reared pumice-fly, *Drosophila ampelophila*. Miss Stevens (1908) found in the cells of this insect three pairs of ordinary chromosomes, and in the female two X-chromosomes, and in the male an X- and a Y-chromosome. In Morgan's laboratory these flies have developed an extraordinary number of mutations (see *Variation*) and these fall into four groups, all the characters in each group being closely correlated in inheritance. The exceptions are explained as due to "crossing over" or to "non-disjunction," and appear to prove the rule. All the characters in one of these groups are sex-linked like color-blindness in man, and the study of the inheritance of these characters combined with microscopical examination of the germ cells has proved beyond doubt that the differentiation of sex in this fly is dependent upon the number of X-chromosomes present in the cells. When there are two X-chromosomes the individual is a female; when one, a male. The Y-chromosome appears to have no effect upon either the external characters or the sex. But in the rare cases where the Y-chromosome is absent in the male the individual has been found to be completely sterile.

The secondary sexual characters of most animals appear to be transmitted equally to both sexes and to have no relation to the sex-chromosomes. Castration and other experiments show that the development of the secondary sexual characters depends on the action of internal secretions of the reproductive organs. In mammals and amphibia removal of the testes prevents the development of secondary sexual characters, while removal of the ovaries has little or no effect on the female. On the other hand, in male birds the development of secondary sexual characters is largely independent of the testes, but removal of the ovaries causes the female to assume of the characters of the male. In crustacea destruction of the gonads by parasites has been seen to cause the male to assume female characters, but has no effect on the female. In insects the inheritance of these characters has been explained on Mendelian principles (Morgan, 1913).

That the mechanism for the determination of sex in man and other mammals is similar to that found in insects is made probable by a number of studies on spermatogenesis. The first record of X-chromosomes in man is due to Guyer (1910), who found in the spermatogonia (see *Maturation*) twenty ordinary chromosomes (autosomes) and two X-chromosomes (formula 20 + 2X). This result was confirmed in part by Montgomery (1912), but he found that the X-chromosomes are of unequal size and the smaller one acts sometimes like a Y-chromosome. Von Winiwarter (1912), whose results are regarded by Morgan as more reliable, makes the formula 46 + 1X. Stevens (1911) found in the male guinea-pig 54 + 1X + 1Y. The formulæ for both sexes of the pig has been determined by Wodsedalek (1913) from study of spermatogonia, oögonia, and somatic cells in male and female embryos. He gives for the male pig 16 + 2X, and for the female 16 + 4X. Moreover, the result of a large number of measurements of mature spermatozoa was to show that they are of two sizes, there being approximately equal numbers of each size.

In spite of the apparently complete demonstration of the relation between sex and certain chromosomes, there are some who still believe that sex may be determined by other factors either internal or external, such as food, supply of oxygen, relative age or vigor of parents, maturity of germ cells, etc. Thus Riddle (1916) returns to the theory of Geddes and Thomson and regards sex as dependent on the intensity of metabolism. In crosses between pure species of wild pigeons, which usually produce a preponderance of males, be obtained by overworking the reproductive powers of the females an increased proportion of female young. Moreover, he obtained different grades of femaleness, as shown by studies of behavior. If it be true that the mechanism of sex determination in birds resides in the gametes of the female, it may be that the size of the yolk or the metabolic condition of the egg influences the process of maturation and thus is a factor in the distribution of the chromosomes and the determination of sex. But Riddle denies that this is the explanation of the results of his experiments.

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Sexual Organs.—See *Genital Organs.*

Shadow Test.—Synonyms: Retinoscopy, Skiascopy, Keratoscopy, Fundus Reflex Test.

This is an exact and comparatively simple objective test whereby the refraction of the eye may be determined. The test possesses unique advantages. Being entirely objective, it can readily be employed in infants, illiterates, deaf-mutes, mental defectives, malingerers, etc. (The writer has with ease determined the refraction of many wild and domestic animals by retinoscopy.) It is rapid and exact, and calls for no extensive or costly apparatus. By its use myopia, hypermetropia, and astigmatism can be measured accurately, and the direction of the principal meridians in astigmatism can be determined.

The principle of retinoscopy consists in determining the point of reversal, or far point, of a myopic eye, or of an emmetropic or hypermetropic eye, given a myopic far point artificially, by the addition of a convex spherical lens. A myopic eye examined by direct ophthalmoscopy presents an erect image; further away from the eye, at the conjugate focus or far

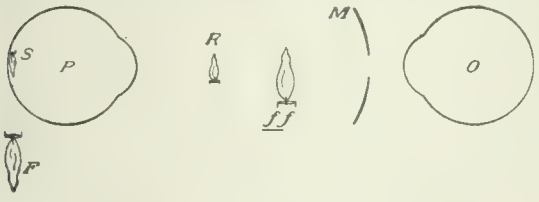

Fig. 4498.—The Shadow Test. (After Landolt.)

point, an inverted image appears, in other words, the erect image is here reversed.

If light be thrown into an eye by means of a perforated mirror, the observer's eye applied to the hole in the mirror will see the entire pupillary area illuminated with a reddish light. If the mirror be then slightly rotated in any axis, the illuminated pupillary area will be traversed by a shadow. The direction of movement of the shadow gives the trained observer a clue to the presence of refractive errors, and the speed of the shadow is roughly indicative of the amount thereof. Thus a rapidly moving shadow means a small error, a slowly moving one a considerable error. The significance of the direction of the shadow movement in this test depends upon the type of mirror used, whether concave or plane. The "illuminated area" is merely the confused image of the source of illumination (flame or lamp) formed at the fundus of the observer's eye, and by "shadow" is meant the place where the illuminated area ends, and is replaced by darkness; it is not to be construed as the shadow of any object thrown on the retina.

Cuignet, in 1873 conceived the idea of utilizing the direction of the movement of the shadow in the pupil for the practical determination of refraction, but it remained for Landolt, five years later, to furnish a satisfactory explanation of the phenomena.

In Fig. 4498, *O* represents the observer's eye, *M* the perforated concave mirror, *P* the observed eye, and *F* the source of illumination. Now *ff*, the real inverted image of *F*, formed by the mirror, becomes the actual source of illumination, and being thrown upon the retina of the observed eye (*S*), appears as an image inverted relatively to the object (regardless of the refraction of *P*). The image being inverted, its movements also are inverted relatively to those of the object. Thus if the mirror be rotated from right to left, the real image *ff* moves from right to left also, but the inverted image *S* moves from left to right.

The retina and the far point of the eye are conjugate foci, images being formed at either according to the refraction of the eye examined. To the surgeon's eye the illuminated area of the fundus becomes the object, and by the law of conjugate foci the image can replace the object and the object take the place of the image. If the eye is myopic one diopter, its far point is at one meter, and this is the point of reversal. If the eye is emmetropic, hyperopic, or myopic less than 1 D, the bundle of rays coming therefrom will not be brought to a focus unless on the retina of the examiner's eye. The surgeon, viewing the fundus in the erect image, the ocular luster moves in the same direction with the image of the flame at the fundus; *i.e.* opposite to the movement of the mirror.

In myopia a different condition obtains. Suppose *P* to represent a myopic eye whose far point is in the plane of *R*. On examining such an eye with a concave mirror, an inverted image of *S* appears at *R*, the inversion being produced by the dioptric media of the eye. *R* therefore has the same direction as *ff* and its movements correspond to those of *ff*. If *ff* moves from right to left with the mirror, and *S* from left to right then *R* moves from right to left. *S* is simply the illuminated part of the fundus which the surgeon observes in the patient's pupil. The pupil is seen in its real position, but the fundus appears inverted. If the mirror passes from right to left the pupil is lighted from right to left, although actually the light passes from left to right at the fundus. Therefore in myopia the shadow moves with the mirror, unless the surgeon approaches the examined eye closely enough to intercept rays before they are brought to a focus (as when *O* is between *R* and *P*, when the shadow would move against, or opposite, the movement of the mirror).

The technique of the shadow test is as follows, *assuming always that a concave mirror is used:* The patient is seated or stands in a darkened room facing the surgeon at a distance slightly more than one meter. The light, a frosted incandescent electric bulb or an Argand burner, is placed to one side of the patient's head and far enough behind it as not to illuminate directly the patient's eye. Each eye is examined separately; the eye not under examination may be covered, but this is not essential. The patient is directed to turn the examined eye toward the corresponding ear of the examiner; *i.e.* the right eye while examined is directed toward the right ear of the surgeon. The surgeon should wear correcting glasses if ametropic, but need not relax his accommodation. The patient's accommodation, however, should be eliminated by a mydriatic or, where this is not possible or advisable, by voluntary relaxation. In infants and children and in adults where mixed astigmatism or spasm of accommodation is present, a mydriatic is especially indicated.

The surgeon holds the ophthalmoscope before his eye, in such fashion that its upper edge rests against the supraorbital ridge and its inner edge against the side of the nose, the aperture in the mirror being just in front of the pupil, and throws the light into the pupil of the patient's eye. A gentle side to side swaying of the surgeon's head causes a shadow to pass across the pupil from side to side; an up-and-down nodding motion similarly produces shadow movement vertically through the pupil.

Myopia of More than 1 *D.*—If the shadow moves with the mirror; *i.e.* in the same direction as the movement of the mirror, both horizontally and vertically, we are dealing with myopia of more than 1 *D*. A spherical −1.00 D lens is now placed before the patient's eye, held either in the patient's hand or in a skiascopic

rack or a trial frame, and the "shadow" operation repeated. If the movement of the shadow now appears reversed, *i.e.* "against" the mirror, the myopia is known to be 2 D at most, whereupon the lens before the patient's eye is changed for one less strong (−0.75, −0.50 and −0.25) until the weakest of these minus lenses is found which is capable of reversing the shadow movement from "with" the mirror to "against" it. Assuming that the shadow moves with the mirror in both the horizontal and the vertical direction when −0.50 sphere is held before the patient's eye, but against it when −0.75 Sph. is employed, the total amount of the error would be Sph. −1.75 D (the addition of −1 D to the correction is necessitated by the fact that the eye is examined at a distance of one meter, the point of reversal of an eye myopic to the extent of 1 D.)

If, however, with a −1 D lens before the examined eye the shadow still moves with the mirror, lenses of successively greater concavity are employed, in steps of a diopter or fractions thereof, until the weakest concave glass is found which is capable of so reversing it. To this lens when found is always added the correction −1 D to determine the total myopia present. If it requires for example a −4.75 D lens to cause the shadow reversal (and a −4.50 does not so do) the eye is myopic −5.75 D.

Emmetropia, Hypermetropia, and Myopia of Less than 1 D.—If with a concave mirror a shadow is observed moving against the mirror, both in the horizontal and the vertical meridian, the eye is either emmetropic, hypermetropic or myopic less than 1 D, and the following technique quickly tells the observer which of these conditions is present and if ametropia, to what extent.

A Sph. +1 D lens is placed before the examined eye and the movement of the shadow noted. If the shadow is reversed by this lens and not by a +0.75 D. the eye is emmetropic. (The correction −1 D added to +1 D =0.)

If a +0.75 lens is sufficient to cause the shadow to move with the mirror the eye is myopic −0.25 D (−1 D+ +0.75= −0.25). Similarly if +0.50 be the lens able to cause the shadow reversal the eye is myopic −0.50 D; with +0.25 needed the error is −0.75 D.

Assuming that with a +1 D lens before the eye the shadow still moves against the mirror, we are then dealing with hypermotropia, and to determine the amount thereof proceed to add to the strength of the lens before the eye by gradations of a diopter or less, until that one is found which causes the shadow to move with the mirror. To this is added −1 D, and the result is the amount of the hyperopia present. A good working rule is to increase the lenses 1 D at a time until the shadow is reversed and then reduce this strength by steps of one-half or one-quarter diopters until the weakest convex lens is found capable of causing the shadow to move with the mirror. For example if +1 D does not change the direction of the movement, nor +2 D, nor +3 D, but +4 D does, try +3.75 D; if that also reverses the shadow try +3.50 D. If +3.50 D does not reverse the shadow the total hypermotropia is Sph. + 2.75 D (−1 D + + 3.75 D = +2.75 D).

No shadow movement at all across the pupil but a diffuse illumination under movement of the mirror from a distance of slightly more than one meter indicates a myopia of 1 D (−1 D+0 = −1 D.)

Astigmatism.—In the above examples the shadow reversal is the same in *both* principal meridians, *i.e.* a lens able to reverse the horizontal shadow similarly affected the vertical one. In astigmatism, however, a different condition obtains. Here the two principal meridians differ as to their reaction with the same correcting lens; for example, a lens reversing the horizontal shadow fails so to affect the vertical shadow. Therefore it is necessary separately to correct the two principal meridians, the difference between which constitutes the amount of astigmatism. While the positions of the two principal meridians are usually vertical and horizontal, they may be oblique, in which event the movement of the shadow is also oblique and the ophthalmoscopic mirror must be turned in such manner as to be moved parallel and also at right angles to the direction of the movement of the shadow. The degree of deviation of the shadow is an accurate measure of the axis of one of the principal meridians.

Assuming that in the eye examined the shadow moves against the mirror in both principal meridians and that while it requires a Sph. +1.50 D lens to reverse the vertical shadow, the horizontal shadow still moves against the mirror. The process of increasing the strength of the convex lenses before the eye is continued until one is found which reverses also the horizontal shadow. Suppose this to be +3.50 D. The eye is therefore hyperopic +0.50 D (−1 D+ +1.50 D), with an additional astigmatism of 2 diopters, and the correction is written Sph. +0.50 DCyl. + 2.00 D, axis vertical.

It must be remembered that the shadow is always at right angles to the meridian tested; for example, the horizontal shadow and its reversal determine the error in the vertical meridian.

Astigmatism, myopic or hyperopic, may be present without accompanying error of refraction in the other principal meridian, or both myopic and hyperopic astigmatism may exist in the same eye. For instance, a vertical shadow moving against the mirror is reversed by +1 D (emmetropia), but the horizontal shadow requires a +3.25 D lens to reverse it. This indicates simple astigmatism of +2.25 D in the vertical meridian and is written Cyl. +2.25 D axis vertical.

Assuming again that the vertical shadow moves *with*, and the horizontal shadow *against* the mirror we proceed with convex lenses to reverse the horizontal shadow, finding it to require for example +4 D. The vertical shadow is then found by the use of concave spheres to require for its reversal, let us say −1D. The error therefore is a hyperopic astigmatism of 3 D in the vertical meridian, together with a myopic astigmatism of 2 D in the horizontal meridian. For practical purposes opticians prefer this being written Sph. +3.00 DCyl. −5.00 D, axis horizontal.

The determination of the exact axis of the principal meridians is facilitated by the use of an axonometer, a black disc with a central opening which is rotated before the eye in a trial frame until the white lines bisecting the disc coincide with the long axis of the shadow, whereupon the point on the rim of the trial frame coinciding with the white line indicates a principal meridian.

In retinoscopy with the *plane* mirror the shadow movement is the reverse of that which obtains in using the concave mirror; *i.e.* with the plane mirror the shadow moves with the mirror in hypermertropia, emmetropia and myopia of less than 1 D, and against the mirror in myopia of greater degree, when examined from a distance of one meter.

The findings in retinoscopy do not necessarily determine the exact amount of correction to be prescribed. An excellent general working rule is to give *as much* of the total hyperopic correction found as the patient can take and still see 20/20 and *as little* of the myopic correction as is necessary to bring the vision to 20/20. In convergent strabismus in children, where hyperopia is usually found, the full correction of the error is advisable. It is well always to check up the retinoscopic findings with the ophthalmometer and the trial case. CYRIL BARNERT.

Sharon Springs.—Schoharie County, New York.

POST-OFFICE.—Sharon Springs. Hotels, boarding-houses, and cottages.

Access.—Via Delaware and Hudson Railroad direct to the springs; also via New York Central Railroad to Palatine Bridge, and thence by auto bus nine miles to springs.

The village of Sharon Springs is situated in a valley about 1,100 feet above the sea-level; the streets are provided with good sidewalks, and are well shaded with maple-trees. The air is pure and bracing and free from malarial influences. Even in the warmest of summer weather the nights are cool and pleasant for sleeping. The springs are easy of access within the village limits on the edge of a natural forest abounding in pleasant walks. The surrounding country is hilly and affords interesting drives and pleasant scenery. Excellent accommodations, comformable to any taste or grade of expenditure, may be obtained in the village. Sharon is one of the well-established old resorts of New York State, its waters having been used for medicinal purposes since early in the last century. The old bathing buildings were destroyed by fire a few years ago and have been replaced by the present spacious establishment, believed to be unexcelled for its purposes any-where in the country. There are several valuable springs at Sharon, the most important being the White Sulphur, the Magnesia, and the so-called Eye-water Spring. The waters of the White Sulphur Spring are used both internally and for bathing purposes. The water is clear and bright as it issues from the spring, of an agreeable temperature for drinking (48° F.), and free from the roughness and acerbity which so often characterize sulphur waters. It is conducted to the bath-house and heated to any desired temperature for bathing. This spring yields 1,400 or 1,500 gallons of water per hour, so that the supply is always fresh and abundant. The waters possess undoubtedly a degree of radioactivity. The Magnesia Spring is also valuable for drinking purposes. The third spring is used extensively as a lotion for inflammatory conditions of the eye, which fact has led to the designation of the Eye-water Spring. A chalybeate spring is also found within the village limits. The following analyses of three of the springs were made a number of years ago.

One United States Gallon Contains:

Solids.	White Sulphur Spring. (Lawrence Reid.) Grains. 48° F.	Gardner Magnesia Spring. (J. G. Pohll.) Grains. 48° F.	Eye-water Spring. (Lawrence Reid.) Grains. 48° F.
Sodium bicarbonate		0.54	
Calcium bicarbonate		9.70	
Magnesium bicarbonate	24.00	1.36	32.00
Calcium sulphate	85.40	93.50	77 50
Magnesium sulphate	34 00	19.68	7.50
Sodium chloride	2.70	1.23	2.50
Magnesium chloride		0.44	
Calcium chloride		0.16	
Calcium sulphide	3.00	0.63	
Magnesium sulphide			
Silica		0.40	
Total	149.10	127.64	119.50
Gases.	**Cu. in.**	**Cu. in.**	**Cu. in.**
Sulphureted hydrogen	20.50	6.00	
Carbonic acid		2.22	
Atmospheric air		3.00	

The sulphur baths here have a wide reputation in the treatment of gout, rheumatic affections, and certain forms of paralysis. They are also serviceable in cases in which exudations are to be absorbed, *e.g.* in old gunshot wounds, stiff joints, glandular enlargements, skin diseases, and catarrh. It is said that many of the consequences of high living, such as congestion of the liver, abdominal plethora, and hemorrhoids, are quite certain to be benefited by a course of the Sharon waters. They are useful also in metallic poisoning and in ridding the system of chronic syphilitic infection. The methods of employing sulphur waters at the well-known French spas, Aix-les-Bains, Challes, and Allevard, were adopted at Sharon Springs in 1884, and have been in successful operation since that time. The sulphur water of Sharon is also used commercially.

Emma E. Walker.

Shasta Springs.—Siskiyou County, California.

Post-Office.—Shasta Springs. Hotel and cottages.

Access.—Via Southern Pacific Railroad. At the foot of Mt. Shasta, on the banks of the Sacramento River lie the celebrated Shasta Springs. The climate is delightful and invigorating, and the scenery unsurpassed.

A scenic railway connects the hotel with the Southern Pacific Railway Station, and offers a matchless panorama of hills, forests, streams, water-falls, and cascades—the entire scene presided over by Shasta, the monarch of mountains. The new fifty-mile private automobile boulevard to the McCloud River affords one of the most beautiful drives in the world.

The recently completed concrete swimming pool, open to the sky and surrounded by stately pines, is 150 feet long, 30 feet wide, and from 4 feet to 8 feet deep. Hunting, fishing, and various other amusements are at the service of the guests. The solid ingredients of Shasta water are sodium bicarbonate, sodium chloride, sodium biborate, sodium phosphate, potassium chloride, potassium sulphate, lithium bicarbonate, calcium fluoride, magnesium carbonate, iron carbonate, and alumina.

The therapeutic effects of the water depend largely upon the alkaline ingredients and the iron. As an alterative and tonic this water is calculated to prove of decided value. Among the disorders most likely to be benefited by Shasta water are gout, the dyspepsias, constipation, anemia, chlorosis, irritation of the bladder, many skin diseases, sterility in women, the neuralgias, and rheumatic disorders.

Emma E. Walker.

Shivering.—A shiver is a wide tremor or rhythmical agitation of the voluntary muscles of both physiological and pathological origin. Muscular agitation comparable to shivering is present in the coarse tremors of neuroses, psychoneuroses and organic disease of the central nervous system. Physiological shivering is due chiefly to cold or to strong emotion—principally fear. Any kind of physiological tremor seems—at least in theory—to exhibit degrees which could be termed shivering; but in individual cases the possibility of an exquisite neuropathic substratum must be borne in mind, and such tremor would be pathological. Shivering is a condition which is readily simulated.

In the thesis of Busquei (Paris, 1904) entitled "le tremblement physiologique" the author states that physiological tremor is a condition unrecognized before 1860. Barthez, who remarked its occurrence in animals, named it amyostasia. Busquei recognizes four sorts of physiological tremor, viz., from cold, fatigue, emotion, and brief muscular overexertion. In each of these the number of oscillations is the same—seven per second—while the amplitude varies greatly. In shivering with cold the amplitude is very large.

It is hardly possible to discuss shivering without a parallel account of physiological tremor. Most readily isolated from the latter is shivering from cold. Grasset (Dict. encyclop. des sciences médicales, 1880) makes several more or less artificial degrees of this phenomenon. In the mildest there is a subjective feeling of cold beginning on the back and loins and involving the entire trunk, which is agitated slightly. Such a chill may go no further and may not be repeated.

In a somewhat higher degree the shivering is recurrent, and the cold sensation may extend to the limbs. Goose-flesh develops. The face and surface in general become pale, the tissues shrivel, so that the rings may drop from the fingers. The subject hunches himself together as a defense against the cold. This kind of chill is seen especially when passing suddenly from a warm to a cold temperature. The muscular agitation is more marked than in the first degree.

In the highest degree the agitation is universal and violent and the teeth chatter rhythmically from agitation of the masseters, etc. There is no direct relation between the degree of cold and that of muscular agitation. A pathological chill may also be slight or severe.

In regard to shivering as a result of cold bathing it has long been known that hot water, say at a temperature somewhere between 104° and 122° F., is able to produce a similar effect, although much less pronounced.

The subject of shivering from strong emotion is most familiar and a good sized volume could be devoted to it. According to Mosso, the basis of a tremor is either an excess of nervous tension, or a weakened condition, such as is common in convalescence from serious illnesses. The former is seen when we hold at arms length a heavy object, while the latter is involved fundamentally in emotional muscular agitation.

It has long been held that the kneeling position is the inevitable result of feelings of extreme awe, adoration, supplication, terror, and the like. All of these acts or feelings have a component of fear or apprehension. The limbs weaken and tremble violently, and refuse to support their burden. In stage fright the knees knock together.

Dogs and horses may shiver violently from suspense and anticipation. In both animals and savage men the sexual approach may be preceded by violent trembling. Bleuler in his work on "Schizophrenia" calls attention to the universality of this association which appears to be too profound for elucidation.

Another well-known phenomenon is the "urination chill," which may amount to a shuddering, just before micturition. It is plainly of peripheral origin and reflex nature, and in this respect resembles shuddering from exposure of the skin to cold and heat.

EDWARD PREBLE.

Shock.—Were medicine like mathematics an exact science, its nomenclature would be unequivocal and simple and its literature comparatively small—but everywhere in medicine names express ignorance as well as knowledge. Thus *shock* is a term which is made to include almost any sudden loss of energy from any cause—from hemorrhage, anaphylaxis, emotion, physical injury, overanesthesia, intestinal perforation, acute onset of infection, etc. Therefore any attempt to unravel all that is popularly included in the word *shock* must include a solution of the most dramatic stage of nearly every form of sudden ill-fortune that can befall man.

There is a significant fact, however, underlying what seems at first to be a confusing identity of title—the fact that whatever the *primary cause* of the condition denominated *shock*, the physiological and histological results are identical. On the other hand, the *physiological manner* in which these identical results are produced has long been a matter of investigation and many theories have been proposed. Not the least interesting circumstance to be noted in connection with this controversy is the extent to which, in connection with each theory, the experimental results used to establish the theory advanced by any one are quoted also by other workers in this field as evidence in favor of their conceptions. The best way to summarize the present status of our knowledge of this condition is to define the leading theories and some of the objections which have been raised against each. Such a procedure includes practically a summary of the recent literature on this subject—a bibliography of which is appended.

THEORIES OF SHOCK.—1. Vasoconstrictor Theory (Boise, Malcolm); 2. Cardiac Theory (Howell); 3. Inhibition Theory (Meltzer); 4. Acapnia Theory (Henderson); 5. Kinetic Theory (Crile).

1. *Vasoconstrictor Theory.*—According to the vasoconstrictor theory of Boise and Malcolm "the essential cause of shock is excessive sympathetic irritation, manifested mainly by a tonic contraction of the heart and arteries." In other words, the increased vasomotor activity which precedes the stage denominated "shock" results in a widespread vasoconstriction which interferes with the circulation. According to Malcolm, this theory is "founded on the well-known physiological fact that stimulation of a sensory nerve causes arterial contraction."

He further states that "in addition to the exhaustion of brain power due to overstimulation of the nerves and the starvation of brain tissue which may be explained by the theory that the vessels are contracted in proportion to the intensity of the stimulus caused by an injury, this theory that the arteries contract also explains fully those cases of sudden death in which the injury, although severe, does not affect any vital organ."

This theory is supported in part by the extensive experimental researches of Seelig and Lyon, who found that the blood-vessels of the retina and the extremities were contracted in shock. On the other hand, Bartlett, after an extensive research into the state of the arteries in shock, reached an opposite conclusion.

The gross phenomena of shock have been cited as supporting this theory. Certainly the cold, white, and bloodless condition of the skin suggests vasoconstriction. The principal arguments which have been urged against it are the following: the vasoconstriction would yield before the death point, so that the process would be automatically self-cured; vasoconstriction would raise the blood pressure while in shock the blood pressure is low, although in this connection it should be stated that Malcolm believes that a state of low blood pressure is thoroughly consistent with contracted peripheral arterioles; were shock due to tonic contractions of the blood-vessels, then the condition should be relieved by nitroglycerin or by spinal anesthesia—these measures do not relieve shock. This theory fails also to account for the acidosis existing in shock and it fails to explain why the direct transfusion of blood in sufficient quantity does not at once overcome the symptoms of shock as completely as it overcomes the symptoms of an acute hemorrhage. Porter and Quinby, as a result of a research into "the condition of the vasomotor neurons in shock," came to the conclusion that "exhaustion in the vasoconstrictor neurons cannot therefore be the essential cause of the symptoms termed 'shock.'"

2. *The Cardiac Theory.*—Howell, the sponsor of the cardiac theory believes that shock is "due to an inhibition of the centers in the medulla, that is, an inhibition of the tonus of the vagus center which causes acceleration of the heart and an inhibition of the vasomotor center which leads to vasomotor shock." Although accepting vasomotor disturbance as an es-

sential factor in shock, Howell considers cardiac shock in all instances as the primary factor, and distinguishes between two classes of cases, one, in which cardiac shock exists without vascular disturbance, the other in which cardiac shock is associated with vascular shock.

While it is certain that the action of the heart is always disturbed in shock, yet that this disturbance is only incidental may be inferred from the fact that in cases of shock with pronounced cardiac disturbance, the action of the heart is restored nearly to normal by the direct transfusion of blood. A disturbed heart action that can be so nearly restored to normal by blood transfusion is probably due either to anemia or to the presence of some toxic substance in the blood. In either instance the impairment of the heart is an end-effect.

If cardiac disturbance were an important factor in shock, one would suppose that shock would be prone to occur in patients with heart lesions; but clinically, we know that such patients by no means succumb readily to shock.

3. *The Inhibition Theory.*—The inhibition theory of Meltzer is an ingenious explanation of many of the phenomena of shock. According to him, "the various injuries which are capable of bringing on shock, do so by favoring the development of the inhibitory side of all the functions of the body. * * * The normal state of a function results from a proper balance of antagonistic stimulations. * * * Under unusual abnormal conditions, however, there may arise a tendency toward a deviation in one or the other direction; in the direction of excitation of in that of inhibition. * * * Our theory assumes that the injuries which produce shock disturb the equilibrium, causing a tendency toward inhibition."

In favor of this theory is the fact that if the vasomotor, cardiac, respiratory, and muscular mechanisms are inhibited in part, there result many of the phenomena of shock. On the other hand, it is rather difficult to harmonize the inhibition theory with the resemblance of the phenomena of shock to the phenomena of exhaustion—the labored physiological processes, the protracted recovery which may extend over weeks and even months. Moreover it is difficult to prove that an animal may be inhibited to death in response to injury.

4. *The Acapnia Theory.*—The theory advanced by Henderson that shock is due to a reduction of the carbon dioxide content of the blood and tissues apparently accounts for all the phenomena. Henderson's extensive and important researches have been reported at length in a series of illuminating papers, the central point of which is that his observations "indicate that the CO_2 tension in the nerve centers and in the tissues and fluids of the body is a factor in the maintenance of tonus (in the broad sense of the word) of the same order as temperature, oxygen supply, osmotic pressure, and the equilibrium of anions and kations."

Of all the theories thus far proposed, none has offered as much hope as this, because if shock were due to a diminished CO_2 tension in the blood, then, as Henderson has pointed out, it could be prevented by the retention of CO_2 by means of a simple apparatus; and existing shock could be cured by supplying the needed CO_2. In practical experience, however, these hopes have not been realized.

5. *The Kinetic Theory.*—The kinetic theory assumes that shock is the result of an excessive stimulation of the mechanism that transforms energy. In consequence of this excessive activation a state of acute acidosis develops. Whether the acute kinetic drive be the result of emotion, exertion, infection, crushing machinery, or rough surgery, the end-effect is exhaustion, which in each case is manifested by loss of physical and mental power, rapid respiration, rapid pulse, low blood pressure, sweating, etc. These exhaustion phenomena are, in certain respects, identical with the phenomena of acute acidosis.

The pathological identity of surgical shock with the shock resulting from other causes is established in part by identical clinical phenomena; in part by identical histologic changes in three organs—the brain, the adrenals, and the liver; and in part by the fact that probably a decrease in the reserve alkalinity of the blood is present in shock—however produced.

The kinetic theory of shock, therefore, postulates that shock is due to excessive stimulation of the energy-transforming organs; that consequently, the organs especially involved in shock are those whose primary function is the transformation of the potential energy in the body into kinetic energy; that the organs primarily concerned in this kinetic activity are the brain, adrenals, liver, thyroid, and muscles; and finally that since every transformation of energy for adaptive ends is accompanied by increased acid production, acidosis is either the final primary factor in shock, or at least an invariable and important incidental factor.

On this conception *surgical shock* is defined as the result of an excessive driving of the energy-transforming mechanism in response to physical injury. In overwhelming injury without anesthesia the individual may be unable to transform much energy into heat or muscular action, but the organs concerned will still show the same lesions. Although inhalation anesthesia prevents the consciousness of pain and gross muscular activity, the increased energy transformation consequent upon surgical trauma is evidenced, clinically, by increased respiration, accelerated pulse, tense muscles, and lowered blood pressure; histologically, by the characteristic histologic changes in the brain, the adrenals, and the liver; and chemically, by increased H-ion concentration.

Against the kinetic theory stands the work of those who have proposed other theories; the protests of those (Janeway, Mann, etc.) who have been unable to confirm one or another part of the experimental researches upon which this theory is based; the objections of those (Seelig, etc.) who object to the deductions and reasoning of the author of the kinetic theory; and the objections of the clinicians (Bevan, etc.) who do not believe that shock is produced by surgical trauma.

Clinical Phenomena and Treatment of Shock.—However the theories may vary regarding the cause and the pathology of shock, all are agreed regarding the gross phenomena which herald its incidence, and for the most part regarding the therapeutic measures to be employed after the condition exists.

Mumford, with the dramatic exactness which characterizes his scientific writings, thus draws the clinical picture of shock: "The leading symptoms of shock are those of an acute anemia. The blood pressure is low, often below fifty millimeters of mercury, and the pulse is usually rapid and soft, though it may rarely become slowed. The output of the heart constantly diminishes as the shock deepens; the face becomes blanched; the breathing becomes rapid, sighing, irregular and of the Cheyne-Stokes variety; the muscular systems are relaxed; the reflexes are diminished; the sphincters are relaxed and voluntary muscular action is abolished. The functions of digestion and of renal secretion fail also, while the skin becomes moist and cold. The patient usually is apathetic, though he may be talkative and excitable rarely. The blanched face appears shrunken, pinched and elongated, while the chin droops and languor marks the expression. The eyes grow dim and turn upward beneath the half-closed lids, but the pupils react markedly to light. Should the patient die, the symptoms persist, becoming constantly more marked until the end. In case of recovery, however, one notes first a slight improvement in the rate and volume of the pulse, after which the

color returns gradually and the patient begins to rouse himself and take notice of his surroundings, or he may fall into a quiet and normal sleep."

Three fundamental principles are essential to the effective treatment of shock: (1) Further shock must be prevented by the amelioration or elimination of the conditions which produced it; (2) the circulation must be supported; (3) physiologic rest must be secured. As to the importance of these three principles, all writers are agreed, although there is more or less disagreement as to the methods by which these ends are to be secured.

1. All will agree that to accomplish the first end the surgeon "must check hemorrhage; he must relieve pain; he must remove anxiety and distress. Even in those cases of shock which have suffered their misfortune before the surgeon sees them, he can assist greatly by helping to blunt the sensibilities and to quiet apprehension. For this purpose morphine is the surgeon's sheet-anchor. There can be no doubt that mental strain and anxiety about his own condition will increase and prolong the patient's shock, and by just so much decrease his chances for recovery" (Mumford).

2. Formerly the almost invariable first resort of the surgeon in case the clinical aspect of the patient betokened the onset of shock was the use of stimulants —especially strychnine. Mummery, in his exhaustive treatment of "Surgical Shock and Collapse," says of his clinical observations on the results of the use of strychnine in these cases: "In severe degrees of shock when the patient's circulation had almost failed hypodermic injections of strychnine, whether given in small or large doses, seemed in most cases to produce no effect. * * * In lesser degrees of shock the effect of strychnine was more marked, the blood pressure being rapidly raised and marked improvement being apparent. I say apparent because, as a rule, the patient generally relapsed into a more severe degree of shock as soon as the effects of the drug had passed off. The most noticeable fact was that the more severe the degree of shock from which a patient was suffering the less was the effect of administering strychnine. Now it was at once obvious that this was just the reverse of what one would expect to find if strychnine really acted beneficially in the treatment of shock. * * * From the observation of a large number of cases I became quite convinced that strychnine was of very little value in the treatment of shock and that in many cases it directly contributed to a fatal issue."

Of his experimental investigations, Mummery says: "In small doses strychnine produced very little effect upon the blood pressure in a normal animal. In large doses it produced a marked rise in the blood pressure and the blood pressure was maintained at a high level for a considerable time. A second dose was followed by a similar rise in the blood pressure usually not so high and not continued for so long. A third dose was followed by a slight rise and the effect passed off very quickly and on repeating the dose a point was soon reached when no effect at all was produced. After each dose the blood pressure fell to a lower level than before the injection and when the point was reached at which no effect followed the administration of strychnine the blood pressure had reached a very low level, *and the animal was in a condition indistinguishable from that of profound shock produced by traumatism.*" (The italics are ours.) One remark of Mummery in this connection has been quoted by many: "The administration of strychnine in shock is like beating a dying horse, it may call forth an effort if we beat hard enough but it hastens the end."

These observations of Mummery are strikingly confirmed by the author's histologic studies of shock which have proved that strychnine causes histologic changes indicative of exhaustion in the brain, the adrenals, and the liver. The use of stimulants in the treatment of shock is as illogical, therefore, as would be an attempt to ward off bankruptcy by spending more money. On the other hand, morphine and other sedatives do not cause the expenditure of energy but aid in its conservation, a fact not only clinically evident, but proved experimentally by the conservative effect of this drug upon the brain, the adrenals, and the liver in the presence of shock-producing factors which without this protection cause widespread histologic changes in these organs.

Certain mechanical measures may temporarily raise the blood pressure. If the patient's head be lowered and the feet or buttocks raised, the anemia of the brain may be sufficiently relieved to tide the patient over the danger point. Pressure upon the abdomen by an abdominal binder also may accomplish the same purpose. Such measures are of but temporary value, however, and such devices as the pneumatic suit or the pneumatic chamber, devised by the author, present mechanical difficulties and in addition do not reach the root of the trouble.

It is obvious that the one logical and efficient means by which to relieve anemia is by an increase in the amount of circulating fluid in the body. Fluids may be introduced into the circulation either directly or indirectly—directly by intravenous infusion, and indirectly by rectal injection or by subcutaneous infusion. The use of saline solution by one or another of these methods has long been advocated by many surgeons. By each method the blood pressure may be raised temporarily. The rectal injection of saline solution is effective to a limited extent. The subcutaneous infusion is safe and within a limited range, efficient. Although each of these indirect methods may temporarily increase the blood pressure and thus tide the patient past a momentary danger point, they fail in the more severe cases. Intravenous infusion is more prompt in action. Continuous infusion of saline solution at a given rate into a vein of a normal dog causes death in from five to eight minutes, death being the result of the mechanical fixation of the abdominal and the thoracic respiratory muscles and of the diaphragm through the distention of the abdominal viscera. The walls and the lumina of the stomach and intestines are packed with saline, the liver is engorged, the spleen is enlarged, the saline solution runs out through the blood-vessel walls as fast as it enters the vein. Like posture and bandaging, saline infusions, therefore, present a definitely limited though useful remedy.

The final remedy must be some circulating medium that will remain in the circulation, that will do the work of blood, that will not pass through the blood-vessel walls into the surrounding tissues, but can be introduced in large enough quantities to develop a peripheral resistance through stretching the elastic blood-vessels. The heart will continue to act as long as the coronary arteries receive a pressure of forty or more millimeters Hg, and the proper nutriment is given the heart muscle. It is obvious that only one fluid will answer all these conditions—human blood.

Having become convinced of these facts, the author developed a technique for the direct transfusion of blood, many excellent modifications of which have since been devised by others. This has proven to be an ideal method for the treatment of shock. Almost no patient with shock will die of shock alone if given an adequate transfusion of human blood. The transformation in the patient's appearance is dramatic, especially in shock with hemorrhage. The transfusion of blood is a specialized technique, however, the details of which should be mastered in advance of the emergency.

In this connection it is interesting to note that, so far as is known, the first direct transfusion of human blood for traumatic shock was given in Lakeside Hospital, Cleveland, in 1906, for a patient who had

had his arm torn off by a cogwheel and was brought to the hospital in a state of apparently fatal shock. The transfusion was performed by members of the author's house staff, Drs. Sloan and Gamble. The transfusion was continued for thirty-five minutes. The change in the patient was little short of remarkable. Instead of the picture of profound shock, he presented practically a normal appearance. Within the thirty-five minutes his pulse had fallen from 156 to 110 per minute, the volume had increased, the blood pressure had risen from ninety to 128 millimeters, the sweating had disappeared, the skin was dry, his mind was clear, and the stupor had passed away. He was returned to the ward in excellent condition. The symptoms of shock never returned. On the twenty-fourth day after the transfusion he was discharged from the hospital.

Certain drugs, whose specific action is to raise the blood pressure, have a limited field of usefulness, although writers differ as to the extent to which they should be employed. Chief among these is adrenalin. According to Mummery, adrenalin "will raise the blood pressure in all conditions of shock when the vaso-motor centers are completely exhausted and even when they are destroyed." Adrenalin should be used in an extremely dilute form, 1 in 50,000 or even 1 in 100,000, although Mummery and others advocate somewhat stronger solutions. Martin and Pennington, writing in 1903, made the following strong statement regarding the value of adrenalin in shock: "Laboratory experiments apparently show that adrenalin by intravenous injection is the most powerful, practicable cardiac, and vasomotor stimulant yet presented to the profession. Its value is still further enhanced by the fact that it stimulates the respiratory center and increases general metabolism and body temperature." In logical accord with the theory of which he is the principal supporter, Malcolm opposes the use of adrenalin and of any other vasoconstrictor, advocating instead sedatives, antispasmodics and vasodilators, and the application of heat and friction. Pituitary extract has some advocates, as its effect on the blood pressure is more lasting than that of adrenalin, which to be effective must be administered continuously.

We have already spoken of the value of morphine as opposed to the destructive effect of stimulant drugs. In this connection, Wainright states that morphine is the only drug of unquestionable value.

Prevention of Shock.—Discussions of therapeutic measures for the relief of existing shock find their prime application in those cases which have resulted from unforeseen causes—sudden and severe psychic stress, accidental physical injury, etc. In the case of *surgical shock*, however, the factors known to be instrumental in shock production may be foreseen, and to the extent to which these factors may be eliminated or their effects minimized, shock may be prevented.

Since, as all agree, both psychic and physical factors contribute to shock, it is obvious that any methods which obviate in any measure the psychic stress incident to surgical operations, and any methods which lessen the trauma inflicted, will lessen the liability to shock. These two points are not affected in any way by the surgeon's predilection for one or another of the "theories" of shock causation.

It may be well, therefore, to consider the various steps in a surgical operation in sequence and to present the views of various authors as to how the shock-producing factors in each may be minimized.

1. *Preoperative.*—Before the introduction of inhalation anesthesia, the patient's terror of the approaching ordeal, as well as the fearful agony of the operating-table, were often assuaged by laudanum; without this preliminary medication undoubtedly many patients would have died of psychic shock alone. In the calm, indifferent mind induced by opium, even the guillotine was faced without terror by those victims of the French Revolution whose gaolers were merciful enough to grant them this solace. With the advent of inhalation anesthesia, the preliminary, sedative dose fell into disuse. This preoperative "state of mind" is still a potent factor in certain conditions, however, preëminently in exophthalmic goiter, and in lesser degree influences the well-being of all but the most phlegmatic patients. Moynihan, as early as 1899, advocated "the early use of various agents, so as to prevent, to *anticipate* shock," *i.e.* such as would ordinarily be used after the condition of shock is inaugurated. To *anticipate*, therefore, the possibility of shock-producing effects of psychic stress, many clinics, as a routine, administer a preoperative dose of morphine or of some other sedative before the patient is taken to the operating room. A tangible reason for the efficacy of this procedure was found in the author's laboratory in the results of experiments on fear, in which it was found that fear alone produced histological lesions in the brain, the adrenals, and the liver, and increased H-ion concentration of the blood—thus of itself diminishing the factor of safety. According to Mummery, "A hypodermic injection of morphine given before the administration of a general anesthetic decreases the patient's susceptibility to shock during the operation. The action of morphine in preventing shock is probably twofold; in the first place it enables surgical anesthesia to be induced and maintained with a smaller quantity of the anesthetic and in the second place by its action upon the nervous system it diminishes the intensity of many of the afferent nerve impulses reaching the vasomotor centers as the result of stimulation of the peripheral nerves at the field of operation." Our histological studies have shown that in a morphinized animal psychic and traumatic stimuli cause neither the clinical nor the histological changes, nor the degree of acidosis associated with a comparable degree of kinetic stimulation of like type. The preoperative dose of morphine has a directly protective value, therefore, since to some extent it conserves the brain, the adrenals, and the liver from the definite damaging effects of the preoperative psychic stress as well as of the trauma of the operation itself.

In addition to this conserving effect of morphine, any preoperative measure that promotes the comfort of the patient, assuages his fear and gives him confidence in a favorable outcome is directly conserving in its action and therefore has an important place in the prophylaxis of shock.

2. *The Inhalation Anesthetic.*—Here again, as with morphine, the laboratory sheds light upon and gives a new significance to clinical observations. In our laboratory we have found that the prolonged administration of ether will alone produce histological changes in the brain, the adrenals, and the liver, corresponding in kind and in some instances in degree to those caused by stimulant drugs, such as strychnine. In its relation to shock, therefore, ether must be classed with those influences which diminish rather than among those which conserve the patient's resistance, excepting in so far as by inducing unconsciousness it protects him from the greater danger that would result from his consciousness of pain. Because of the directly damaging effects of ether, as well as its unpleasant qualities, which increase the psychic as well as the physical distress of the patient, an increasing number of surgeons are adopting nitrous oxide as the anesthetic of choice. Nitrous oxide is pleasant to take and is devoid of baneful after-results, and to some extent conserves the energy of the patient.

It should be emphasized, however, that while nitrous oxide, because of this conserving power, is the safest of all anesthetics, *when administered by an*

expert, it is the most unsafe of all anesthetics in the hands of one unskilled in its use.

3. *Local Anesthesia.*—Mummery states "that abdominal operations performed under cocaine anesthesia are less liable to result in shock than operations performed in the usual way under general anesthesia," and he goes on to say that this favorable result may be due in part to the absence of the general anesthetic, but in any case it is a striking confirmation of the theory regarding the shock-producing factors and the means of protection against them which are advanced by advocates of *anociation*. Before this (1905), Cushing, Horsley, Hartwell, the author and others, as Mummery states, had used cocaine in addition to the inhalation anesthetic in extensive amputations as a preventive of shock. Later researches in the author's laboratory explained the reason for this protective action of local anesthesia and pointed the way to the general use of the less poisonous local anesthetic, novocaine, in operations of any degree of severity on any part of the body.

As has already been indicated in discussing the kinetic theory of shock, shock-producing stimuli, if intense enough and frequent enough, cause physiological exhaustion and histological changes in the brain, the adrenals, and the liver indicative of this exhaustion. The inhalation anesthetic depresses the associational function of the brain, but does not interfere with the passage of the stimuli from the site of the operation to the brain. As a result of the traumatic stimuli, the brain, adrenals, and liver become exhausted, acidosis is produced and shock may result. By the injection of a local anesthetic into all nerve-bearing tissue before they are divided, these afferent stimuli are blocked and the vital organs are thus protected from injury. Some years ago Thibault, a young physician of Scott, Arkansas, discovered that after the injection of quinine and urea hydrochloride, a local anesthesia was produced which persisted for several days. This drug is an irritant, causing swelling and persistent edema, and if injected into infected wounds in mucous membranes may promote sloughing. The drug, therefore, is used only in an aseptic field, injected at a safe distance from the line of incision, and in cases in which a more complete postoperative control is important. No other agent so completely controls postoperative pain and postoperative shock.

4. *Surgical Technique.*—Nearly all writers upon shock refer to the shock-producing effect of certain manipulations, especially in abdominal operations. "Exposure of viscera, cooling of the intestines, the dragging upon the kidney in attempts to bring it upon the flank, pulling upon mesenteries produce extreme shock. I know of a fatal result in the case of such a renal operation, and have experienced grave anxiety on account of shock due to dragging on viscera when the upper abdomen has been the seat of operation" (Buxton). As the result of an extensive experimental research, Mummery and Symes concluded that "in fully anesthetized animals non-destructive manipulations of abdominal viscera are more productive of shock than are gross injuries. Such manipulations produce shock most rapidly when they implicate the parietal peritoneum, the peritoneal ligaments, or the mesenteries."

In the author's laboratory an exhaustive research to discover the relative shock-producing effects of trauma of different parts of the body and of different types of trauma, showed that the degree of shock bore a direct relation to the supply of contact ceptors in the part traumatized, or to the degree of development in the part of the nerve muscular mechanisms for defense. In other words, the clinical observation that manipulations and injuries of the abdomen and of the chest stand first in their capability for shock production, was supported by the exact methods of laboratory investigation. Next in order follow the extremities, the neck, and the back. In the extremities, the sole and the palm are more susceptible to shock-producing injury than are the dorsa. Within the abdomen, the region of the diaphragm is more susceptible than that of the pelvis; the kidneys, the ureters, and the urinary bladder have a relatively low shock-producing value, while the omentum is practically a negative tissue. Injuries to the peripheral nerve trunks produce intense shock. On the other hand, little or no shock results from direct injury of the brain, or of the deeper portions of the spinal region, the lungs and parts protected within the thoracic cavity. As to the relative effects of different types of injury, the greatest shock is produced by tearing, crushing, and bruising manipulations, by rough manipulations of the parietal peritoneum, by pulling upon the mesentery, by any manipulation which resembles the pulling of distention.

The value, as a means of shock prevention, of gentle manipulations, of sharp dissection, of avoidance of tearing and pulling upon the viscera, and of minimum handling thus becomes obvious. "There are surgeons who operate upon the 'canine' principle of savage attack, and the biting and tearing of tissues are terrible to witness. These are they who operate with one eye upon the clock, and who judge the beauty of any procedure by the fewness of the minutes which it has taken to complete. There are other surgeons who believe in the 'light hand,' who use the utmost gentleness, and who deal lovingly with every tissue that they touch. * * * The scalpel is, indeed, an instrument of most precious use—in some hands a royal scepter; in others but a rude mattock. The perfect surgeon must have the 'heart of a lion and the hand of a lady;' never the claws of a lion and the heart of a sheep" (Moynihan).

Acidosis.—In 1903, Howell, in the course of experiments on the cause of shock, accidentally discovered that sodium carbonate had a distinct therapeutic value in the treatment of shock. In 1913, Seelig, in collaboration with Tierney and Rodenbaugh, reported a series of experiments, in which, "assuming the correctness of Henderson's assumption that shock is due to a deficiency of carbon dioxide in the circulatory blood, (they) attempted to check up his theory by supplying the blood stream directly with an increased quantity of this gas," utilizing for this purpose intravenous infusions of a solution of sodium bicarbonate, this substance furnishing a "direct and immediate increase of the carbon-dioxide content" by the action upon it of the "three elements in the blood which split up the sodium bicarbonate molecule and set free carbon dioxide: (1) The hemoglobin; (2) the serum albumin; (3) the primary (acid) sodium phosphate." The "effects noted upon the cardiovascular and respiratory mechanisms, following the injection of small quantities (25 c.c.) of a molecular sodium bicarbonate solution (were) marked increase of blood pressure, the increase following immediately upon the start of the injection and being well sustained for varying long periods; no influence upon rate of heart beat; marked increase of amplitude of beat, this increase likewise being well sustained over varying long periods of time; varying effects upon rate of respiration; constant effect upon depth of respiration."

Certain recent researches by the author seem to give a new significance to these findings, for they show that coincident with an increased transformation of energy from any cause, the hydrogen-ion concentration of the blood is invariably increased. In shock from any cause, therefore, the normal alkalinity of the blood—and other body fluids—is diminished, and increased strain is placed upon the chief neutralizing organ, the liver, and the protective supply of alkalies and bases is diminished. We may reasonably assume, therefore, that the striking results secured from the use of sodium bicarbonate, by Howell, and by Seelig and his

collaborators, may have been due primarily to whatever influence it had in overcoming the increased acidity in shock.

Clinically it has long been recognized that when a patient is in a state of exhaustion resulting from infection, from injury, from shock, from starvation, from hemorrhage—from any cause whatsoever—he may never recover consciousness after the administration of a general anesthetic. It has been stated that dogs first sufficiently starved, then anesthetized, inevitably die. Clinicians know well how unsafe it is to give a general anesthetic of any kind to a patient on the verge of acidosis. A patient with chronic vomiting, with an acetone odor of the breath, with peculiarly pink lips and dry mouth and tongue, may never regain consciousness after inhalation anesthesia. The aged have been known to die after even short inhalation anesthesia.

Why do not these patients recover? If the patient is conscious before the anesthetic is administered, what happens during the anesthesia to make it impossible for the patient to regain consciousness?

We have already referred to the acid-producing power of stimuli. Shall we conclude, therefore, that the trauma of the operation alone may have pushed beyond the margin of safety the neutralizing powers of the body already taxed by pre-existing conditions; or is the anesthetic itself a factor in producing the fatal result?

Both ether and nitrous oxide produce a marked immediate increase in the H-ion concentration, that is, both cause an increased acidity in the blood during anesthesia. This gives us a clue to the tendency to acidosis and to death under anesthesia in weak and emaciated patients. The increased acidity produced by the anesthesia is sufficient to overcome the already narrow margin of safety. That acid intoxication *follows* the administration of ether and chloroform has been noted by many observers—the acidity being evidenced by the early appearance in the urine of acetone and later diacetic acid. It has also been noted, as one writer states, that the "starvation preceding and following the operation is also a factor of considerable importance."

Our experiments have shown, however, that the increased acidity actually develops *during the anesthesia itself*, sometimes to a fatal degree, and that a starved condition is not only of "considerable" but of *prime* importance, since it means that the acid-neutralizing power of the liver has been surely impaired—possibly lost.

Two more important clues were obtained from the result of H-ion concentration tests after the administration of morphine. The H-ion concentration was not altered by morphine no matter how large the dose. *When the administration of morphine preceded the induction of anesthesia then a smaller amount of the anesthetic was required to produce complete anesthesia, and the H-ion concentration test showed that the acidity was correspondingly less than in anesthetized animals which had not received the preliminary dose of morphine.* The preliminary dose of morphine not only lessened the degree of acidity produced by the anesthetic, but it in no way interfered with the return of the blood to its normal alkalinity; on the contrary—and the following observation is of great significance—*if morphine was given after acidity had been produced by the anesthetic, it prolonged the period of neutralization and if given in large doses prevented the animal from overcoming the acidosis.*

These H-ion concentration or acidity tests of the blood have therefore given us the clue, and an invaluable clue, to the treatment of patients in whom shock may readily supervene by reason of an increased acidosis—and thus indirectly to the treatment of all surgical patients, since in many instances the disease itself has diminished the reserve alkalies and bases. Needlessly long anesthesia is to be avoided, as the increased acidity produced by the anesthetic will diminish the patient's reserve. The degree of acidosis seems to be proportional not only to the length but also to the depth of the anesthesia. Moderately light anesthesia is preferable, therefore. *With starved patients, with patients whose vitality is at a low ebb, in whom acidosis is already markedly present, the inhalation anesthetic may be absolutely contraindicated.* If an operation is mandatory, it may be performed under local anesthesia, or in the analgesic stage of nitrous oxide-oxygen anesthesia combined with local anesthesia.

Although both the preoperative and the postoperative use of morphine is of great value in certain cases, in these cases of existing or threatened acidosis its use must be extremely guarded, since it interferes with the elimination of acid products. Bromides per rectum may be safely given to diminish the preoperative psychic strain. The preoperative and postoperative administration of normal saline, of sodium bicarbonate, and of glucose is of value also.

One other point is of interest in this connection, though perhaps not directly pertinent to this discussion. One of the most noticeable immediate effects of the administration of an inhalation anesthetic is a marked increase in the rapidity and amplitude of the respiration. The respiratory center has evidently been evolved to act with increased vigor proportional —within certain limits—to the increase in the acidity of the blood; whereas the centers governing the voluntary muscles are depressed with the increase in acidity. In these antithetic reactions of the higher cortical centers and the centers in the medulla, we find a remarkable instance of adaptation, by which the animal is prevented from killing itself through the further increase in acidity which would result from *continued excessive muscular activity.* In other words, *as the acidity produced by muscular activity increases and threatens life, the respiratory action, by which carbon dioxide is eliminated and oxygen supplied, thus diminishing the acidity, is increased, while the driving power of the brain, by which acidity is produced, is lessened or inhibited finally, producing unconsciousness.*

Anociation.—The doctrine of anociation, the logical sequence of the enunciation of the kinetic theory of surgical shock in 1910, is finding a steadily increasing number of adherents.

The complete technique, the details of which have been practically covered in preceding sections of this paper, includes not only the combination of narcotics with inhalation and local anesthesia, but also the careful personal management of the patient from the time the surgeon is first consulted until convalescence is complete.

If the preoperative environment of the patient be free from all but the most beneficent suggestions; if his nerves be calmed and his consciousness dulled by the preoperative administration of a sedative; if a non-suffocating, odorless anesthetic be employed; if, during the course of the operation, every division of sensitive tissue be preceded by the injection of a local anesthetic to protect the patient against the painful period of postoperative adjustment; if gentle manipulations and sharp dissection be used; if bleeding be minimized or prevented by clamping each vessel either before or at the instant it is cut—if all these measures be employed, the patient will be protected against all damaging factors except those inherent in the diseased or injured condition from which he is seeking relief.

"There are two factors in shock over which we have the greatest control—the toxic factor due to the anesthesia, and the traumatic factor due to the operative manipulations. * * * *Every patient must be looked upon as handicapped and extremely ill. Every operation must be considered a grave one. Every de-*

tail of technique should be carried out conscientiously. (The italics are ours.) * * * I feel convinced that I have sufficient evidence to prove that this method will be life-saving, if all the other factors of safety are considered, in operations in the late stage of intestinal obstruction; in patients who have to be operated on while in shock after an injury; in the late stages of perforated gastric and duodenal ulcer, and in typhoid perforations; in resection of the stomach and colon for ptosis: in resection of the stomach for cancer and ulcer in patients weakened from prolonged pyloric stenosis; in the radical operation for cancer of the uterus; in the combined abdominal and sacral operation for cancer of the rectum. I think I can also show that the mortality will be decreased when less formidable operations are performed on patients handicapped with lowered kidney function, with sepsis, especially cases of cholangitis and jaundice; patients suffering with diabetes and arteriosclerosis; high blood pressure from various causes; in the presence of pneumonia and bronchitis; in patients feeble with advanced age" (Bloodgood).

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Shoulder, Anatomy of.—The region of the shoulder comprises the bones forming the joint, viz., the scapula and the upper part of the humerus, the clavicle and acromioclavicular articulation, also the upper and outer part of the thorax, which takes part in forming the axilla. These bony structures, with the softer tissues enveloping them, would be included in the term *shoulder*.

Surface Anatomy.—Beneath the skin can be easily felt the outer end of the clavicle, the acromion process, and the coracoid. Where the clavicle joins the acromion there is a distinct elevation which can be without difficulty detected by running the finger nail over it. The line of this articulation would correspond to a vertical line running up the middle of the front part of the arm. The acromion in the stoutest person may easily be made out by following the spine

of the scapula, and the coracoid process is just inside the shoulder-joint and below the clavicle. Between the coracoid and the acromion processes is the rounded prominence of the shoulder; this is formed partly by the thick deltoid muscle, but also in part by the upper end of the humerus which lies below it. As the arm

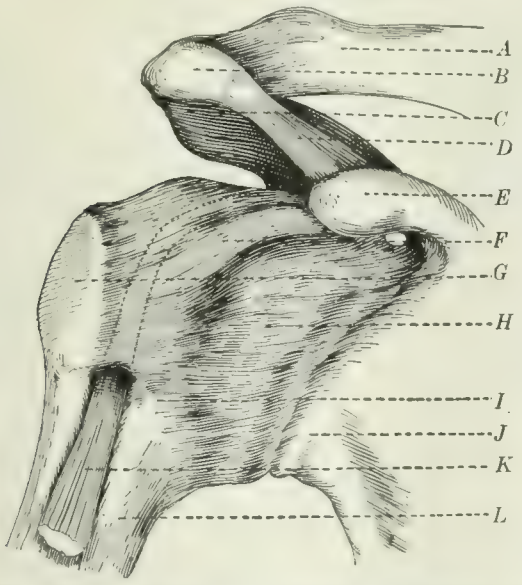


Fig. 4499.—*A*, Clavicle; *B*, *C*, acromion; *D*, coraco-acromial ligament; *E*, coracoid; *F*, coracohumeral ligament; *G*, great tuberosity of humerus; *H*, capsular ligament; *I*, lesser tuberosity; *J*, scapular neck; *K*, long tendon of biceps; *L*, humerus.

is rotated the tuberosities can easily be felt beneath the muscles. In dislocation of the humerus, instead of a prominence there is a flattening, and in pressing with the fingers a well-marked depression is found where the head of the bone is normally felt. If in suspected dislocation the thumb be placed on the coracoid process and one of the fingers of the same

Fig. 4500.—Skin and Fascia have been Removed. 1, Pectoralis major; 2, deltoid; between these muscles is seen the cephalic vein; 3, biceps; 4, coracobrachialis, close to which lies the brachial artery and the median nerve drawn to one side. (After Roser.)

hand on the acromion, the space will be found wanting in roundness and the finger can be easily pushed into a hollow; the upper end of the bone can be no more felt on rotation. The portion of the humerus which in normal joints is felt beneath the deltoid is not the head, but the tuberosities. The head can be felt through the axilla if the fingers be well pushed up and the arm be strongly abducted. The head of the humerus faces in the direction of the internal condyle, this latter being always a good guide to the position of the upper end of the humerus.

The adjacent margins of the deltoid and pectoralis muscles cannot be felt below, but above there is a considerable triangular interval which forms the infraclavicular fossa below the clavicle. This fossa is well seen in thin persons, but is obliterated in subcoracoid dislocations, in fracture of the clavicle, and by inflammatory tumors and new growths. In subclavicular dislocations the depression is replaced by an eminence. The space between the two muscles lodges the cephalic vein (Fig. 4500).

The back of the shoulder is comparatively flat; here the deltoid muscle is thinner. By abducting the arm the deltoid becomes prominent and various vertical elevations appear which correspond to the muscular tissue between the various tendinous intersections which run down from the acromion through the muscle. The axillary border of the scapula and inferior angle may be brought out by placing the forearm behind the back; to bring the vertebral border and superior angle into evidence, the hand should be placed over the opposite shoulder.

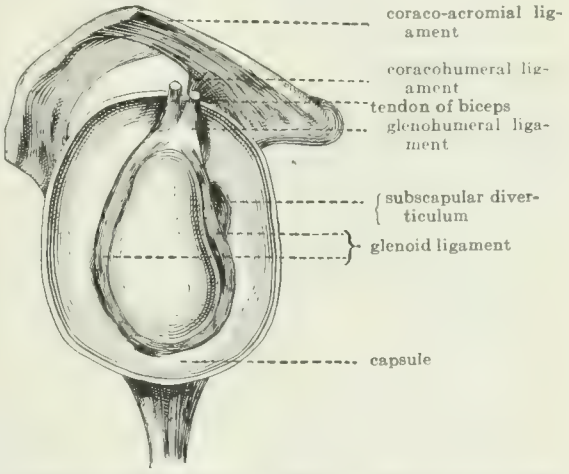


Fig. 4501.—Glenoid Fossa of Scapula, with Part of Capsule Attached.

Surface Marking of Axillary Artery.—At a point internal to the coracoid process and below the most convex portion of the clavicle the axillary artery may be compressed against the second rib. The course of this artery can be easily marked out by drawing a line from the most convex portion of the clavicle to the inner border of the elevation formed by the coracobrachialis muscle. If the arm be raised from the side, the third part of the axillary artery may be felt pulsating as it passes into the arm beneath the anterior fold of the axilla, and in a line corresponding to the outer border of the axillary hair, that is, at the junction of the anterior with the middle third of the space between the axillary folds. At the junction of the upper with the middle third of the deltoid muscle the posterior circumflex vessels and nerves wind round to the back of the humerus under the muscle.

The *deltoid region* comprises the point of the shoulder and is confined to the limits of the deltoid muscles which cover the shoulder-joint and upper end of the humerus. Between the deltoid muscle and the joint is a large bursa, the subdeltoid or subacromion bursa. Owing to the exposed position of the shoulder-joint it is liable to many injuries and diseases; fatty tumors are not infrequently seen here and may attain to a large size.

The shoulder-joint is of the ball-and-socket variety (enarthrodial), and so is very freely movable; the socket in the scapula is very shallow but is deepened by the glenoid ligament, to which the long head of the biceps is attached. It is small in size compared with the large articular surface of the head of the humerus. This disparity gives greater freedom of movement with lessened security and more liability to displacement in extreme movements.

The circumflex nerve supplies the deltoid, shoulder-joint, and skin over the lower two-thirds of the shoulder and upper part of the triceps. In injuries to the shoulder this nerve is frequently damaged, and paralysis with atrophy of the deltoid may result; marked flattening of the shoulder may as a consequence ensue.

Relations of the Joint.—Muscles of great strength surround the shoulder except inferiorly; above we have the deltoid and supraspinatus, internally and in front the subscapularis, and externally and behind the infraspinatus, both these latter separated from the capsule by a bursa. The capsule of the joint, though strengthened by these muscles, is very loose, so that when the muscles are either paralyzed or cut the humerus may be drawn from the scapula for nearly an inch. The capsule is thicker above than below and is strengthened by various accessory ligaments in addition to the muscles mentioned above as being in relation with it, such as the coracohumeral, inferior humeral, glenohumeral, etc.

There are three perforations of the capsule, the most important being that for the long head of the biceps at its lower part; it is also perforated by the supraspinatus and not infrequently by the infraspinatus. *The tendon of the long head of the biceps* has synovial membrane prolonged along it and surrounding it. This tendon keeps the head of the humerus against the glenoid cavity and prevents the bone rising up toward the acromion. The tendon is sometimes ruptured, thus causing weakening of the upper limb and a drawing up of the humerus forward and inward against the coracoacromial arch. The tendon may be dislocated —that is, it may slip out of its groove to one side or the other. In such cases the head is prominent and drawn up under the acromion; owing to the higher position of the greater tuberosity, abduction is not so free.

Rupture of the tendon is more apt to occur in persons the subjects of rheumatic disease; in them the joint is dry and perhaps the tendon is partially worn. In old persons it is not uncommon to see the long tendon of the biceps attached to the upper end of the humerus, the head of the bone having worn through the tendon and the capsule, and entered the subacromion bursæ. In very old persons the under surface of the acromion process will be eburnated as well as the surface of the humerus which has been in contact with it. As a rule the joint is well protected above by the acromion and coracoid processes, and the ligaments between these.

The Epiphyses.—There are a number of epiphyses about the shoulder-joint, some of which are of importance. It is of importance to know that the epiphyseal end of the acromion, which articulates with the clavicle, may sometimes remain separated throughout life and may be mistaken for a fracture; in fact, Sir Astley Cooper described it as such. The coracoid process is also formed by a separate ossific center, and the head of the humerus forms a single epiphysis in the fifth year; this is composed of no less than three fused secondary centers and it is limited by the surgical neck. Separation of the upper epiphysis of the humerus may be mistaken for dislocation, but the easy reduction and the fact that the glenoid cavity is always full should prevent one from falling into this error.

Bursæ.—The bursæ about the shoulder are many, (see vol. ii., p. 558) and any one of them may become inflamed and distended with fluid as the results of strain or direct injury.

The Clavicle.—The skin over this bone is very loose and easily rolled on the bone. Cutting down the subclavian artery and pulling the skin firmly over the clavicle, the surgeon cuts freely on the bone, and when the skin is released the incision is well above the clavicle, and the external jugular vein, which it was intended to avoid, comes into view. Passing over the clavicle are seen the clavicular branches of the superficial cervical plexus, and these nerves may be easily injured here. In disease of the cervical spine there is frequently pain over the collar bone. Beneath the clavicle and subclavian artery, the vein and cords of the brachial plexus rest on the first rib. The apex of the lung passes up into the neck behind the clavicle, encircled by the first rib, and can be percussed in the supraclavicular fossa.

The sternal end of the clavicle is near very important structures, such as the innominate and left carotid artery, the pneumogastric and recurrent nerves, and the large venous trunks. The acromioclavicular joint is sometimes dislocated and is hard to retain in place when reduced; the sternal end also may be displaced and this joint may be attacked by tuberculous disease.

Axilla.—The axilla (*ala*, a wing) is the space which exists between the upper arm and side of the thorax. It is of a pyramidal shape, and is bounded in front by the pectoral muscles, behind by the subscapularis, teres major, and latissimus dorsi, on the inner side by the serratus magnus, intercostal muscles and ribs, and on the outer side by the upper part of the arm and shoulder-joint. The base is formed by the skin stretching between the anterior and posterior boundaries. The hollow between the anterior and posterior folds is commonly known as the armpit, but anatomically we imply more by the term axilla than this depression: we include all the deeper space which reaches up to between the scalene muscles, and contains the axillary vessels, brachial plexus of nerves, and lymphatics. This deeper space is surgically continuous with the neck.

Superficial Anatomy.—The skin of the armpit proper, which is very thin, sensitive, attached to the fascia beneath, and of a darkish color, is supplied with glands which secrete an odorous sweat. In some cases this sweat is of a peculiar color, and stains the linen. The skin is abundantly provided with hairs which never grow to any great length; their limit is generally well defined, the outer border furnishing a good surface mark for the axillary artery in the third part of its course. The armpit is of different depths in different individuals; in women and children it is not so well marked as in men, chiefly because in them we have less muscular development and more adipose tissue. When the arm is lifted above the head the depression almost disappears and the skin is put so much on the stretch that nothing can be felt of the deeper part; the depression deepens as the arm is lowered to the side, the skin being relaxed and thrown into folds. The fingers can now be pushed high enough to feel the head of the humerus. When it is necessary to examine the deeper structures, the arm ought only to be slightly drawn away from the side. In operations on the axilla the arm should always be abducted and raised to lessen the depression.

It is not uncommon to see suppuration of the follicles in this region; these small follicular abscesses, owing to the sensitiveness of the skin, are very painful and should be opened early.

The skin covering the anterior fold is thick, not closely adherent to the deeper structures, and free from hairs. Close below the clavicle and internal to the shoulder, the coracoid process can be felt.

The lower border of the great pectoral muscle follows the line of the fifth rib; the first visible serration

of the serratus magnus on the inner side of the space is the sixth. The posterior fold is thicker than the anterior on account of the great thickness of the teres major muscle. When the arm is raised from the side the axillary artery can be felt pulsating as it passes into the arm, and may be easily compressed.

Fascia.—On removing the skin from the axilla we come upon a strong fascia, the disposition of which it is important to know because of its influence on the course of abscesses, which not infrequently form in the neighborhood. The strong fascia which covers the great pectoral muscle and is attached to all the subcutaneous bony prominences, winds round its lower border and splits into two portions, one of which continues to ensheath the pectoralis muscle on its inner surface, while the other forms the floor of the axilla and, after covering the latissimus dorsi and teres major muscles, passes upward and backward and is lost in the strong deltoid aponeurosis. The portion of this fascia which covers the pectoralis major muscle externally sends a process between it and the deltoid muscle, and this process becomes continuous with the costocoracoid membrane.

The costocoracoid membrane (Fig. 4502) is a strong aponeurosis which is continuous with the deep cervical

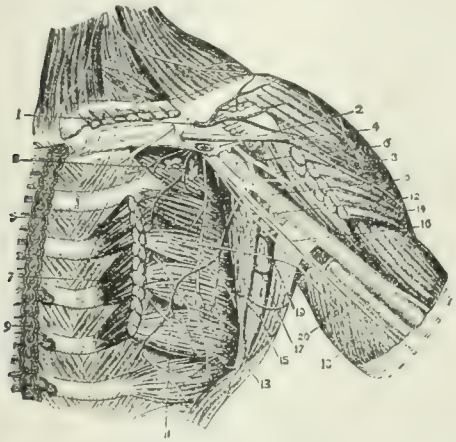


FIG. 4502.—Brachial Plexus and Axillary Artery. 2, Costocoracoid membrane; 3, superior thoracic and ulnar arteries; 5, long thoracic artery; 6, axillary artery; 8, musculocutaneous nerve; 10, median nerve; 15, subscapular artery; 16, ulnar nerve; 18, internal cutaneous nerve; 19, circumflex nerve; 20, nerve of Wrisberg, joined by intercostohumeral.

fascia; it splits to enclose the subclavius muscle, is attached to the clavicle and to the coracoid process, and is continued to the capsule of the shoulder. It is also attached to the cartilages of the first and second ribs, and is continuous with the aponeurosis over the serratus magnus muscle. This fascia is the costocoracoid membrane proper, and covers the first part of the axillary vessels and nerves. When it reaches the edge of the small pectoral muscle it again divides to enclose it; reuniting again, it passes down to the base of the axilla, and becomes attached to the skin and the fascia covering the great pectoral; externally it is continuous with the brachial aponeurosis. Gerdy calls this process the *ligamentum suspensorium*, because he says it is the ligament of the skin of the armpit, which it pulls upward. This suspensory ligament, then, divides the axilla into an anterior and a posterior compartment, the posterior containing blood-vessels and nerves, and the anterior the loose cellular tissue which separates the two pectoral muscles and intervenes between the lower part of the fascia and the great pectoral. Now, when an abscess forms in front of the suspensory ligament—that is, below the small pectoral or between the two pectorals—it would tend to point at the lower border of the anterior axillary fold, or in the interspace between the deltoid and the great pectoral muscle; but if pus forms behind the suspensory ligament and is not evacuated early, it may burrow into the neck and thence find its way, through the upper opening of the thorax, into the mediastina; it may also find its way beneath the latissimus dorsi and point in the back, or it may burrow into the subscapular fossa and thence get into the shoulder-joint. Abscesses in the axilla should be opened early.

Boundaries of the Axilla.—The *anterior boundary* (Fig. 4500) is formed by the two pectoral muscles, the great pectoral alone forming the lower border of the anterior fold. It is important, surgically, to remember that the fibers of the large pectoral go downward and outward, and those of the lesser upward and outward. The interspace between the great pectoral and the deltoid may be very small or wanting, and the division between the two muscles can be made out only by the position of the cephalic vein and a branch of the acromial thoracic artery.

Owing to the pectoralis major muscle having an origin from the clavicle, it is necessary, in fracture of that bone, that the arm should be placed close to the side to prevent the muscle pulling down the inner fragment, and so delaying union. In females the lower edge of the anterior border of the axilla, owing

FIG. 4503.—Dissection of Axilla, showing the Axillary Vein (2, 2) and Parts in Relation with it. 1, 1, Axillary artery; 2, 2, axillary vein; 3, 3, basilic vein; 4, cephalic vein; 5, 5, pectoralis minor; 6, axillary glands.

to the presence of the mammary gland, is not so easily seen as in the male. In the female the mammary gland moves freely on the great pectoral muscle, there being an abundance of cellular tissue between the muscle and the gland; but in advanced cases of cancerous disease of the breast every movement of the pectoral muscle is painful because of the gluing together of the breast and the muscle by infiltrated tissue.

The acromial thoracic vessels and the internal and external thoracic nerves are seen on the inner surface of the pectoral muscle. The long thoracic artery generally runs along the lower border of the lesser pectoral.

In rare cases the great pectoral muscle is wanting altogether, or the clavicular portion alone may be wanting. The lesser pectoral may be attached to as many as five ribs or as few as one. Its insertion may be transferred from the coracoid process to the coracobrachialis muscle or humerus itself.

The *posterior boundary* of the axilla is formed by three muscles which are supplied by the same set of nerves, viz., the three subscapular, and all three muscles are internal rotators of the humerus. The tendon of the latissimus dorsi, with the teres major, forms the lower edge of the posterior fold, the posterior wall of the deeper portion being principally formed by

the subscapularis. The axillary vessels rest on this posterior wall, held together by a dense cellular sheath and separated from the rest of the axilla by the above-described suspensory fascia.

The *internal boundary* of the axilla is formed by the ribs, intercostal muscles, and the upper digitations of the serratus magnus. On this wall, which is somewhat convex, a large nerve is seen running down in a vertical direction, to be distributed to the serratus magnus muscle. This nerve is a branch of the brachial plexus, and is called the long thoracic. We also find there branches of the posterior and long thoracic vessels. Abscesses and tumors, as a rule, lie along this wall, and are fortunately well away from the axillary vessels; in removing tumors we always dissect toward the inner wall.

The *external boundary* of the axilla is formed by the upper part of the humerus and coracobrachialis muscle; along this boundary, and on the inner side of the coracobrachialis are seen the axillary vessels and nerves closely bound down by their fascial covering.

The *inferior boundary* or *base* of the axilla, which is formed by the skin and fascia stretching between the anterior and posterior folds, has already been described.

The apex of this cone-shaped space may be said to be continuous with the posterior triangle of the neck, as vessels, nerves, lymphatics, cellular tissue, and fascia reach the axilla from the neck through this apex. It is the space between the upper edge of the scapula, clavicle, and first rib. Abscesses of the neck have been seen passing through this opening and pointing in the axilla.

Contents of the Axilla.—The axillary vessels, with the lymphatic glands, fat, and loose cellular tissue, are the principal contents of the axilla. The loose cellular tissue permits of free movements of the arm to and from the body, but it also permits of the collection of large quantities of blood and pus. The vessels and nerves are bound together by a sheath of thick cellular tissue; they lie on the outer wall of the space internal to the coracobrachialis.

Axillary Vein (Fig. 4503).—This is the most superficial of the contents of the axilla. In the upper part of its course it is so fixed by fascia connecting it with the coracoid process and pectoralis minor muscle, that if wounded it tends to gape, and air is apt to enter. The vein is formed by the junction of the venæ comites with the basilic vein. This union may occur low down or high up; the normal point of union is at the lower edge of the subscapularis muscle, though the junction not infrequently takes place higher up, sometimes as high as the clavicle. It is always shorter than the artery, measuring about 7.5 centimeters (three inches) in length. Union occurring high up complicates operations upon the artery, owing to the numerous transverse communicating branches which cross the artery. The vein lies to the inner side of the artery, and generally overlaps it. When the arm is drawn away from the side almost altogether covers the artery. In the course through the axilla, this vein receives many tributary branches, the largest of which is the subscapular. It receives the cephalic vein immediately above the lesser pectoral muscle. In operations on the axilla, the vein and its branches are frequently wounded —more often than the artery—but it is rarely injured by external violence. In reducing dislocations of the shoulder, and using extreme traction, the artery is much more frequently injured than the vein, owing to its proximity to the heart and its fixed position; the vein, when wounded, bleeds freely, and there is great danger of air entering it. This accident has many times occurred, especially in operations for removing diseased glands, and not a few fatal cases are on record. It is always well before dividing the veins, especially about the neck and axilla, to tie them with a double ligature and cut between.

In almost all diseases of the axilla there is swelling of the arm caused by pressure on the veins and absorbents.

Axillary Artery (Fig. 4502).—This vessel, which is the continuation of the subclavian, extends from the lower border of the first rib to the lower border of the teres major muscle; it measures about fifteen centimeters (six inches) in length, and its direction is altered with the position of the arm. When the arm is close to the side, it forms a curve having its convexity upward and outward; when the arm is held at right angles to the body, the artery is in almost a straight line; and again, when the arm is held above the head, the slight curve thus formed has its concavity upward. Its upper portion lies close to the chest and rests on the upper serrations of the serratus magnus; the long thoracic nerve is behind it, and in front is the costo-coracoid membrane. Its lower part lies principally on the subscapular muscle. The vein is superficial to the artery above, and the nerves of the brachial plexus lie to its upper and outer side; lower down the vein becomes more internal and the nerves surround the vessel, the two heads of the median embracing it. For convenience of description the axillary artery is divided surgically into three portions—the part above, that beneath, and that below the pectoralis minor muscle. It lies deepest above this muscle and is most superficial below it. The large thoracico-acromial branch is given off immediately above the pectoralis minor, and might be wounded in the operation of tying the axillary in its first part. A number of small branches are given off which are not surgically important. The *subscapular artery*, given off near the lower edge of the subscapular muscle, is a large branch, which runs to the side of the chest and near its origin gives off the dorsalis scapulæ. The *external mammary* is given off below the lesser pectoral, and is sometimes of large size; it is always cut in the operation of excision of the breast, and may give rise to slight hemorrhage. The *circumflex arteries* closely embrace the neck of the humerus, and should be looked for and avoided in excision of the head of the humerus. In wounds of the first part of the axillary artery the vein is so closely in relation with it that it rarely escapes; lower down the artery may be wounded and the vein remain intact.

Wounds of the axillary artery may result from stabs, fracture of the neck of the humerus (Fenwick), violence during the reduction of old dislocations. Hemorrhages may be slight or severe, according to the size of the wound. The loose tissues of the axilla admit of great and rapid distention by bleeding from either vein or artery. The treatment is first to compress or temporarily ligature the third part of the subclavian and then cut down on the artery in the axilla, turn out the clots, and ligature above and below the wound in the vessels. It is well to remember that in reduction of an old dislocation the artery has been torn when simple manipulation was practised, owing to the adhesions which had formed between the capsule and the vessel. The artery is usually tied in the third part of its course, where it is most superficial. It has been tied on the first part, but owing to its depth and the thick covering of muscle, and also its close connection with the vein, ligature of the third part of the subclavian is preferred, as being the safer and simpler operation. The third part of the subclavian is more easily compressed than the first part of the axillary.

Aneurysm not infrequently affects the axillary artery; this is, perhaps, owing to its nearness to the heart and to the curve the artery makes at its upper part. It has been occasionally ruptured in reducing dislocation of the shoulder.

Nerves of the Brachial Plexus (Fig. 4502).—These nerves are derived from the lower four cervical and first dorsal. They are to the outer side of the artery in the first part of its course, but lower down they

surround it. When the axillary artery divides into two trunks, one of which gives off all the branches, this latter is, as a rule, embraced by the two heads of the median. The axillary nerves are rarely torn by traction on the limb; when forcibly stretched they may be torn away from their attachment to the cord in the cervical region, as in a case recorded by Flaubert, where this accident happened in endeavoring to reduce a dislocated shoulder. The median is the nerve most frequently injured in wounds of the axilla, the musculospiral, from its very deep and protected position, always escaping. The axillary nerves are occasionally injured in fracture of the neck of the humerus, and may be compressed in dislocation of the shoulder.

Lymphatics.—The axilla is richly supplied with lymphatic vessels and glands. The glands, which are ten or twelve in number, are mostly placed along the axillary vessels and form a continuous chain with the cervical glands. A few are situated on the serratus magnus muscle and near the lower edge of the pectoral muscle (see vol. vi., page 168).

The glands of the axilla are frequently enlarged from sympathy with disease or inflammation of neighboring parts, and not infrequently run on to suppuration. They may be the subject of cancerous infiltration when the breast is affected with malignant disease; occasionally, malignant disease first affects these glands. Scrofulous enlargement of the axillary glands is not uncommon, and their removal is sometimes called for.

Supernumerary mammæ have been frequently reported as occurring in the axilla. Mr. Birkett describes several cases of *cystic tumors* occurring in early life in the axilla and extending into the neck. He strongly advocates excision in these cases. *Fatty tumors* frequently develop in this region; they can be removed without much difficulty.

FRANCIS J. SHEPHERD.

Shrady, George Frederick.—Born in New York, January 14, 1837, and graduated in medicine from the

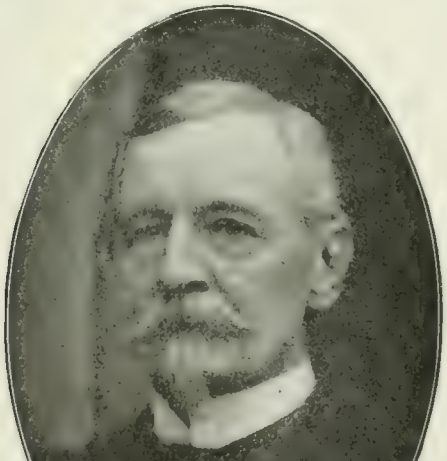


FIG. 4504.—George Frederick Shrady.

College of Physicians and Surgeons in that city in the class of 1858. His surgical skill was foreshadowed during his undergraduate career by his special predilection for anatomy, and in the same year that he received his degree he was also awarded the Wood Intercollegiate Prize for proficiency in anatomy. After graduation he served a term as interne in the surgical division of the New York Hospital. During the Civil War he served as surgeon in the Federal Army, and on the close of the war he returned to New York and resumed private practice. He was a proficient stenographer, and this led in his early days to employment in reporting the meetings of the local medical societies for the *Medical Times* of which journal he later became editor. In 1866 the *Medical Record* was founded with Dr. Shrady as Editor, and for thirty-eight years he gave his best thought and his skill as a writer and editor to the conduct of this journal. He was an indefatigable worker, and for many years conducted the journal almost single-handed, doing whatever the occasion demanded to make it a worthy representative of medical opinion. One of the "hits" which attracted much attention at the time was the publication of a series of articles, entitled "Pine Ridge Papers," purporting to be written by a country practitioner, in which he treated, with the satirical wit of which he was a master, of the foibles and the tendency to charlatanism of certain practitioners of the time. He died November 29, 1907.

Dr. Shrady was a skilful surgeon, but too conservative to gain the wide reputation to which his ability entitled him; he believed firmly in Nature's healing power and always refused to perform a mutilating operation or one endangering life unless the indications were imperative. His colleagues, however, paid willing homage to his judgment as well as to his technical skill and often turned to him for advice in difficult situations.

In addition to his anonymous contributions to the editorial pages of the *Medical Record*, Dr. Shrady wrote numerous papers from time to time, chiefly on surgical subjects, many of which were read at meetings of the Medical Society of the State of New York, and of the Practitioners' Society of which latter he was a founder. Most of these papers were published in his own journal. T. L. S.

Sideroscope.—The use of a magnetic needle for detecting foreign magnetic bodies in the eye was first advocated in 1880 by Thomas R. Pooley, of New York, but the suggestion did not attract much attention until the subject was taken up by Edward Asmus in 1894, who utilized the principle in an instrument which he called a *sideroscope*. Since then several modifications of the instrument have been brought forward, of which Hirschberg's model is probably the best known. This consists essentially of a magnetic needle suspended by a vertical thread, to which is attached a small mirror. The deflections of the needle produced by a foreign body in the eye of a patient is indicated by a beam of light from a lamp which is reflected by the mirror upon a graduated scale. By noting the amounts of deflection for different positions of the eye the foreign body can be accurately located. To obviate the effect of the magnetism of the earth as well as that of objects in the vicinity of the patient, Spuler has recently devised an astatic system of two needles and two revolving magnets. The chief disadvantage of the sideroscope lies in its instability, for which reason it can be used with success only in places free from vibration The instrument has never come into general use, most ophthalmologist relying for localization upon the x- ays or upon the pain reaction produced by the giant magnet.

FREDERICK HERMAN VERHOEFF.

Siderosis.—Ordinarily this term is used to designate the pigmentation of the lungs produced by the

inhalation of any sort of metallic dust, but strictly it should refer to the deposition of iron pigment alone in any of the tissues of the body. True siderosis is usually due to the breaking down of the red corpuscles of the blood, and is best spoken of as *hematogenous siderosis*. This takes place to some extent in many chronic diseases but especially in pernicious anemia, and involves particularly the liver, spleen, bone marrow, and kidneys. It also occurs as the result of the disintegration of hemorrhages, as is the case, for instance, in chronic passive congestion of the lungs, and not infrequently in tumors. For this reason tumors should always be subjected to the test for iron when there is any doubt as to their melanotic nature.

Siderosis Bulbi.—A condition of importance in ophthalmology is siderosis bulbi, which is due to the presence of iron within the eye that has lodged there as the result of an injury. Thisis of little importance where the severity of the injury has been so great as to destroy sight at once, or where it has given rise to panophthalmitis, but not infrequently a small bit of iron may penetrate the globe without producing much damage or setting up serious inflammatory disturbances. Under these conditions certain of the ocular tissues gradually take on a distinct rust color which in marked cases may be very intense. The most serious effect is upon the retina, which slowly undergoes atrophy manifested by night-blindness, contraction of the visual field and finally total blindness. In advanced cases there may be erido-cyclitis of low grade. Clinically the diagnosis can usually be made even when a history of injury is lacking, by the rust color of the iris and the presence of pigment just beneath the lens capsule. The latter pigment typically forms two more or less complete circles. The inner is situated at the pupillary margin; the outer circle can be seen only after the use of a mydriatic and probably corresponds in position to the place where the iris leaves contact with the lens. In cases that have been followed a long time after the removal of the foreign body, the abnormal pigmentation of the iris has been found to disappear.

Microscopically, iron pigment granules are found in the epithelial cells beneath the lens capsule, not in the capsule itself. In the iris, the stroma cells, and the cells of dilatator and sphincter muscles are affected. The ciliary muscle is pigmented only in the vicinity of the filtration angle. The chorioid and optic nerve are not affected, but the disc may be pigmented. In the retina the pigment is found in the supporting tissue, in neuroglia cells, and in cells not definitely identifiable. The pigment epithelium of the *pars optica retinæ* is markedly affected, whereas only the inner (normally unpigmented) layer of the *pars ciliaris retinæ* acquires the pigment. The cornea is not involved unless iron particles have lodged within it, in which case the corneal corpuscles may become packed with iron pigment.

Just how the pigmentation takes place in siderosis bulbi is not definitely known. Leber assumed that the iron was slowly dissolved by the carbonic acid of the intraocular fluid and then precipitated in the tissues. Since all kinds of cells are not affected it is necessary to assume that certain kinds have especial affinity for iron. Siderosis does not always result when a particle of iron remains in the eye, because sometimes the foreign body is thoroughly encapsulated in connective tissue.

Siderosis bulbi can also be hematogenous in origin, sometimes resulting from an intraocular hemorrhage. In order to distinguish from this the siderosis dependent upon the presence of a foreign body, von Hippel applies the term *xenogenous siderosis* to the latter. *Siderosis conjunctivæ* may be produced by the long-continued use of sulphate of iron as a collyrium. The best differential method of staining histological sections for iron is to place them for six hours in a two-per-cent. solution of equal parts of potassium ferro- and ferricyanide, and then in acid alcohol for six hours. In this way both the ferrous and ferric salts give a beautiful blue reaction.

Another important method of distinguishing autocthonous pigment from iron pigment depends upon the fact that the former is bleached by treatment with a saturated solution of potassium permanganate followed by a solution of oxalic acid, while the iron pigment is unaffected.

Frederick Herman Verhoeff.

Sidonal, piperazine quinate, is a compound designed to combine the solvent power of piperazine for uric acid with the power of quinic acid to restrain uric-acid formation. Blumenthal and Levin found the compound to reduce the excretion of uric acid and to increase that of hippuric acid. Bardet, in three cases of gout, administered gr. xlv.–lxxv (3.0–5.0) a day, and tested the urine twice a month; there was a moderate but steady decrease in uric acid. Salfeld speaks highly of the remedy in gout, but obtained no effect in a case of acute articular rheumatism. F. F. Ward, of New York, applied the remedy in various cases with gouty, rheumatic, or neuralgic pains. In those cases with excessive secretion of uric acid there was marked amelioration, and in all other cases no effect. The dose of sidonal is fifteen grains (1.0) several times a day. Its combination with lithium citrate is called "urosin." Sidonal is an expensive remedy, and to obviate this feature "new sidonal" was introduced. This is described by Huber and Lichtenstein as quinic anhydride. It is given for gout in dosage of forty grains (2.6) a day.

W. A. Bastedo.
R. J. S. Scott.

von Siebold, Karl Theodor Ernst.—Born at Würzburg, Germany, on Feb. 16, 1804. He studied medicine at first in Berlin and afterward in Goettingen, and in due time received the degree of Doctor of Medicine. During the earlier years of his career he practised medicine to a certain extent, but only half-heartedly, as he had a very strong preference for zoological pursuits. In 1840 he received a call to occupy the Chair of Zoology, Comparative Anatomy, and Veterinary Medicine at the University of Erlangen. Then afterward he received similar calls from the following universities: Freiburg in Breisgau (in 1845); Breslau (in 1850); and Munich (in 1853). He died April 7, 1885, after a prolonged illness.

Of his published writings the most valuable is unquestionably his treatise on the comparative anatomy of invertebrate animals; and it is important to add that von Siebold and Koelliker were the founders of the *Zeitschrift für wissenschaftliche Zoologie.*

A. H. B.

Siegle, Emil.—Born at Scheer on the Danube July 2, 1833. He studied medicine at the universities of Pisa, Tübingen, Vienna, and Paris, received his doctor's degree in 1863, and then settled in Stuttgart as a specialist in affections of the throat and ears. His invention of a speculum (known as *Siegle's otoscope*) by means of which one may examine the behavior of the drum membrane under varying conditions of air pressure in the external auditory canal, has given his name a permanent place in the history of medicine.

A. H. B.

Silicosis.—This term is applied to the pulmonary condition arising from the inhalation of dust containing free crystalline silica. The histological changes and the symptomatology are identical with those of *chalicosis*, or "marble-cutter's lung." Sili-

cosis is of much less frequent occurrence than the latter condition, and is seen chiefly in those parts of the country in which mining, crushing, and stamping of quartz ores are carried on ("miner's consumption"). In granite-workers silicic dust is deposited in the lungs in association with the dust of the other constituents of the stone. The condition of silicosis may also be seen in the lungs of individuals exposed to silicic dust, in such occupations as the crushing of flints in glass manufacture, polishing and cutting of rock crystal, agate, sandstone, etc. It has been said that the symptoms of silicosis develop more rapidly than those of chalicosis, and as a rule are more severe, for the reason that the quartz dust is more irritating and less capable of solution by the body juices than is dust composed of calcium carbonate. Collis has shown that the inhalation of dust containing free crystalline silica leads much more often to phthisis than does the inhalation of limestone dust. He believes that this is due to a difference in the chemical constitution of the dusts rather than the form of the dust particles. The clinical picture of silicosis is that of a fibroid pneumonia, and, as secondary tuberculosis is of very frequent occurrence, the final course of the disease is usually that of a fibroid tuberculosis. (See *Pneumonoconiosis*).

ALDRED SCOTT WARTHIN.

Silver.—See *Argentum.*

Silver, Poisoning by.—See *Argyria.*

Simpson, Sir James Young.—Born at Bathgate, Scotland, June 7, 1811. His father was a baker, and James was the youngest of a family of seven. At the age of sixteen he began his medical studies, and in 1833 he received the degree of Doctor of Medicine. In 1837, while he was acting as the assistant of Dr. John Thomson, who then occupied the Chair of Pathology in the University of Edinburgh, he was given the opportunity to deliver the lectures on pathology during the professor's illness. This brought him favorably to the notice of the authorities. In

FIG. 4505.—Sir James Young Simpson.

1840 he was elected to the professorship of medicine and midwifery in the university. In 1846, having observed at an operation performed by Robert Liston how completely unconscious the patient had been rendered by the inhalation of sulphuric ether, he began at once to use this agent in midwifery practice. In 1847 he advocated the superiority of chloroform as an anesthetic agent, not only in midwifery practice but also in ordinary surgical operations. His advocacy of the use of this agent for the relief of pain in obstetrical practice gave rise to one of the angriest and most widespread controversies of the time. In the same year he was appointed a Physician to the Queen in Scotland. Between 1859 and 1866 he introduced a number of improvements in the methods of gynecological diagnosis and in obstetrical practice. In the latter year he was created a baronet. He died in Edinburgh on May 6, 1870, and was accorded a public funeral. His statue in bronze now stands in West Princes Street Gardens, Edinburgh.

Of Sir James Y. Simpson's numerous contributions to medical literature the following deserve special mention: "Obstetric Memoirs and Contributions," 2 vols.; "Homœopathy;" "Acupressure;" "Selected Obstetrical Works;" "Anæsthesia and Hospitalism;" and "Clinical Lectures on the Diseases of Women."

A. H. B.

Sims, J. Marion.—Born in Lancaster County, South Carolina, Jan. 25, 1813. He studied medicine first at Charleston, in his native State, and then at the Jefferson Medical College, Philadelphia, from which latter institution he received the degree of Doctor of Medicine in 1835. In 1840 he settled in Montgomery, Alabama, and remained there for thirteen years, his practice being largely of a surgical character. In 1845, while he was practising in that city, he devised "a method of treating vesicovaginal fistula, an affection for which physicians of various countries had in vain sought a cure. . . . . After experimenting for three years and a half, he finally devised the silver-wire suture, which remains sacculated in the living tissues, and which has since been employed in many branches of surgery, and with which he effected a perfect cure. During his experiments he invented various instruments, chief of which was the duck-bill speculum, commonly called the Sims speculum." (Stone, *op. cit.*) This instrument, which enabled the physician to examine the vaginal walls and the os uteri much more satisfactorily than had ever before been possible, opened the way for the discovery of several other pathological conditions besides vesicovaginal fistula, and thus rendered it possible to treat them successfully. In 1853 he removed to New York, and was soon actively at work demonstrating to the medical men of that city that the surgical methods which he employed were thoroughly effective in curing or relieving a large class of ailments peculiar to women. Despite some very strong and influential opposition on the part of many of the older and ultra-conservative surgeons, Dr. Sims succeeded in winning for his methods the recognition which he had a legitimate right to claim, and which in the course of a few years was freely granted to him by the entire Profession. The establishment of the Woman's Hospital of the State of New York, in New York City (1855–76), is another of the triumphs which must be credited to the personal zeal and genius of Dr. Sims. Subsequently he visited Europe and demonstrated his methods in all the larger European cities; honors of all sorts being showered upon him in these cities, for his great achievements in gynecological surgery. In 1868 he settled permanently in New York. He died Nov. 13, 1883. A bronze statue of Dr. Sims, of heroic size, now stands in Bryant Park, New York City.

Of his published writings the following deserve to receive special mention: "Trismus Nascentium;" "Silver Sutures in Surgery;" "Clinical Notes on Uterine Surgery;" "Intrauterine Fibroid Tumors;" and a "Treatise on Ovariotomy." A. H. B.

Simulidæ.—The family of Diptera which includes the sand-flies or black-flies. The eggs are deposited in streams and the larvæ live attached to rocks in swift rapids. The adults are biting flies and often occur in such numbers as to cause serious trouble. These insects have been believed to carry pellagra, apparently without sufficient evidence, and other diseases. A. S. P.

Sinapis.—Black Mustard, or Sinapis nigra, "the seed of *Brassica nigra* (L.) Koch," and White Mustard, or Sinapis alba, "the seed of *Sinapis alba* (L.) (fam. *Cruciferæ*)," are thus separately official in our Pharmacopœia. Since they agree in most respects, they may be discussed together, and their differences pointed out in passing. Both are natives of Europe and western Asia, cultivated and naturalized in most countries. Both are slender, tall, and widely spreading, weedy-looking herbs, with coarsely pinnatifid or pinnate leaves, the upper entire, and yellow flowers. The two are best distinguishable by the habit of their pods. In the black mustard these are erect on spreading pedicels; in the white, both the pedicel and the pods are spreading. White mustard is also a rougher and smaller plant. The herbage of both is reputed antiscorbutic, and is used as a salad, also for poultices. The relationship of these plants to some of the forms of turnip, rape, cabbage, and colza is close and confusing, so that in India, where mustard is most cultivated, a number of ill-defined forms exist. This condition—partly the result of natural causes and partly effected by design—results in much admixture in some lots of seeds. The following are the descriptions of the Pharmacopœia:

White Mustard.—"About two millimeters in diameter, almost globular, with a circular hilum; testa yellowish, finely pitted, hard; embryo oily, with a curved radicle, and two cotyledons, one folded over the other; free from starch; inodorous; taste pungent and acrid."

Black Mustard.—"About one millimeter in diameter, almost globular, with a circular hilum; testa blackish brown or grayish brown, finely pitted, hard; embryo oily, with a curved radicle, and two cotyledons, one folded over the other; free from starch; inodorous when dry, but when triturated with water, of a pungent, penetrating, irritating odor; taste pungent and acrid."

The principal adulterant of whole black mustard is rape seed, which can readily be distinguished by its slightly larger size and its peculiar bluish tinge. Charlock seed, distinguished by its smooth surface, is also frequently found admixed. In the ground condition, white mustard is often mixed with it. This addition, if kept within moderate limits, only adds value to the product, for reasons stated below. Most other adulterants either contain starch—which may be determined by the iodine test—or, like curcuma, the most common of these, they contain resins, which may readily be indicated by the use of sulphuric acid.

Pure ground black mustard is almost too strong for safe use upon the table, and curcuma is usually added to dilute it. Advantage is taken of this to use excessive quantities of the substance selected for admixture. Hence the importance of the preparation of black mustard for medicinal purposes by purely pharmaceutical agencies.

Composition.—The constituents of the two varieties of mustard, although presenting close relationships, are not exactly identical. They both agree, however, in containing a considerable amount of a bland, light-colored, non-drying *fixed oil*—a mixture of the glycerin combinations of *oleic, stearic,* and *erucic acids;* in white mustard oil *benic acid* is also found. This oil amounts to about twenty-two or twenty-three per cent. of the seeds. The most remarkable constituent of black mustard is the crystalline, bitter-tasting, inodorous glucoside, *myronate of potassium,* or *sinigrin;* soluble in water, but not in alcohol or ether, and in its watery solution decomposing, in the presence of various ferments, especially of one to be mentioned below, into glucose, bisulphate of potassium, and the horribly acrid, sulphureted, *essential oil of mustard* (*allyl isothiocyanate,* etc.), to which mustard is indebted in part for its medicinal value, and which is described below. This oil is not present in the dry seeds or their powder, but is produced only when they are moistened. The development of the odor upon wetting mustard flour is very evident, and distinguishes this from that of white mustard. The albuminous ferment which assists in this decomposition is called *myrosin,* and is common to both kinds of mustard.

The glucoside in white mustard, resembling the sinigrin of the black, has been correspondingly named *sinalbin,* a neutral crystalline substance, soluble in cold water, and decomposed in a similar way as sinigrin into *sugar, sulphate of sinapin,* and *sulphocyanate of acrinyl,* the latter corresponding to the essential oil of the black mustard. It is an acrid and vesicating substance, but much milder than the glucoside of the black variety, and not volatile.

To bring out the full percentage of the black mustard oil, a certain amount of myrosin, additional to that contained in this drug, is desirable, and is obtained by judiciously adding a certain quantity of the white mustard. The flour from this mixture is the strongest and best that can be made. That obtainable in our market is often the flour of white mustard only.

An oil exactly resembling that of black mustard has been made synthetically and is in the market.

Action and Use.—Both sorts of mustard seeds possess the same qualities; they vary only as regards the degree of pungency, the black being the stronger. Swallowed whole they do not disintegrate much, but pass through the digestive tract. In this way white mustard seed, particularly, is now and then given, in doses of a teaspoonful for dyspepsia, constipation, etc.; like nearly everything else, it has also been employed in chronic cases of bronchitis, rheumatism, and some skin diseases, without any rational indication for such employment. Its rare use at present for these purposes shows its slight value.

Ground mustard, white, black, or mixed, is an active local irritant as soon as wet with water so as to produce the acrid decomposition products of the drug. Applied to the skin, it is quickly and painfully rubefacient; and if allowed to remain in contact with it for a long time, it is vesicant—producing a crop of fine, deep, eczematous blisters, easily ruptured, very painful, and rather slow to heal after rupture takes place. Internally, mustard, in small doses of gr. iij.–v. (0.2–0.3), is an aromatic stimulant, and as such is in every-day use at the table. In larger quantities (tablespoonful) it is a prompt and valuable emetic, usually coming up in from two to five minutes after being swallowed. On this account, and because it is almost always at hand in the house, it is the most valuable emergency emetic at our command. For poisoning by opium or by other narcotics it is a remedy almost without an equal.

Administration.—The employment of whole mustard has been noticed sufficiently above. The ground mustard in use in this country is that sold by grocers for family use, and is seldom, if ever, a plain mixture of the two sorts of seeds and nothing else, which gives the most perfect product. It is oftener ground white mustard alone, and oftener still mustard diluted with a varying amount (generally considerable) of inert yellow powder. It is therefore subject to considerable variation in strength. This is used both internally and externally—internally, as a stimulant (condiment) and emetic; externally, always as a rubefacient. For an emetic, from a dessert- to a tablespoonful should be given, as a less amount may fail to produce vomiting but still cause considerable gastric distress. Externally, it is chiefly employed in foot-baths and sinapisms—for the former, from one to two tablespoonfuls may be added to a small tubful or bucketful of warm water; for the latter, the mustard meal is simply mixed with a little water and spread upon a cloth, or it may be diluted with meal or flour to

reduce its strength. In this way mustard is the most widely used local remedy for the sudden and intense pain or distress of pleurisy, colic, some neuralgias, etc. It is also used as a derivative in nervous vomiting, cerebral and spinal inflammations, etc., and in many other conditions when acute attacks of pain are present. Both kinds of mustard are greatly damaged, or even spoiled, if mixed with hot water, as this destroys the ferment which brings out the active decomposition principles. The following preparations are official: *Charta Sinapis*, U. S. P., made by taking ground black mustard, exhausting it of its fatty oil by percolation with benzin, then mixing it with enough solution of india rubber to make a paste, and spreading it upon paper. This mustard paper is almost never made by the dispensing apothecaries, since several manufacturers here and in France make excellent substitutes for it that can be easily obtained and carried everywhere. The activity of the mustard paper is not developed until it is moistened in cold or merely warm water.

Oleum Sinapis Volatile, U. S. P. The oil of black mustard is also official, and may be made synthetically or obtained from black mustard by maceration in water and subsequent distillation. It must contain not less than ninety-two per cent. of allyl iso-thiocyanate.

It is colorless or pale yellow, strongly refractive, and extremely pungent and acrid in odor and taste, and has a specific gravity of 1.013 to 1.020 at 25° C. It distils completely between 148° and 154° C., all portions having the same specific gravity. Its vapor when concentrated is intensely disagreeable, causing lacrymation and severe pain in the nose. Applied to the skin, it blisters severely. Diluted with nine parts of alcohol, or three parts of olive oil, it causes, when rubbed upon the temples or forehead, a sharp temporary tingling that occasionally relieves mild headache. The compound liniment of mustard (*Linimentum Sinapis Compositum*, U. S. P.) contains:

Volatile oil of mustard	3 parts.
Fluid extract of mezereum	20 parts.
Camphor	6 parts.
Castor oil	15 parts.
Alcohol	q.s. to make 100 parts.

It is a good stimulating liniment.

HENRY H. RUSBY.

Sinuses, Accessory Nasal, Diseases of the.—GENERAL CONSIDERATIONS.—By the accessory cavities of the nose are meant the mucous-membrane-lined pneumatic spaces that, under normal conditions, drain the secretion from their lining membrane into the nose. They are named from the various bones which they occupy, as follows: frontal sinus, sphenoidal sinus, ethmoidal cells, and maxillary sinus or antrum of Highmore.

As a rule, these cavities are symmetrical as to the two sides of the head but there are many variations from this rule—for instance, whereas the normal head has one frontal sinus on each side, there may be no frontal on either side, or there may be a frontal on one side and none on the other, or there may be several frontals on either or both sides. There is as a rule no evidence of a frontal sinus before the seventh or eighth year although it has been seen as early as the fourth year. The sphenoidal sinus is present as early as the first year, is usually single on either side but the sinuses of the two sides may vary greatly in size. The ethmoidal cells are present at birth, occupy the body of the ethmoid bone, and may push into and occupy portions of the frontal or middle turbinated bones; they are present on both sides and are divided into anterior and posterior ethmoidal cells according as they drain into the middle or superior meatus of the nose. The maxillary sinus occupies the body of the upper maxillary bone in adult life, is situated between the teeth, the palate bone of the upper jaw, and the orbit. At birth this sinus is but a depression on the nasal side of the maxillary bone, the body of that bone being occupied by the alveoli of the two sets of teeth. As growth takes place the face elongates, the alveoli of the permanent teeth separate from the inferior orbital wall, and the antrum pushes into, enlarges, and occupies this space.

The frontal sinus, antrum of Highmore, and anterior ethmoidal cells open and drain into the middle meatus of the nose, that is, between the middle and inferior turbinated bones; the posterior ethmoidal cells and the sphenoidal sinuses drain into the upper or superior meatus of the nose, that is, above the middle turbinated bone. Knowledge of this fact frequently aids one materially in determining just what sinus or sinuses are diseased. For instance if pus be seen in the middle meatus only, as a rule the sphenoid and posterior ethmoidal cells may be cleared of suspicion; whereas pus seen only in the superior meatus indicates that the frontal, anterior ethmoidal, and antrum of Highmore are free from disease. It should be borne in mind, however, that there are exceptions to this rule. There may be a closed empyema in any of the sinuses, and theoretically there are all degrees of drainage from the various sinuses, from the normal free drainage to the closed cavity.

The last stated fact should be illuminating to those men who claim that operation for the relief of acute sinusitis is never demanded and seldom excusable. The writer has opened frontal sinuses acutely diseased, the anterior walls of which have presented the shaven beard appearance and in which the bone has been so softened as to be easily removed with a spoon curette. The posterior wall may be similarly diseased and by this route the brain and its coverings are not infrequently involved. Such cases demand speedy, extensive, and radical operation.

The accessory cavities are lined by the extension of the nasal mucous membrane, although the epithelial covering of the membrane may be modified to meet the requirements of any particular cavity; for instance, the opening into the nose from the antrum of Highmore is very near the top of that cavity, the lining of that cavity is covered by ciliated epithelium, the cilia so moving in the healthy cavity as to carry all secretions toward and to the opening. The openings from the other accessory cavities are for the most part at the lowest portions of the cavity; drainage is by gravity, and the epithelial covering is of the squamous or pavement variety.

Because of the above, the sinuses are not infrequently involved by the extension of a catarrhal condition from the nose. This catarrhal sinusitis may exist in all cases of chronicity.

The symptoms are, as a rule, less severe than those of a purulent sinusitis and the treatment less heroic but along the more conservative lines suggested in discussing treatment under the term Sinusitis.

ETIOLOGY.—For the most part disease of the accessory cavities is due to the activity of one or more of the infecting organisms accompanying the ordinary infectious diseases, notably influenza, pneumonia, and the exanthemata. Occasionally we see the disease develop in an individual who has no knowledge of having had any previous ailment. To this more general mode of infection should be added that of the antrum through diseased teeth.

Disease of any accessory sinus may occur from extension to that cavity from a diseased neighboring cavity. In an individual suffering from a constitutional vice such as syphilis, the disease of the accessory cavities may have its origin in the bony walls and extend outward to the membrane.

The various sinuses may be independently or associatedly diseased; it is not uncommon to find all sinuses of one side of the head involved—a condition spoken of as pansinusitis of the right or left side as the case may be.

Pathology.—The condition of the membrane lining an infected sinus varies from a simple round cell infiltration to granulation thickening on to polypoid degeneration, which condition continuing may end in a devitalization of the membrane and bone necrosis. The changes in bone and membrane may be specific or tuberculous. It should be borne in mind that, because of the structure of the membrane lining the accessory sinuses, the above progression of pathological changes may be very rapid. A certain number of fulminating cases develop so rapidly as to fall almost immediately into the emergency class. Such cases present evidence of great pressure and a considerable toxemia on account of which there is considerable danger to the eye or brain. These patients, on account of the swelling and pain about the eye, are prone to consult the occulist or present themselves at an ophthalmic clinic. Patients in whom drainage is better, as a result of which there is a considerable purulent discharge from the nose, consult the rhinologist.

Prognosis.—In all acute cases of the last class the tendency is to spontaneous recovery. Treatment directed to the establishment of drainage is practically all that is called for both for the relief of symptoms and for the hastening of recovery.

Diagnosis.—The diagnosis is made from the study of a complex picture into which as elements enter the history and subjective symptoms plus the findings by intranasal inspection, extranasal palpation, and percussion of such sinuses as can be reached, the findings by the use of the transilluminating lamp, and the *x*-ray picture. The most positive diagnosis can be made by washing out such sinuses as can be entered through either their normal or their artificial openings.

Diagnosis is easy or difficult according to the prominence and clearness of the various elements of the picture. It may occur that all the above-named elements are present in so indefinite and indistinct a way as to make a positive diagnosis impossible. At times one obtains help from the study of the eye as to the condition of the nerve head and the fields of vision—especially the fields for color.

Treatment.—Treatment will vary according to the form of sinusitis and to whether it be acute or chronic.

Acute Sinusitis.—As has been stated acute sinusitis tends to recovery. The attendant's part is to assure himself that there is sufficient drainage and then pursue an expectant plant of treatment. A warm saline douche or the inhalation of steam tends to remove stagnating and obstructing secretions from the nose, thus favoring drainage and conducing to a more comfortable feeling on the part of the patient. Drugs may be necessary for the temporary relief of pain. The author's apparatus for the application of negative and positive currents, the positive current carrying medicated vapor or nebula, is of the greatest service.

In those fulminating cases due to lack of proper drainage in which the patient generally consults the oculist, one must adopt a most active form of treatment. The question as to whether drainage shall be established by intranasal or extranasal methods should be decided by what one believes to be the condition of the membrane and bony covering of the cavity involved. The writer believes that it is better to err on the radical side, as by so doing one sees the condition of the membranous and bony walls and so obviates all chance of serious complication. The operator, having decided to enter the nose by an extra-nasal incision in an acute case of sinusitis, will be guided as to the extent of the removal of the anterior wall of the frontal sinus and the ethmoidal cells by his findings. If the bony wall of the frontal sinus be healthy it need not be removed. The floor of the sinus and the anterior cells of the ethmoid should be removed to insure permanent drainage. Such an operation leaves neither scar nor deformity.

Chronic Sinusitis.—The treatment of chronic sinusitis will depend largely upon the severity of symptoms at the time the patient is seen and upon the history of the case as to acute exacerbations.

If seen during an acute exacerbation, the case should be treated on principles governing the treatment of acute sinusitis. If seen during the more quiescent stage, one will not resort to radical operation until the more conservative non-surgical methods have been faithfully tried out. The author believes that no other plan of treatment offers such rational and practical results as does the use of his combination negative and positive pressure apparatus by which the diseased accessory cavities of the nose are cleaned and treated. The apparatus (Fig. 4506) consists of two bottles; the larger, connected with a working exhaust pump, becomes a vacuum bottle into which, when connected with the nose, is drawn the secretions from its lining membrane and its accessory cavities. At the same time a partial vacuum or negative pressure is established in any and all cavities opening into the nose. The second and smaller bottle contains any oily solution that one wishes to introduce into the sinuses. When this bottle is connected with a positive air-current a nebula is formed in the bottle which is thrown out between the bottles or into the nose according as the switch key between the bottles is turned. To use the instrument both the negative and positive currents should be on at the same time, depending upon the position of the switch key for either the negative (cleaning) or positive pressure (medicating) effect. The change from one effect to the other is immediate, so that the first thing offered to the vacuumized cavities is the medicated nebula.

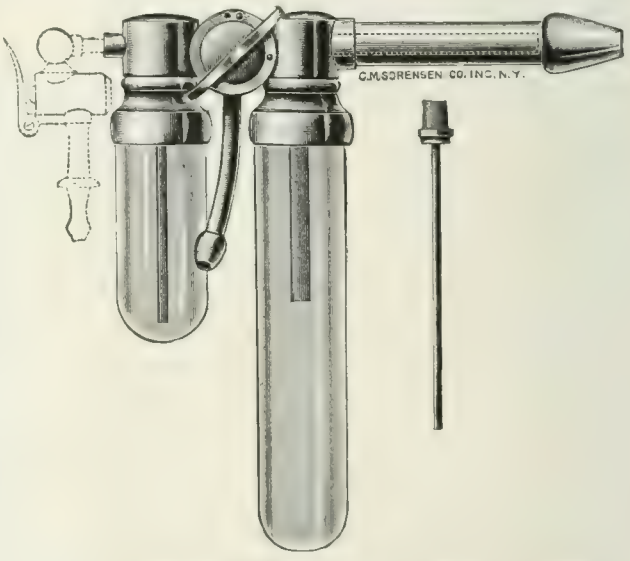


Fig. 4506.—Apparatus for Cleansing and Medicating the Sinuses.

The writer finds that he has had his best results by the use of a suspension of Bulgarian bacilli in mineral oil. Such a suspension was prepared for him by Dr. W. McK. Higgins. The oily preparations of iodine have also been used. By means of a properly bent cannula this same method of treatment may be applied to individual sinuses. One should see to it, even with this method of treatment, that fair drainage is established.

A palliative form of treatment may be instituted, consisting in the use of the nasal spray or douche. Either of these measures may be placed in the hands of the patient who by their use may be made so comfortable as to require no more radical measures.

Of the two methods the writer prefers the douche. The apparatus consists of a somewhat modified Amberg's ear syringe to which is attached at one end a weight which serves to hold the tube in the solution container, and to the other end is attached an olive-pointed nose-piece. A physiological saline solution to which has been added a few grains of bicarbonate of soda fulfills all requirements for the wash. The patient should be instructed to fill the syringe, apply the nasal tip to one nostril, incline the head over a wash basin, open and breathe through the mouth, and gently squeeze the bulb of the syringe; the solution flows under these conditions, from the open nostril under little pressure and no harm will be done the ear. Stress should be laid on the open mouth and if one nostril is considerably obstructed the douche should be used only from that side.

Individual Sinusitis.—The *antrum of Highmore*, because of its position and the fact that it is open to infection from diseased teeth, is perhaps more frequently independently diseased than any other sinus. Acutely diseased, if the infection has not been by the way of a diseased tooth, an antrum tends to recovery. If however, such recovery does not take place within

Fig. 4507.—Showing the Communication made by the Trocha between the Inferior Meatus and the Antrum.

a short time (one week) or it is believed the disease is secondary to a diseased tooth active measures should be adopted. If it is secondary to a diseased tooth the tooth should be pulled, when recovery may speedily follow. If such recovery does not take place the antrum is treated the same as is any antrum subacutely or chronically diseased which is as follows. A trochar is pushed through the antronasal wall in the inferior meatus after the part has been thoroughly cocainized (see Fig. 4507). The cannula is now attached to a syringe and the cavity washed out with a warm saline solution. This may be followed by an injection of a weak solution of hydrogen peroxide or a twenty per cent. solution of argyrol. Improvement should be early and steady; if it is not, more radical procedure must be adopted as follows: a large opening into the antrum is made at the site of the hole made by the trochar, through which drainage takes place and the patient may be taught to pass a cannula and wash the cavity.

Occasionally it happens that even more radical operation must be done to remove the disease effectively. Such operation is as follows: An incision to the bone is made in the supradental fossa from opposite the second or third molar to near the median line. The periosteum is raised and the bone of the superior maxilla exposed to near the line of the infra-orbital foramen. By chisel and forceps the anterior wall of the antrum is now readily removed and the entire cavity explored for polypi, bared or necrosing bone, etc. Diseased membrane and necrosing bone areas are subjected to a thorough curettage. The cavity is washed and the flaps made by the incision in the dental fossa are sutured with catgut. The cavity may or may not be packed. In case it is packed the gauze is put in in such a way that it is easily removed through the opening in the antronasal wall in the inferior meatus of the nose. This complete operation is known as the Caldwell-Luc operation.

The Ethmoidal Cells.—Although disease of the ethmoidal cells is liable to be associated with disease of the frontal sinus or antrum, it may exist independent of those cavities. In the acute disease of these cavities, the treatment has already been described under that of Acute Sinusitis. Treatment of chronic ethmoiditis may be either surgical or non-surgical. The non-surgical treatment may consist in the education of the patient as to the toilet of the nose which means the proper method of using douche, spray, etc. Not much good can be expected from this form of treatment, however, beyond a greater comfort to the patient.

Greater relief and better results may be looked for by the use of the author's negative and positive pressure apparatus; but, to get the greatest good from this form of treatment it is frequently advisable to do a certain amount of surgery for the establishment of drainage before resorting to the use of the apparatus referred to.

Surgical Treatment.—In those cases of chronic ethmoiditis in which on inspection the nose is seen to be crowded full of what looks like a polypoid mass, in which it is sometimes difficult to differentiate between the middle turbinated and the swollen boggy-looking tissues over the ethmoid and in which mucopurulent secretion is seen in all crevices, or in cases in which the eyes seem to suffer from the nasal disease, radical surgery is demanded for the relief of both symptoms and disease. The entire ethmoidal tract including sphenoid must be opened up and the diseased tissue removed. This may be done either intra- or extranasally with practically the same results. The following points must be considered in determining which route one will follow: The intranasal route in my opinion should never be followed except under local anesthesia, therefore the intranasal route is attended with considerable pain and requires a goodly amount of fortitude on the part of the patient. The extranasal route may leave a slight scar. Knowledge of this fact frequently adds to the fortitude of the patient and pain is borne with greater grace.

Because of a deviated septum, good intranasal work on the ethmoids is often impossible until a very radical resection of the septum has been done. I have at times chosen the extranasal route for the last reason. The temperament of the patient must be taken into account. The writer's method of exenterating the ethmoids intranasally is as follows: The nose having been cleaned as well as possible a narrow chisel is placed at an angle of about 45° with the median anteroposterior plane of the body against the body of the ethmoid in the vicinity of the attachment of the middle turbinated, and tapped

gently through the nasal wall of the ethmoid. If on tapping the chisel, it seems to be against very solid bone, it should be shifted, probably backward, possibly downward, until with a slighter tapping it is felt to pass through the side wall of the ethmoidal body.

The chisel is now moved upward and downward like a knife, breaking down the thin wall of the ethmoidal body. This having been done the gap thus made is widened by pressing the chisel sidewise toward the septum of the nose. The chisel is now withdrawn and through the opening just made is entered one blade of a Luc's forceps, the other blade being

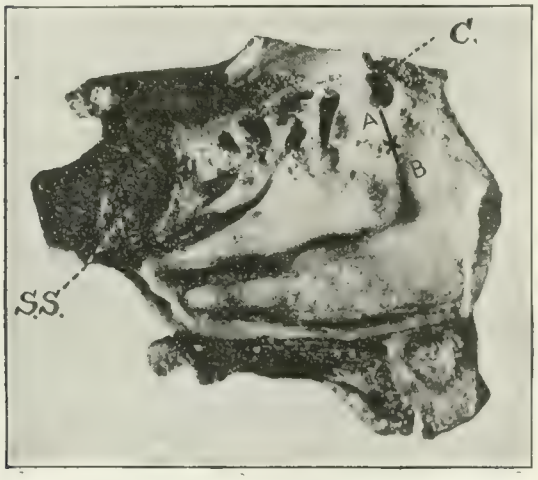


Fig. 4508.—Showing the Relation of the Ethmoid Cells to the Lateral Wall of the Nostril.

free in the nostril. The blades of the forceps are now closed and by a slight twisting motion one is able to remove a considerable portion of the ethmoidal body.

As a rule three or four such bites carry one well back and possibly into the sphenoid. If the sphenoid is not open one easily finds its ostium which can be enlarged by curette or biting forceps. This operation is fairly painful but is quickly done. The surprising thing about it is the absence of hemorrhage; packing of the operated field is seldom if ever required. One can generally easily probe the frontal sinus after the above procedure.

Figure 4508 is a photograph of the lateral wall of the left nostril of a four-year-old child, the ethmoid cells above the middle turbinal having been uncovered. To do the operation above described the chisel is made to enter the ethmoidal body at the point marked *x* and by an up-and-down stroke the chisel is made to break down the light bony wall along the line *a-b*. By a study of the picture it will be seen how readily by means of a wide-bladed forceps, one blade being entered through the chisel-made opening, the ethmoidal cells may be exenterated, removing the middle turbinal at the same time. *S. S.* is the sphenoidal sinus; *C.* is an anterior ethmoidal cell which extends upward sufficiently high that it was opened when the frontal bone was cut off; it is probably a rudimentary frontal sinus. The ethmoids having been exenterated as described, it will be seen from a study of the picture how accessible are the frontal and sphenoidal sinuses.

An operation much in use is that described by Dr. Mosher of Boston. The technique is as follows: A small spoon curette slightly bent at the junction of the blade and handle is made to break into the ethmoid body at *x* when the curette is turned so as to cut downward and a series of downward sweeps is made from near the top of the ethmoidal body into the middle meatus of the nose each sweep being just posterior to the one previously made, until the anterior wall of the sphenoidal sinus is reached. The blade of the curette should now be turned forward and the most anterior ethmoidal cells are broken down until one senses by the feel of the curette that he is against the smooth hard surface of the frontal process of the superior maxillary bone. This attack on the ethmoidal cell is made between the middle turbinal and the orbit. The operation is completed by the removal of the middle turbinal and any torn and shredded parts by forceps. The frontal and sphenoidal sinuses are easily entered after the operation.

Exenteration of the Ethmoidal Cells by the Extranasal Route.—This route may be desirable under the following conditions:

1. A case demanding speedy relief, having a septum so deviated as to make intranasal work on the ethmoids almost impossible.
2. The temperament or physical condition of the patient may be such as to forbid such a considerable and trying operation under local anesthesia.
3. A more thoroughly radical operation can be promised by the extranasal route.
4. In those cases in which it seems advisable to open the frontal sinus by extranasal incision.
5. This route should be chosen in dealing with children under twelve years of age—for the double reason that children of that age will not stand conscious operation well and the size of the nose makes almost impossible good intranasal attack on the

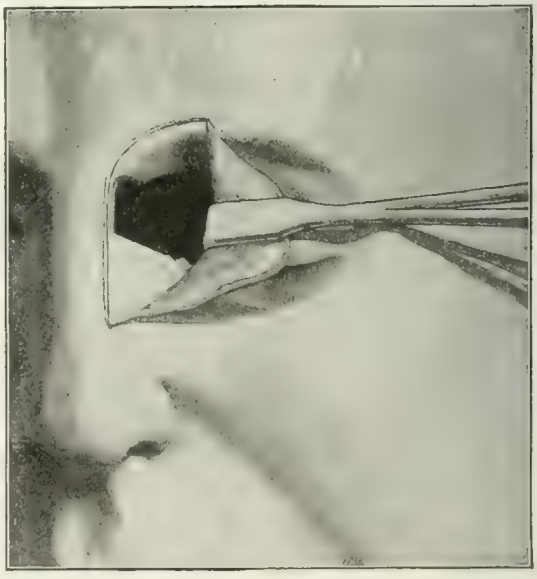


Fig. 4509.—Showing the Mode of Approach in the Operation for Exenteration of the Ethmoid Cells.

ethmoidal tract. The technique of the operation is as follows: An incision beginning on the nasal side of the supraorbital notch is made along the upper border of the eyebrow, curving around the nasal end of the brow to the side of the nose to a point about one-fourth inch from the ridge of that organ and extending parallel with the ridge or dorsum as far as the lower border of the frontal process of the superior maxillary bone. The flap on the orbital side of this incision is freed from the horizontal bone of the frontal sinus well into the orbit and from the side of the nose until one sees that the tear sack has been raised from its bed. With a curved V-shaped chisel three sides of

a rectangle are now marked out on the exposed bone of the nasal wall. The first groove is cut parallel to and just external to the incision along the side of the nose. The second groove is made perpendicular to the first and at such a point that it passes into the bony seat of the tear sack. The third side of the rectangle is cut at the upper end of the first groove and is cut into the external horizontal plate of the frontal bone. These grooves having been carried through the bone, the large rectangular piece of bone so outlined is easily picked out exposing the most anterior of the ethmoidal cells (Fig. 4509). A Luc's forceps is pushed into the ethmoidal tract and by them the cells are easily broken down and the broken-down bone and membrane removed. At a depth of about one and three-fourths inches one encounters greater resistance on account of having reached the anterior wall of the sphenoidal sinus. A probe is now used to explore for the ostium of that cavity which having been located, a medium sized curette is carried to thispoint and the opening enlarged. When the diseased tissue along this tract has all been removed hemorrhage ceases and the external incision is closed. No packing of the operated tract is necessary nor is it excusable. Stitches may be removed in from forty-eight to seventy-two hours. No deformity follows this operation and little scarring.

Sphenoidal Sinus.—Treatment of the sphenoidal sinus has been sufficiently indicated under the discussion of the treatment of the ethmoidal cells.

Frontal Sinus.—Aside from the radical surgery of the frontal, the treatment of that sinus has been also sufficiently suggested in the discussion of the treatment of the ethmoidal cells.

For a discussion of the radical treatment of the cavity the reader is referred to the monographs and text-books on the subject. I believe the radical Killian operation has come to be regarded almost universally as the operation of choice. It consists essentially in removing the entire anterior wall of the sinus except a strip of bone about one-third of an inch in width immediately under the eyebrow, the removal of the floor of the sinus and doing the radical exenteration of the ethmoid cells by the external route. LEWIS A. COFFIN.

Siphonaptera.—Fleas. Wingless insects with highly chitinized and laterally compressed bodies. Over 400 species are known, and several attack man. Aside from their bites, the chief medical importance of fleas is as carriers of the bubonic plague. See *Insects, Parasitic.* A. S. P.

Siphunculata.—The true sucking lice. These are small wingless insects with reduced mouth parts. Lice infestation is known as pediculosis. There are three species of lice which commonly attack man: *Pediculus humanus*, the head louse; *P. corporis*, the body louse; and *Phthirius pubis*, the crab-louse. See *Insects, Parasitic.* A. S. P.

Sitka Hot Springs.—Location on Baronoff Island, Alaska, fifteen miles south of Sitka. They are reached from Sitka by boats only. Houses have been built at this place, several with bath-rooms attached. Comfortable accommodations are afforded. In 1841 a hospital for rheumatic troubles and skin and blood diseases was opened by the Russian-American Company. The baths were found to be very beneficial in syphilitic affections. The Indians have resorted to the springs for many years. They are about thirty feet above the sea-level, and distant from salt water about fifty yards. The springs are four in number, but the rate of water flow is unknown. The temperature of the water is 145° F., and it is said to contain sulphur, sodium, lithium, potassium, iron, manganese, chlorine, and radium. The weather in this region is generally clear during the summer months, with a temperature ranging from 60° to 80° F. The spring season is considered preferable for visiting the springs. The climate is mild, tempered by the warm ocean current, and the rainfall is not heavy. Game and fish are found in abundance and boating facilities are unexcelled. The grandeur of the scenery is noted. Other hot springs are located on Chickagoff Island, about eighty miles from Sitka. Little is known concerning them, except that they have some reputation among the Indians in the same diseases as those mentioned above. Within half a mile of Sitka, on a road called Davis Avenue, there is an iron spring flowing from a rock. It was formerly esteemed by the Russians for its tonic properties. The Sitka Hot Springs water is bottled, corked, and sealed at the springs. EMMA E. WALKER.

Skagg's Hot Springs.—Sonoma County, California.

POST-OFFICE.—Skagg's Springs. Hotel and cottages.

ACCESS.—Via the Sausalito Ferry, San Francisco to the Marin shore, where two trains daily connect for the Springs. At Geyserville an automobile is in waiting to carry the traveler over nine miles of picturesque road through the enchanting Dry Creek Valley, then through Warm Springs Canyon to the Springs.

Skagg's Hot Springs are pleasantly located in the Coast Range Mountains, in a picturesque spot, nine miles west of Geyserville and twenty miles east of the coast. The surrounding mountains are clothed with every variety of California verdure, and they abound with trout streams. Many varieties of game are also found, including bear, deer, grouse, and quail. The springs, four in number, yield thirty gallons per minute, the water having a temperature of about 125° to 135° F., and a somewhat pungent, agreeably alkaline taste. The water is as clear as crystal, and bubbles of gas give it the appearance of boiling water. Excellent bathing facilities have been provided. Analyses have been made by Prof. Eugene W. Hilgard and Dr. Winslow Anderson, which show no material difference in their results. That of Professor Hilgard is as follows:

	In 10,000 parts.	Grains per gallon.
Potassium chloride	0.035	0.200
Potassium sulphate	0.043	0.260
Sodium chloride	1.012	5.900
Sodium iodide	Trace.	Trace.
Sodium biborate, borax	4.542	26.470
Sodium bicarbonate	27.672	161.270
Lithium carbonate	0.010	0.060
Barium carbonate	0.040	0.240
Strontium carbonate	0.004	0.024
Calcium carbonate	0.377	2.197
Magnesium carbonate	0.191	1.113
Iron carbonate	0.009	0.054
Alumina	0.004	0.004
Silica	1.205	7.023
Total solid ingredients	35.144	204.815

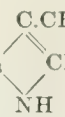
Free carbonic acid gas, 124 cubic inches.

There is a concrete swimming tank, thirty-two by sixty-eight feet, as well as concrete plunges and porcelain tub baths. This so-called velvet bath of water containing hot soda, borax, and sulphur water is an ideal "beauty bath."

There are no winds or fogs or sudden changes; the days are never too warm, and the nights are always cool.

Many forms of amusement are provided for the guests.

The waters here are very useful in rheumatic troubles, neuralgia, sciatica, neuralgia, bronchitis, asthma, and catarrh, as well as in affections involving the stomach, bladder, and kidneys. They are highly recommended by medical men on the coast, and the proprietor has determined to keep the resort open all the year. EMMA E. WALKER.



Skatole, or β-methyl-indole—C_6H_4 CH.—Skatole with indole is formed from protein by putrefaction. In the intestine it is absorbed, oxidized to skatoxyl and eliminated in the urine as either the ethereal sulphate or as a glycuronate. Skatole crystallizes in shining leaves, having a melting-point of 95° C. Skatole has an intense fetid odor. It is volatile with steam, soluble in ether and alcohol, and in an alcoholic solution forms with picric acid a compound which crystallizes as red needles. See also *Putrefaction.* F. P. U.

Skin and Appendages, Anatomy of the.—The skin, or integumentum commune, of the body acts as a covering and a protection for the deeper portions, besides being an organ of secretion, of excretion, of special sense—the sense of touch—of common sensation, and the conservator of animal heat. Embryologically, it is developed from those two primitive layers of the blastoderm, the ectoderm and the mesoderm, which are formed by the cellular division of the impregnated ovule. The epidermis, or most external layer of the skin, is formed from the ectoderm, while a superficial portion of the mesoderm furnishes the remaining constituent parts—the corium, or cutis vera, and the subcutaneous or fatty tissue.

GENERAL CHARACTERISTICS.—When fully formed the skin can be regarded as a completely closed sac, which models itself so closely upon the portions of the body which lie immediately below it, that it allows their shape and configuration to be more or less accurately distinguished. This, naturally and to a great extent, will depend upon the amount of intervening fatty tissue. When the latter is present in excessive amount, symmetry and roundness of form are lost.

The skin does not stop abruptly at the natural openings of the body. It is continuous at these points with the mucous membrane which clothes the cavities. At the nares, on the labia majora and minora, and on the external surface of the anus, the transition of the skin over to the mucous surface is gradual, but at the mouth, on the eyelids, and at the meatus urinarius, it is abrupt.

The integument is very variable in thickness. In general, it varies between 0.5 and 4 millimeters ($\frac{1}{50}$ to $\frac{1}{6}$ in.), exclusive of the subcutaneous tissue. It is thinnest on the eyelids, and thickest on those portions which are subjected more especially to pressure, as on the palms of the hands and soles of the feet, or which serve as points of insertion for muscles, as on the upper lip, alæ nasi, etc.

Density and Elasticity.—It has been found that the skin possesses considerable solidity and very perfect elasticity. Sappey concluded from his experiments that a strip of skin 3 millimeters long and 10 millimeters broad was able to support a maximum weight of 12 kilograms (26½ pounds). The solidity was also in direct ratio to the thickness of the piece of skin used in the experiment. As mentioned, the elasticity is very perfect, but slight; a considerable amount of stretching may result from the application of a small weight, and complete rectification takes place after its removal. The skin is not of uniform texture, but consists of bundles of connective-tissue fibers arranged like a net, between which are spaces of various sizes which are rhombic in shape. In these spaces there is found a cementing substance, and it is due to it and the enormous network of elastic fibers that the former are able to regain their natural shape after having been stretched.

Cleavage.—The cleavage lines of the skin were demonstrated by Langer. He pierced the skin with small round awls in multiple places, and, after removal of the instruments, observed that the wounds which were made were linear. He then made series of them in rows and close together, and from uniformity in the direction of the long axes of a more or less greater number of them, he concluded that the skin possessed complete linear cleavage over the greater part of the surface of the body. In some places, as on the forehead, on many points on the scalp, etc., the wound made was a triangular one, and this occurred where two spaces met which possessed linear cleavage in opposite directions. The explanation of the fact that the skin is, to a great extent, cleavable linearly, is to be found in the arrangement of the spaces between the bundles of fibers.

Tension.—Except upon the scalp, the palms of the hands, and the soles of the feet, the skin is more or less in a state of tension. Where the skin possesses linear cleavage, the tension is in the direction of these lines; but where this condition does not exist, it occurs uniformly in every direction in the plane of the surface. The tension likewise depends upon the movements of the joints and muscles, the amount of fat deposited in the subcutaneous tissue, and also upon morbid conditions, such as edema, or upon the existence of pregnancy. In this latter condition the degree of tension may be so great that a permanent change may result in the direction in which the fibrous bundles run.

Color.—The color of the skin differs according to the individual, the race, and the age, and it also varies upon different portions of the body. It cannot be ascribed in certain races to climatic influences alone, since in the same zones people of different color are found, as in Africa, negroes, and in a corresponding portion of America, the much lighter colored Indians. The difference in color depends upon the amount of pigment present in the rete Malpighii, where, under the form of granules, it is found especially in its lower layer or stratum basale. In the white race the color changes, within certain limits, in the various seasons of the year. When the skin is exposed to the sun in summer, there is an increase in pigment deposit, but this disappears in winter.

Under certain physiological conditions, such as pregnancy, there is likewise an increase in the amount of pigment in particular portions of the skin—the areola around the nipple, the linea alba, etc. A large portion of this increase often disappears after the birth of the child, but a considerable amount usually remains. In the male the scrotum and penis, and in the female the vulva, are of a darker color than the rest of the skin. The pink or red color seen on certain portions of the body, as the cheeks, or induced by certain temporary causes, as those which produce flushing, is due to the blood in the vessels of the cutis. When venous congestion is present the color is more or less of a bluish tinge. In old age the skin acquires a more or less yellow color, due to the atrophic changes that take place in it, and also to the lesser amount of blood supplied to it.

The Folds and the Furrows of the Skin.—Many furrows are seen on the skin. Some are long and deep, others are short and shallow. The former are present to a great extent from birth, and are seen running in a transverse direction across the extensor and flexor surfaces of joints. The latter are represented by the wrinkles on the face which develop with age. These latter are due partly to the diminished elasticity and turgescence of the skin, but they are induced more

often by muscular contraction and stretching of the cutis.

The folds seen in very emaciated persons are brought about by the loss of fat and the consequent change in the arrangement of the fibrous structure of the skin. Coarser furrows are also seen on the palms of the hands and on the soles of the feet. These furrows are permanent, being caused by the firm union of the skin to the tissues below by means of short bundles of connective-tissue fibers. Dimples, where they occur, are due to the same cause; that is, the skin is at these points attached to the underlying tissues and does not move together with the rest of the skin of which it forms a portion.

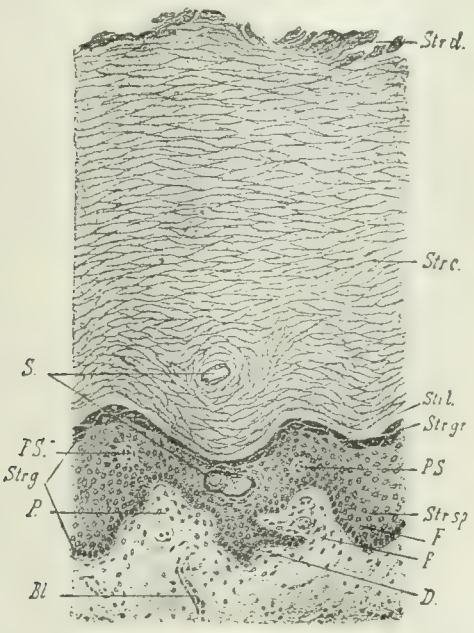


Fig. 4510.—Section of the Skin (Epidermis and the Papillary Portion of the Corium) on the Sole of an Adult Foot. Magnified 90 diameters. (After Rabl.) *Str.d*, Stratum disjunctum; *Str.c*, stratum corneum; *Str.l.*, stratum lucidum; *Str.gr.*, stratum granulosum; *Str.g.*, stratum germinativum; *Str.sp.*, stratum spinosum; *F*, fold of epithelium; *D*, glandular ridges; *S*, outlet channel of a sweat gland; *P*, papillæ; *Bl*, blood-vessel.

Structure.—The integument is composed of several layers. The most external of these consists of epithelium and is termed the epidermis. It clothes the outer surface of the corium, the line of division between the two being very sharply defined. The corium is a closely knit tissue, consisting of connective tissue, elastic fibers, and unstriped muscle. It contains the glands of the skin and the hair, and is rich in blood-vessels and in nerves. It is not sharply limited on its under surface, but goes over here gradually into the subcutaneous or fatty layer of the skin. This layer, the panniculus adiposus, is in reality the deeper portion of the cutis, and consists of connective-tissue fibers loosely put together, which contain in their cells and in the spaces between them a more or less large amount of fat.

Epidermis.—*Embryology.*—The epidermis, the most external layer of the skin, is formed from the ectoderm, and in the first month of life and the beginning of the second consists of only a single, or in its thicker portions of two or three rows of polygonal cells. Below these is a layer of very small cells, which represent the origin of the stratum mucosum or rete Malpighii. This increases, in the course of development, to several rows of cells, the layer becoming more and more distinct and thicker. In the meantime the outermost cells have also become flatter, and represent the primitive horny layer, which, however, remains during fetal life of a low grade. It is subjected to constant desquamation, and the scales from its surface are mixed with the secretions from the skin to form the vernix caseosa. As early as the eighth month (Unna), granular cells begin to appear between the horny and mucous layers, and the cornification of the epidermis cells becomes more marked. Nevertheless, and before this, the horny layer has become strong enough to oppose sufficient force to the epithelial growth and to the proliferation of its cells, so that the increase in thickness of the rete Malpighii can no longer take place in the direction of the external surface, but is compelled to proceed downward toward the cutis propria. It penetrates, in its further development, into the spaces between the rudimentary papillæ, springing from the surface of the cutis, and thus forms the interpapillary prolongations of the epidermis. It is by virtue of these ingrowths of the epidermis that, when fully formed, it lies upon the derma as an accurately fitting coat, which follows closely the outlines and inequalities of the true skin.

Thickness of the Epidermis.—The thickness of the epidermis, as a whole, varies from birth to old age, on different parts of the body, and is also influenced by external causes, as pressure, rubbing, etc. At birth it is from 0.15 millimeters to 0.25 millimeters in thickness, but in adult life from 0.75 millimeters to 1.66 millimeters. The differences are due, for the most part, to the thickness of the horny layer, which in some situations, as on the palms and soles, or on any surface subjected to constant pressure, may be very considerably increased.

Layers of the Epidermis.—The epidermis is divided into two major layers. The most external one, consisting of horny cells, is firm and resistant, and termed the stratum corneum, while the one immediately below it, lying in contact with the derma, is called the stratum mucosum, or rete Malpighii. This consists of soft epithelial cells. Each of these layers is still further subdivided according to the appearance of its cells, or to their staining reactions.

Stratum Mucosum.—The most deeply situated cells of the stratum mucosum, in immediate contact with the derma, are cylindrical in shape and form the basic layer or stratum basale. These cells represent the productive part of the stratum mucosum. In normal skin they are the only cells which show the caryokinetic figures occurring in epithelial growths. Their long axes are directed perpendicularly to the corium, and if the layer is carefully examined, small basic cells, resulting from the cell division, are seen pushing their way in between the older ones.

The cylindrical cells send out into the corium more or less long prolongations, but the spines, which characterize the entire rete (Malpighii), are seen clearly only upon their upper contours. It is in these cells, that pigment granules are deposited, which give the various shades of color to the skin of different individuals and races.

Above the basic layer, cells of various shapes and sizes are found. Over the papillæ, and in the interpapillary portions of the rete, round and cuboid and polygonal cells are seen. In the interpapillary prolongations, however, round cells predominate. As the external surface is approached the cells become larger, and have their long axes more parallel to the surface of the skin. The cells themselves have a body consisting of finely granulated protoplasm, which contains a clearly defined nucleus, in which are several nucleoli. According to the position of the cells in the rete, the shape of the nucleus varies. In the uppermost portions it is oval, in the middle, round, and in the cylindrical layer, rod-like, thus agreeing more or less accurately with the shape of the cell. The varying forms of these cells are due in general to the degree

of mechanical pressure to which they are subjected by the individual growth of each, and by other causes. The cells do not lie in close contact with each other, but are held in apposition by protoplasmic prolongations from their surfaces, which are continuous with the protoplasm of the cell body. These have been termed spines. It is due to this characteristic that the entire layer has been named the stratum spinosum.

The spines, which characterize these epithelial cells, were first observed by Schrön, and the function of binding the cells together has been attributed to them. The manner in which this occurs has, however, always been a subject of controversy. These spines can be studied best in rapidly proliferating growths of the rete, as in condylomata acuminata. Whether the spines are active or passive in their nature is likewise a disputed point. But, as Unna has pointed out, they are in all probability the result of active protoplasmic movement, since they are purely prolongations of the cell body and consist of the same protoplasm.

Intercellular Spaces.—The arrangement of these spines is such that small spaces are left between them. These, the intercellular spaces of the stratum mucosum, are of great importance, inasmuch as they serve as channels for the passage of the nutrient fluids from the corium to the epithelium. The wandering cells coming from the vessels of the cutis and seen in the rete are also enabled to wander along by means of these spaces, and they are the source of the pigment sometimes seen in these situations.

Stratum Granulosum.—Situated above the stratum spinosum, but in close contact with it, is a layer of cells consisting of one or two rows upon whose surface shortened spines may still be seen. The cells also contain granules of various sizes and shapes; it is owing to the presence of these that the layer has received the name of stratum granulosum. These granules react toward certain coloring substances in a marked manner, and stain very deeply. Unna, who has studied this layer very carefully, states that it makes its appearance in the epidermis toward the end of fetal life, but that it can be seen much earlier in the inner root sheath of the embryonic hair.

The stratum granulosum is present over the entire skin, except on the vermilion border of the lips and in the nail bed. The granules appear white by direct light, and for this reason Unna asserts that they are the cause of the white color of the Caucasian race. Such an explanation is, however, scarcely a reasonable one, owing to the fact that this same stratum granulosum is present in the skin of the negro as well as in that of the other dark races. The granules have been the subject of much discussion, but Waldeyer has furnished the most satisfactory and correct information in regard to them. He found that they agreed chemically very closely with the hyalin of Recklinghausen, a product of degeneration, and for this reason he suggested the name of keratohyalin for the substance. Keratohyalin, according to Unna, is found to a small extent around the nucleus of the cells in the middle portion of the stratum spinosum, but it exists to a considerable extent only in the stratum granulosum. The granules here are small, and though the cells are filled with them, yet a small peripheral zone always remains free from encroachment. The cells in this layer have atrophied nuclei, which, however, still stain well, and the intercellular spaces are narrowed to such an extent as to be almost entirely absent. The significance of keratohyalin and its relation to the process of cornification have received much attention. The general opinion at present is in favor of regarding these granules, not as the cause of the cornification of the rete cells, but as a phenomenon accompanying that process, and as one which is produced by the act of cornification taking place in the periphery of the cells.

Stratum Corneum.—The outer layer of the epidermis lying above the stratum granulosum is the stratum corneum. It varies greatly in thickness on different portions of the body, being usually most marked on the palms of the hands and on the soles of the feet, and also being always much increased on any portion of the skin which is subjected to constant pressure. Its lowest portion, that which is next to the stratum granulosum, possesses great transparency. This stratum is narrow, sharply defined, and is known as the *stratum lucidum* of Oehl, but its existence has never been satisfactorily explained. The cells forming the stratum corneum are clear and transparent, showing neither granules nor nuclei. Unna claims to have found traces of the spines seen on the cells of the stratum spinosum even here, and asserts that the coherence of the cells forming the horny layer is due to their persistence. By means of artificial digestion with pepsin and trypsin, it has also been found that the entire cell does not become cornified, but only the peripheral portions. After employment of this method it is clearly seen that it is the contents of the cells which are destroyed, while the peripheral portions remain and have the appearance of horny shells.

The several layers which have just been described as entering into the formation of the epidermis should be carefully considered in the study of the anatomy of the skin. It is from the epidermis that the appendages of the skin—the hair, the nails, and the glands, originate.

The Corium, Derma, or Cutis Propria.—*Embryology.*—The corium, or true skin, is that portion which lies between the epidermis and the subcutaneous or fatty layer. It is derived from a superficial portion of the mesoderm, consisting at first of only round cells. In the second month of fetal life, however, spindle-shaped cells begin to appear, but only very little intercellular substance is present. Very shortly after this, it is noticed that the cells in the upper portion of this primitive corium become more closely aggregated together than in the lower portion, and at the same time the formation of fibrillated tissue begins in this latter. The fibers increase greatly in number, and by the fourth month the presence of fat is detected. It is in this way that the subcutaneous or fatty layer is developed, and it is to be considered, in reality, a part of the derma, since it has the same embryological source, and not a separate and distinct layer of the skin. The transformations which take place among the closely aggregated cells in the upper portion are shown by the penetration of fibers between them and by the deposition of collagenous material. The individual cells are thereby more and more widely separated from each other, and the corium attains a considerable degree of thickness. Gradually blood-vessels and nerves pass into it, and upon its superficial surface the papillæ begin to form. These latter appear about the sixth month of fetal life as small eminences upon the surface of the cutis. They are formed by the growth of the epidermis, which pushes before it the weaker and more yielding portions of the cutis. They are first seen on the palms of the hands and the soles of the feet, but are quite general toward the end of fetal life. The development of the papillæ is not fully completed until after birth.

Divisions of the Cutis.—The major part of the cutis consists of fibrous connective tissue, poor in cells, which is arranged in the form of bundles. The texture of the cutis is closely knit in that portion which is next to the epidermis, but is much looser in the parts below this. In this situation, the fiber bundles crossing each other form the rhombic spaces, which have been mentioned as the cause of the linear cleavage of the skin. On account of the difference in the texture of the cutis, it has been divided into two layers: the one in immediate contact with the epidermis being termed the pars papillaris, that below it, the pars reticularis.

Pars Reticularis.—The pars reticularis of the corium

is composed of bundles of fibers of various sizes and lengths. They are continuous with the connective tissue of the inner portions of the body—the fasciæ, etc.—and pass upward perpendicularly, or slightly inclined to the surface of the skin, until they arrive at the cutis. Here they run obliquely, crossing each other at various angles, and serve as boundaries for spaces which are formed by their intersection. These spaces are, in general, rhomboidal in shape, but oftentimes polygonal, their regularity depending upon the length and uniformity of course of the fiber bundles forming them. The length of the fiber bundles and the absence of their firm adhesion to the underlying tissues are very important factors. It is owing to such an arrangement that the skin is freely movable over the greater portion of the body. On the scalp, the palms of the hands, and the soles of the feet, where these bundles of fibers are short and intimately united to the underlying fascia, the skin is only very slightly movable.

The bundles under normal conditions are in a state of tension, and are for the most part straight, but under the microscope they are found presenting a wavy appearance. They consist to a great extent of collagenous material. The fibers themselves are bound together in bundles by an albuminous semi-fluid cementing substance, which Rollet has found to be similar to mucin. According to Fleming, this cementing substance not only exists between the fibers, but also surrounds the bundles, and Tomsa claims that it binds together all the constituents of the cutis.

The fibers possess cells, but they are numerous only in the vicinity of the large blood-vessels. These cells are the usual connective-tissue cells; they are large and contain nuclei and nucleoli. They lie upon the bundles in the same manner as endothelial cells and for this reason have been regarded as forming an endothelial lining for the rhombic spaces between the bundles. It has, however, been demonstrated that they differ from the cells of endothelium in that their edges do not lie in contact with each other, and they do not form a continuous covering for the bundles (Ranvier).

Elastic Tissue.—Elastic fibers are exceedingly abundant in the reticular portion of the cutis. They spring from the fascia below the skin, and, passing up between the fat masses, penetrate into the cutis. In their course they divide continually in a more or less forked manner. These bundles may be traced upward to just below the epidermis. The muscles of the cutis also serve as points of origin for bundles of elastic fibers, and Unna claims that they can be seen attached to the muscles at their points of origin and insertion, having a tendon-like appearance.

Another relatively fixed point of the elastic basework of the cutis is seen in an extensive network of fibers, which follows with the greatest regularity the outline of the epidermis, where this latter is in contact with the corium. This network, which Unna terms the subepithelial elastic net, is situated just below the surface of the cutis, being separated from the epidermis by a narrow homogeneous strip of the derma, in which there are very few blood-vessels. From this network fine fibers are given off, which proceed upward perpendicularly and are lost sight of between the basic epithelial cells of the epidermis.

There is, also, in the papillary portion of the skin, an extensive network of elastic fibers. It is formed by the repeated division of fibers which originate from the subepithelial network. All of these elastic fibers do not exist independently of the rest of the cutis, but are more or less closely connected with the fiber bundles of connective tissue which have already been treated of.

The elastic fibers are found to be entirely absent around the coils of the sweat glands, but quite abundant about the ducts, along which they run in a parallel direction. Unna concludes from this that the contraction of the elastic network of the skin, acting with the fiber bundles with which it is in close union, produces a pressure on the ducts, and shortens them by diminishing the thickness of the skin. In this way the passage of the secretion of the glands through the the ducts is favored.

Unstriped Muscle.—With the exception of the palms of the hands and the soles of the feet, the skin of the entire body contains a more or less large number of unstriped muscular fibers and bundles. They are found to attain their highest development in the skin of the scrotum, in the penis, and in the nipple and its areola. The vermicular movements of the scrotum are due to these involuntary muscles, as is also the erection of the nipple. They are situated in the cutis propria, and lie perpendicular to the plane of cleavage of the skin. On the penis they are arranged in a circular manner, and they follow a similar course in the nipple and in its areola.

Besides these, there are other muscles in the cutis which, owing to the connection existing between them and the hairs, are termed the arrectores pili. They are formed by the union of several small muscular bundles, which, originating in the pars papillaris, run an oblique course through the reticular portion of the cutis, and are attached to the hair follicle. The point of their attachment is not uniform—sometimes to the middle portion of the hair sheath, sometimes low down in the lower third. It will usually be observed that in their course to their point of attachment, they curve around the sebaceous gland attached to the hair follicle and are in quite intimate connection with it. According to Tomsa, the fixed point of the arrector muscles is the hair follicle, while the point of movement is the pars papillaris of the cutis.

The arrangement of the involuntary muscular fibers in many places in the derma, as in the cutis of the forehead, cheeks, back, is in the form of a network. This net originates in the pars papillaris and is distributed throughout the upper two-thirds of the pars reticularis. By the action of these muscles the skin is kept more or less in a condition of tension. According to the direction in which they exert their action, the muscles have been divided into horizontal and oblique tensors. The elastic bundles and fibers connected with the muscles play here an important part, inasmuch as Tomsa has shown that they stand in the same relationship to them as do the tendons to the voluntary muscles, and serve as fixed points from which the contraction of the cutis tensors takes place. The action of these muscles also regulates to a great extent the circulation of the lymph in the cutis, while the contraction of the arrectores elevates the hair, compresses the sebaceous glands, and facilitates the propulsion of their secretion into the hair follicle.

Pars Papillaris.—The papillary portion of the true skin is constituted by a series of small eminences or papillæ, which spring from its upper or free surface. It is in direct contact with the epidermis, which, as has already been described, sends down prolongations of epithelial cells between the papillæ.

The papillæ of the skin are found most fully developed on the palms of the hands and on the soles of the feet. They are arranged here in long double rows, which form the curvilinear ridges seen in these situations. Between these rows there is a narrow path in which are the external orifices of the sweat ducts. On other portions of the body the papillæ are arranged more or less in groups or in short rows, and the surface of the cutis seems to be divided into rhomboidal spaces of various sizes by the deeper penetration of the interpapillary prolongations of the epidermis. The long diameters of these spaces agree with the line of cleavage of the portion of the skin where they are situated, and their shape is dependent upon the arrangement of the connective-tissue bundles in the reticular portion of the cutis.

The papillæ are more or less conical in shape, sometimes single, or again cleft into two or more points,

forming compound papillæ. They differ greatly in shape, size, and distribution on the various portions of the body, and also vary according to the age of the person (Unna), becoming in old age almost flat. They are very numerous on the penis, the nipple, the labia minora, and the clitoris, appearing in these places as low hills. The largest papillæ are found in the cutis of the nipple and of the corona glandis. Those distributed generally over the surface of the body are very small, about 0.05 millimeter in height. On the ends of the fingers, under the free borders of the nail, they attain a size of 0.5 millimeter; but their height varies in general between 0.05 millimeter and 0.2 millimeter.

The papillary portion of the cutis consists of a closely woven network of fibers, which are derived directly from those forming the pars reticularis. The papillæ are very rich in elastic fibers, and contain blood-vessels, lymphatics, nerves, and, in certain situations, tactile corpuscles. The manner in which the papillary body and the epidermis are joined together must be studied on specimens which have been macerated, and from which the epidermis has been removed *in toto*. When this has been done, it is seen that the entire surface of a papilla has a finely ribbed aspect. On sections made horizontally through them, they look as though their contour was toothed. The ribs have a slightly wavy course and are at times arranged in a concentric manner, having much the same appearance as may be observed on the palmar surfaces of the ends of the fingers. These ribs on the papillæ have been found to correspond to minute furrows on the cells forming the basic or cylindrical epithelial layer of the epidermis and to fit into them, each cell requiring usually three or four ribs. From the fibrillated appearance it might be thought that these ribs were connective-tissue fibers, but such has been found not to be the case. They consist in reality of a transparent homogeneous substance, which covers thinly the surface of the papillæ. The proof that it is a distinct membrane has never been satisfactorily made, and it seems better to accept Unna's view, that it stands in intimate connection with the cementing substance of the cutis in general, since it has been found that, when the cutis is subjected to the action of trypsin, this homogeneous substance covering the papillæ disappears in the same way as the cementing substance in other portions of the derma.

Subcutaneous Connective Tissue or Fatty Layer.—It was mentioned, in speaking of the embryological origin of the skin as a whole, that the subcutaneous or fatty tissue was derived from the mesoderm. It is that portion which attains its full development the earliest of all the layers of the skin, and in which the deposition of fat between the fibers constituting it takes place very early in fetal life. The subcutaneous connective tissue, or panniculus adiposus, though in reality the lower portion of the corium, is regarded as forming the third layer of the skin, and it is characterized by the presence of a greater or less amount of fat included within its meshes.

It is composed of bundles of connective-tissue fibers, a network of elastic fibers, and fat, and is rich in large cells. These have long poles and are situated either in or between the fiber bundles, occurring in the form of spindle-shaped cells. At the time of birth the panniculus adiposus is very greatly and uniformly developed over the entire body. As the child grows, however, it diminishes in quantity and remains of considerable extent only on certain portions. Its function is protection to the underlying tissues, and it serves to give roundness to the outline of the body. Those portions of the body which are firmly bound down to the fascia by short bundles of fibers, as the scalp, the skin of the palms and of the soles, etc., possess only a small fatty layer. Where great mobility is necessary, as in the eyelids, or where there is a great amount of muscular tissue, as in the scrotum, the panniculus adiposus is also absent. Over the joints, where the skin lies in close contact with the bones, and by their movements is continually subjected to pressure and tension, bursæ develop in the subcutaneous tissue after birth. In this layer the large arterial and nerve trunks going to the cutis are found, and also the veins and lymphatics which come from the derma and unite to form large efferent branches. In certain localities the Pacinian bodies are also present.

Glands.—There are two sets of glands which are found in the skin, the sweat glands and the sebaceous glands.

Sweat Glands.—*Embryology.*—The primary evidences of the development of these glands of the skin are seen in the fifth month of fetal life. They appear first on the palms and on the soles, under the form of rows of epithelial prolongations from the inferior border of the epidermis into the cutis. At this stage they are solid, club-shaped, and surrounded by a homogeneous membrane. Their further development consists in the elongation of these epithelial ingrowths downward, and in the formation, by the seventh month, of a cavity along the axis, which is later further extended through the epidermis to the external surface. In the meantime, the gland tube at the end in the cutis has become coiled up, forming a ball, and the excretory duct in its course through the skin is twisted upon itself. The development of these glands is very rapid, and by the end of fetal life they have already attained their full development. In certain situations, however, they enlarge even after birth, and in their structure differ somewhat from the ordinary and smaller ones distributed generally over the body. These larger glands are found in the axillæ, the inguinal regions, around the anus, the nipple, and in the auditory canal (ceruminous glands).

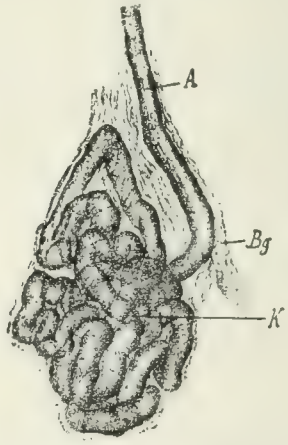


Fig. 4511.—Terminal Coil of a Sweat Gland, from the Skin of the Back of the Foot. Magnified 80 diameters. (After Mracek.) *K*, Terminal coil; *Bg*, enveloping connective tissue; *A*, outlet of the gland.

The sweat glands are present everywhere in the integument of the body, with the exception of the glans penis, the undersurface of the prepuce, and the vermilion border of the lip. They are small bodies, consisting of a convoluted tube and an efferent duct which leads to the external surface, and they are situated in the corium or even in the subcutaneous connective tissue. They vary greatly in size. The coils of the large ones situated in the axilla are from 1 millimeter to 2 millimeters in diameter; the smaller ones on the general surface are from 0.2 millimeter to 0.3 millimeter. They are most numerous on the palms of

the hands, Krause estimating that there were 2,800 orifices in a square inch on those surfaces.

The sweat glands, as a whole, are composed of two distinct portions, a secretory and an excretory. The former is represented by the coils, the latter by the duct which leads to the external surface of the skin. The histological anatomy of the smaller glands differs somewhat from that of the larger ones, and will be considered first.

Histological Anatomy.—The coils, or secretory portions of the sweat glands, consist of a single layer of columnar epithelium, arranged around a rather irregularly shaped lumen. The cells are cloudy throughout, with the exception of a narrow portion along their free margin, which is clear. They are bounded externally by a layer of involuntary muscular fibers, which run spirally around the mass of cells, and which are so arranged that small spaces are left between them.

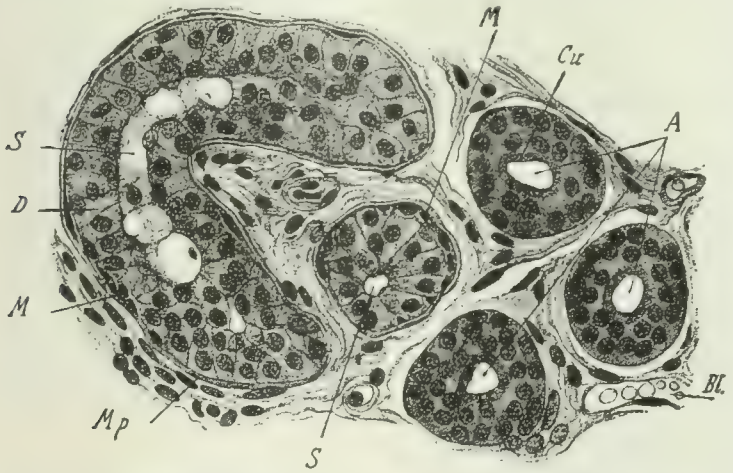


FIG. 4512.—Portion of a Sweat Gland from the Skin of the Back of the Foot. Magnified 400 diameters. (After Rabl.) *S*, Secreting portion of the coil; *D*, gland cells; *M*, smooth muscle fibers; *Mp*, membrana propria of the glandular tube; *A*, cross sections of the outlet portion of the gland; *Cu*, cuticula of the same; *Bl*, blood-vessel. Specimen hardened in a saturated aqueous solution of bichloride of mercury, and stained with hematoxylin and eosin.

The secreting cells send out processes into those spaces, and these form a union with the limiting membrane or membrana propria of the glands, which is composed of connective tissue. The excretory portion of the gland, or duct, consists of a connective-tissue coat, a structureless membrane, and bounding its lumen are two rows of epithelial cells, the free margins of which are covered by a cuticula. There are no muscle fibers in the coats of the sweat ducts. These latter begin in the inner portion of the coils, and rise to the surface in an oblique direction having a more or less spiral course, and they always reach the epidermis at an interpapillary prolongation. The duct here loses its membrana externa, which goes over into the tissue of the papilla, and also its cuticula, so that the lumen is bounded for a short distance in the stratum spinosum by the spiny cells alone. The cells which limit the lumen in its course through the epidermis, show granules of keratohyalin very early, and considerably below the level of the stratum granulosum; and it can further be seen that all the layers of the epidermis became interested and aid in forming the boundaries of this spiral canal in its course to the external surface.

The histological anatomy of the larger sweat glands, as has been already mentioned, differs somewhat from that of those just described. The differences are shown both in the coils and in the duct, by a dilatation and a narrowing of the canal in places. Where the lumen is larger there is only a single layer of epithelial cells; but in the narrower portions there are several. It is also claimed that muscle fibers are present in the former situations, but they are always absent from the latter.

SEBACEOUS GLANDS.—*Embryology.*—The sebaceous glands of the skin make their appearance from the beginning of the fourth to the fifth month of pregnancy (Gegenbauer). Those glands which open directly upon the external surface of the skin, are formed from ingrowths of the rete Malpighii, which penetrate into the cutis. These epithelial prolongations are at first solid, but a canal soon forms in them by the fatty degeneration of the central cells. In its further development it is found that, by a process of cell proliferation, solid buds are given off from the original epithelial ingrowths, canals form in the axes of these, and the gland, finally consisting of several lobules, has become racemose. The origin of the sebaceous glands attached to the hairs is the same, except that the epithelial ingrowths proceed from the external root sheath of the hair. They appear very soon after the formation of the hair follicle by the prolongation of the rete into the cutis.

Distribution and Size.—The sebaceous glands are distributed very generally over the body, and are found everywhere in the skin, except upon the palms of the hands, the soles of the feet, and the last phalanges of the fingers and of the toes. They are particularly numerous upon the face and the scalp, where they are set very closely together. On the rest of the body they are found to be fewer in number and more widely separated. The glands vary very greatly in size. Of those connected with the hairs, the smallest are the ones on the scalp, 0.1 millimeter to 0.16 millimeter in diameter, but larger ones are attached to the hairs of the beard and axilla, from 0.16 millimeter to 0.24 millimeter; but the largest are on the mons veneris, the labia majora, and the scrotum. The sebaceous glands which are in connection with the lanugo hairs are from 0.25 millimeter to 1 millimeter in diameter. The length of the glands is from 40 to 160 μ, but the large ones on the nose measure even as much as 1 millimeter.

In shape there is also considerable variation. The simplest ones resemble small pouches, but the glands are usually found to be racemose or acinous, that is, composed of several lobules which possess one duct in common.

These glandular bodies are situated for the most part in the upper portion of the corium, above the level of the coils of the sweat glands. Some extend, however, through almost the entire thickness of the cutis.

They are found either directly attached to the hair follicles, into which their ducts open, at a variable distance from the orifice on the cutaneous surface, and empty the fatty matter secreted by them; or the external opening of their ducts is situated on the surface of the skin. These latter are the glands with which the lanugo hairs are associated. Besides these two forms, there are others which are entirely unconnected with hairs, and which also open directly upon the outer surface of the skin.

The sebaceous glands which open into the cavity of the hair follicles are the most numerous. They are seen wherever fully developed hairs exist, as on the scalp, the beard, etc. There is sometimes only one gland, but more often there are two, situated on opposite sides of the follicle, of different sizes, and at

different heights. Their excretory ducts are short and pass obliquely upward to enter the follicles, the larger glands opening more superficially, the smaller ones more deeply, but the common location is at the junction of the upper and middle thirds.

The sebaceous glands which are associated with the lanugo hairs, and which open directly upon the external surfaces, are distributed over the forehead, cheeks, sides of the nose, and areola especially. They occur also more or less scattered over the trunk, the extremities, and the genitals. These glands are the largest, and also the most complicated in their structure. The duct is usually broad, and its orifice dilated. The hair attached to it is really an appendage, and passes through the duct to reach the outer surface of the skin. It has no follicle of its own, except at its deepest portion.

The glands which are in no way associated with hairs, and which open directly upon the external surface, are situated in special localities. They have received distinguishing names, and are known as the Meibomian glands in the eyelids, and the glands of Tyson on the glans penis and prepuce. To this class also belong the large glands of the labia minora, and those of the vermilion border of the lip.

Histological Anatomy.—A sebaceous gland may be considered to be composed of an outer wall and an inner mass of cells. The wall is formed of connective tissue, which is derived from the external sheath of the hair follicles; but in those glands which are associated with the rudimentary or lanugo hairs, and in those unconnected in any way with hairs, the fibrous envelope is obtained from the corium. The wall acts as a support for a basement membrane, or membrana propria, which bears upon its inner surface a layer of cylindrical epithelial cells, and it also contains the nerves, blood-vessels, and lymphatics supplied to the glands. The membrana propria is exceedingly thin and amorphous. The single row of cells which are in connection with it is a continuation of the basic layer of the epidermis, the spiny cells stopping at the neck of the glands. The cavity of the glands is filled with large oval and polyhedral cells having large nuclei, but in the central portions there is a semi-fluid homogeneous mass, the sebum. The source of the sebum seen in the sebaceous glands are the cells, which are found presenting all stages of fatty degeneration. The most external ones are granular, the succeeding ones contain small drops of fat, which gradually increase in size as the central portion of the cavity is reached, until there is no trace of protoplasm remaining, the cell being completely filled with fat.

Blood-vessels.—The vessels which supply the skin with blood are branches from the larger arteries which lie below the subcutaneous fatty tissue. They pass up through this latter and form at its junction with the corium a more or less horizontal network. From this network further branches are given off, some to supply certain portions of the skin, others to ascend obliquely and perpendicularly through the cutis, having only few branches, until they reach the subpapillary layer of the corium. Here they again form a more or less horizontal network, which also gives off many branches.

The plexus of arteries at the junction of the cutis and subcutaneous tissue is very rich. It supplies the papillæ of the hair, the coils of the sweat glands, and also sends off branches which break up into capillaries in the panniculus adiposus. The subpapillary network of arteries supplies vessels to the external root sheath of the hair, the sebaceous glands, the unstriped muscles, and the ducts of the sweat glands. In addition, this plexus gives off branches which break up into capillaries just below the papillæ, and into each of these a tortuous arterial capillary ascends almost to its upper end, where it forms a loop and goes over into a venous capillary. These latter unite to form venules in the same plane as the arteries, and course along them. When they arrive at the subcutaneous layer they, together with the veins from the

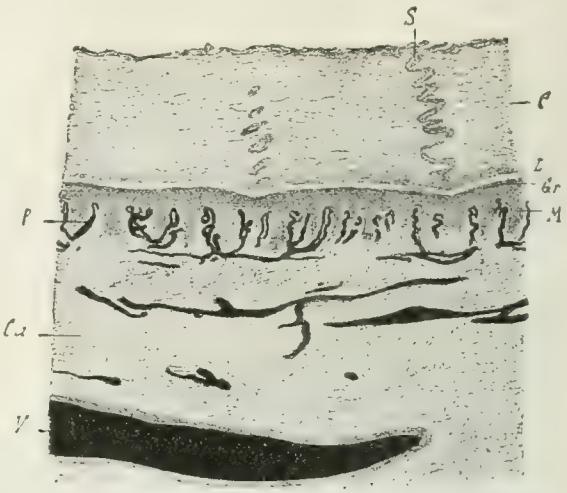


Fig. 4513.—Section of the Skin of the Palm of the Hand. The cutting was done in a direction parallel to the ridges. The blood-vessels have been filled with gelatin colored by carmine. Magnified 50 diameters. (After Rabl.) *C*, Stratum corneum; *L*, stratum lucidum; *Gr*, stratum granulosum; *M*, stratum Malpighii; *P*, papillæ; *Cu*, corium; *V*, vein at the lower border of the corium; *S*, orifice of a sweat gland. Portions of the cutaneous plexus of blood-vessels and of the capillaries belonging to the papillæ are also shown in the picture.

other portions of the cutis, unite to form large venous trunks in the same plane as the large arteries. Between the two horizontal plexuses of arteries there is a

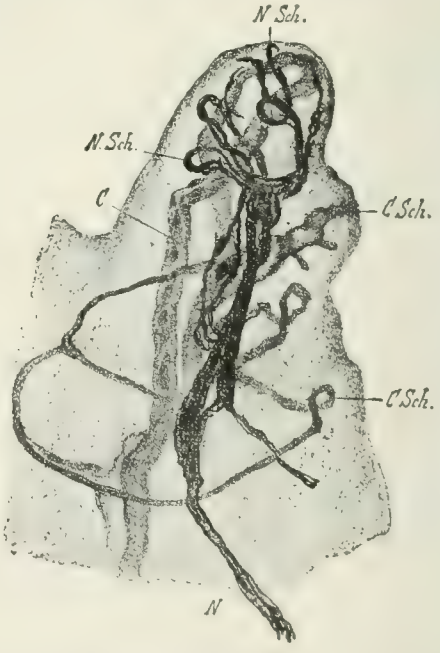


Fig. 4514.—Papilla from the Skin of the Tip of the Finger, showing Capillary Blood-vessels and Numerous Nerve Fibrillæ. Gold preparation. (From Rabl, after Ruffini.) *N*, Nerve trunk; *C.Sch.*, capillary loop; *N.Sch.*, nerve filaments surrounding the capillaries. (Greatly enlarged.)

portion of the cutis which has a very poor blood supply, and here even the bundles of fibers which go to form the pars reticularis do not receive any vessels.

There are considerable differences in the distribution of the blood-vessels of the skin, and in the area supplied by any one branch. These areas are very small on the palms of the hands, the soles of the feet, and the face; also at the sulcus coronarius and the corona glandis, in which places each branch from the subpapillary arterial plexus, when it breaks up into capillaries, supplies only a few papillæ. The areas which are furnished with blood by one arterial branch are much larger in the greater part of the skin—the vessels breaking up into a number of capillaries—and it is in general observed that they are more extensive on the extensor than on the flexor surfaces of the extremities.

Peculiar circulatory conditions are found in certain portions of the skin. On the ear, the alæ nasi, and in the region of the lips, large lacunæ are seen into which the venous capillaries empty from above, while from below the venules are given off. On the ends of the fingers there is likewise a special arrangement of the vessels. It has been found that here some branches of the digital arteries empty directly into the large veins of the bed of the nails, without there being any intervening capillaries. Also it is observed that, after the vessels for the panniculus adiposus and sweat glands have been given off, but before the upper horizontal plexus for the supply of the papillæ has been formed, small arterial branches divide and break up into many small coils. In the inner portion of these they empty directly into venules.

The lumen of the arteries of the skin is narrow, but that of the veins is large and wide. Their coats are slightly marked in the cutis, and they show only near the subcutaneous connective tissue an adventitia and a media. But even there these are poorly developed. All the vessels of the papillary layer of the corium are capillary in character, that is, simple endothelial tubes.

Lymphatics.—There are in the integument of the body two forms of channels which contain the lymphatic fluid, and through which it flows, viz., the lymphatic vessels proper, those which possess an endothelial lining, and the numerous spaces which occur between the elements composing the various layers of the skin.

In regard to the latter, it has been proved that they are the origin of the lymphatic system of the skin, by the successful injection of the intercellular spaces in the spiny layer of the rete Malpighii from the lymphatics of the subcutaneous connective tissue (Retzius, Axel Key, et alii). Other lymph spaces exist between the membrana propria and the secreting cells of the coils of the sweat glands, and between the epithelial cells of the sweat ducts. The intercellular spaces in the stratum spinosum of the hair follicles and in the sebaceous glands are also points of origin for the lymphatics. The bundles of unstriped muscle fibers and the coils of the sweat glands and the bundles of connective-tissue fibers forming the cutis are sheathed by lymph spaces, as are also the fat clusters. According to Klein, very fine channels proceeding from these lymph sheaths penetrate the latter and ramify between all the fat cells of which they are composed.

The papillæ are also extensively traversed by lymph spaces, which empty into the lymphatic vessels proper. These vessels are lined with endothelium, and begin in the upper third of the papilla by means of a cul-de-sac. They course downward in the form of a plexus through the cutis, and at its junction with the subcutaneous connective tissue unite to form a few large vessels, which, according to Heming, have a muscular coat.

Nerves.—The nerves which are supplied to the skin are derived from branches of the cerebrospinal system. They pass up through the subcutaneous connective tissue, in the same manner as the blood-vessels, from the larger trunks situated below. In the upper part of the panniculus adiposus the course of the nerves is a horizontal one, and they give off a large number of small branches for its innervation. They penetrate the cutis together with the arterial vessels, and accompany them more or less in their distribution. In their course they give off branches to supply the various constituent portions of the cutis. Those which supply the hair follicles pass to them in the neighborhood of the sebaceous glands, to which fibers are sent. They penetrate the hair sheath and are distributed between the cells of the root sheaths. The sweat glands and their ducts are also furnished with nerves. Unna claims to have seen nerve endings between the secretory epithelial cells of the coils.

The nerves form a rich plexus, just below the epidermis, which gives off a great number of branches. These break up into fine fibrillæ which terminate in the endothelium of the papillary blood-vessels, or in the connective tissue of the papillary body, or penetrate into the interepithelial spaces of the stratum spinosum. Longer branches from this plexus ascend into the papillæ, and in certain portions of the integument end in the tactile corpuscles.

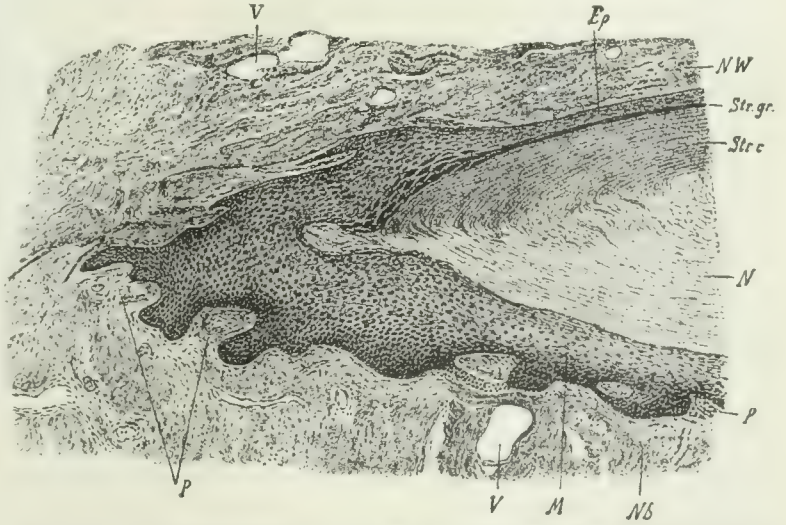


Fig. 4515.—Longitudinal Section of the Bed of the Nail, with the Posterior End of the Root. Magnified 80 diameters. (After Rabl.) *N. W.*, Wall of the nail; *Ep*, eponychium; *Str. gr.*, stratum granulosum; *Str. c*, stratum corneum; *N*, nail; *M*, matrix of the nail; *P*, papilla; *V*, vein of the corium beneath the matrix.

The nerve fibers which, it is claimed, have been traced between the cells of the epidermis are non-medullated. They are said to be distributed generally throughout the rete Malpighii, as far up as the stratum granulosum, and to end in the intercellular spaces, either tapering to a point or with a small rounded extremity.

Besides the above-mentioned ways in which the nerves end in the skin, there are special forms of termination. These are represented by the tactile corpuscles, the tactile discs of Ranvier, the Pacinian bodies, and the end bulbs of Krause. See article *End-organs, Nervous.*

The Nails.—*Embryology.*—The first steps in the development of the nails occur in the third month of fetal life, and consist in the marking out of the nail bed and furrow. This is covered by the ordinary stratum corneum of that period of life, and represents the eponychium of Unna. According to Kölliker, there appears in the fourth month, between the eponychium and the stratum mucosum, a layer of large, pale, horny plates, forming the primitive nail. The nail in its further growth increases in thickness quite rapidly, possesses a free border by the sixth month, and by the seventh month is fully formed.

General Characteristics.—The nails of human beings are elastic structures of a horny texture situated upon the dorsa of the last phalanges of the fingers and toes. Each is convex upon its external surface, concave upon its internal, and moulded upon the cutis, to which it is firmly adherent. The exposed portion of the nail is called the body; the anterior extremity, the free edge; the semilunar portion posteriorly, which is of a white opaque color, the lunula. The portion of the cutis upon which the nail is situated is the nail-bed. It is bounded laterally by two rolls of the skin, which are known as the walls of the nail. Around the nail-bed is a groove which is covered by the nail-wall, and in this lie the lateral edges of the nail, while the posterior portion, the nail-root, is implanted in a similar though much deeper groove; this latter represents the matrix, and it is from here that the growth of the nail takes place.

Histological Anatomy.—The bed of the nail consists of the corium and the stratum mucosum. The connective tissue bundles of the cutis run here partly longitudinally and parallel to the axis of the fingers, partly in a perpendicular direction from the periosteum to the external surface. The epithelium covering the corium is composed of cells identical with those in the stratum mucosum of the epidermis, and is sharply defined from the nail, except at the matrix.

The corium at the matrix of the nail shows a well-developed papillary body, and is very vascular, each papilla receiving a blood-vessel. In front of this and beneath the lunula the papillæ are very small, and still more so anteriorly; the cutis forming the nail bed has no papillæ but fine longitudinal ridges, in which run the blood-vessels, which give off capillary branches at regular intervals. These ridges of the corium are covered by the epithelial cells of the stratum mucosum, which also dips down between them.

The nail itself consists of horny lamellæ, which are closely bound together, and which are composed of cells similar to those of the epidermis, except that they contain nuclei.

In the formation of the nail the matrix plays the important part, and it is from this portion that regeneration of the nail is continually going on.

The Hairs.—*Embryology.*—The first steps in the development of the hairs occur at the end of the third or the beginning of the fourth month of fetal life. They are shown by the formation of small, solid prolongations of the rete Malpighii, penetrating into the cutis and increasing in length by the proliferation of the cells composing them. Arriving in the deeper portion of the cutis, the lower end of the prolongations is very soon surrounded by an aggregation of round and spindle cells, which partly form the papilla of the hair and partly grow around the epithelial ingrowth in order to form the sheath of the hair follicle (Unna). During this time changes also take place in the epithelial column. In its inner portion a conical-shaped mass of cells, with its apex directed externally, becomes differentiated from the remainder, and this represents the primitive hair body. From it the hair and its inner root sheath are formed. The primitive hair body having grown around the newly formed papilla, it increases in length upward and keratogenesis begins and proceeds from above downward. The external root sheath is constituted by the portions of the epithelial ingrowth of the rete Malpighii which remain after the differentiation of the primitive hair body and surround the entire hair.

From the sixth to the eighth month of life the fetus has become covered with hair, which, however, falls out and is replaced by new hair. This regeneration of the hair on the fetus is continuous as in adults, but

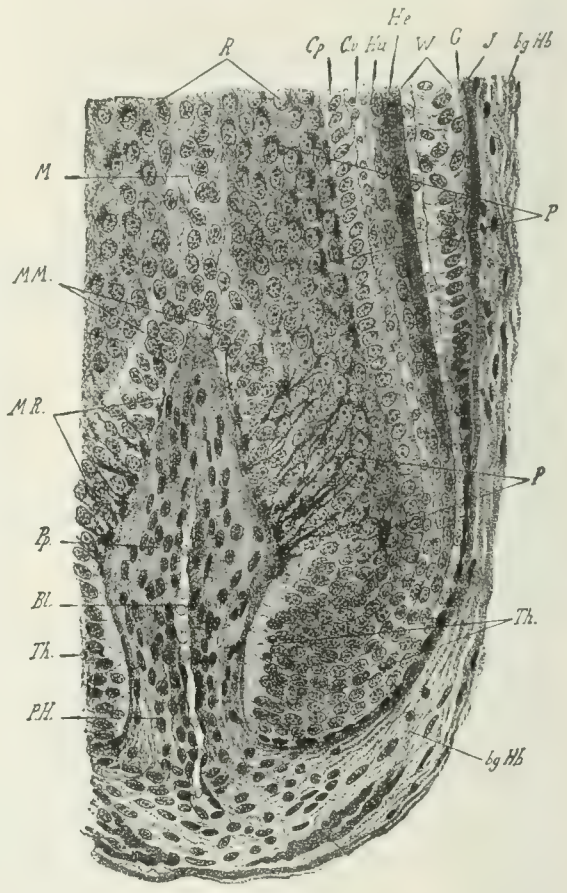


Fig. 4516.—Longitudinal Section of a Papilla, a Hair Bulb, and the Lowest Part of the Shaft of the Hair with its Sheaths, from the Scalp of an Adult. Magnified 300 diameters. (After Rabl.) *Pp.*, Papilla; *P.H.*, neck of the papilla; *Bl.*, blood-vessel; *M*, cells of the medulla of the hair; *R*, cortical cells; *MM.*, matrix cells of the medulla; *MR.*, matrix cells of the cortex; *Th.*, cells undergoing karyokinesis; *P*, pigment; *Cp*, membranous envelope of the hair; *Cv.*, membranous envelope of the root sheath; *Hu*, Huxley's layer; *He*, Henle's layer; *W*, outer root sheath; *G*, vitreous membrane; *J*, innermost layers of the connective-tissue hair follicle (*bg Hb.*).

the rapidity of the change ceases a few weeks after birth. The embryonic or lanugo hairs, which have a much shorter length of life than those which grow after birth, give place to more permanent ones, and on certain portions of the body acquire a much greater development than they do on others. The new hairs originate from the epithelium forming the external root sheath of the lanugo hairs, which sends out solid buds from which the hair develops in exactly the same way as has just been described, and grows up alongside of the embryonic hair to the external opening of the follicle. The old hair has, in the meantime, been separated from the papilla and become completely horny, owing to its loss of nourishment, and, being pushed upward by the new-formed hair, falls out when the external surface is reached. In this way

the temporary hairs are replaced by the permanent ones, and an entirely similar procedure is furthermore constantly seen repeating itself, even in adults.

General Characteristics.—The hairs, which are modifications of the epidermis, are found in greater or lesser amount over the entire body, with the exception of the palms of the hands, the soles of the feet, the vermilion border of the lips, the glans penis, the labia minora, and inner surface of the labia majora. Over the greater part of the surface they are short, rather colorless, having the character of the embryonic hairs, and hence are termed the lanugo hairs; but on the head, the eyebrows, and the eyelids, in the axillæ, on the pubes, and in the male sex on the cheek, chin, and upper lip, they attain a much higher grade of development.

The hairs which are present upon the scalp, eyebrows, and eyelids become gradually more marked, thicker, and longer after birth, but at the age of puberty the hairs on the pubes and in the axilla, and the beard in the male, begin to develop and to increase rapidly. Hair also is found around the anus in the male. It is not unusual in certain races, that women, as they approach and pass the climacteric, acquire a stronger growth of hair on the face.

The hairs are for the most part placed obliquely in the skin and are situated in the hair follicles. The portion of the hair situated in the follicle is the root, that above the level of the skin, the shaft. At the lower extremity of the root there is a whitish, soft, bulbous enlargement, the hair bulb, which has a concave end that fits upon the conical vascular eminence already mentioned as being the hair papilla.

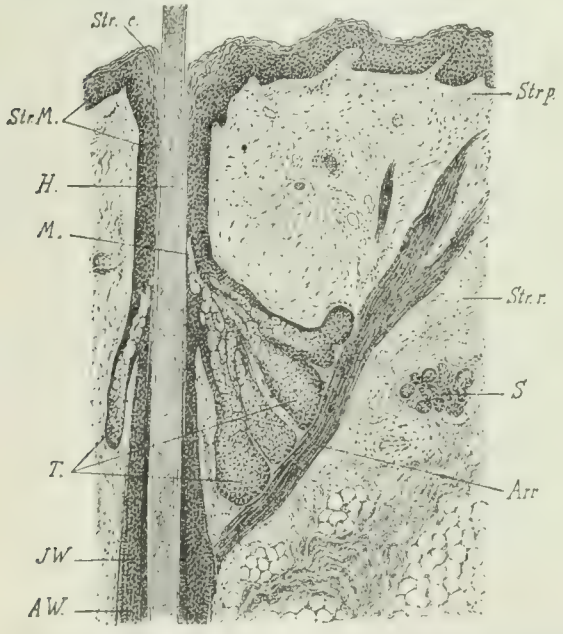


Fig. 4517.—Hair of an Adult at its Point of Emergence from the Scalp. Magnified 50 diameters. (After Rabl.) *H*, Shaft of hair; *J.W.*, inner sheath of root of hair; *A.W.*, outer sheath of root; *T*, sebaceous gland; *M*, outlet of this gland; *Arr.*, arrector pili; *Str.c.*, stratum corneum; *Str.M.*, stratum Malpighii; *Str.p.*, stratum papillare corii; *S*, sweat gland.

The hair follicle itself may be divided into three parts, according to its form. From its upper extremity, where it opens out upon the surface of the skin, it descends, shaped like a funnel, as far down as the opening of the duct of the sebaceous gland. It then becomes narrowed for a short distance, but broadens again near the papilla to receive the hair bulb.

On cross-section the hairs are either round, oval, triangular, or square, having convex or concave sides. The angular and flattened hairs are found in those localities where the hair is curly, the round ones where it is straight.

Histology of the Hair and of its Follicle.—*The hair follicle* is represented by a sac-shaped cavity composed of connective tissue. At its lower end is an eminence known as the hair papilla. This body, upon which the concave extremity of the hair root is accurately fitted, is oval in shape, and at its base is a distinctly marked constriction—the neck of the papilla. It is composed of connective tissue, similar to that of the cutis, of which it is a part, and contains blood-vessels.

The hair follicle envelops the lower two-thirds of the hair and of its sheaths, but above the openings of the ducts of the sebaceous follicles it is not demonstrable as a separate formation, becoming lost in the tissue composing the papillary body. It consists of three coats. The most external is a portion of the cutis proper, and is composed of connective-tissue fibers, which run longitudinally, and is quite rich in connective-tissue cells. In it are distributed the blood-vessels and nerves supplied to the hair. The next coat is composed of elements similar to those which are found in the external, but they are arranged in a circular manner running around the hair follicle. There are many nuclei found in this coat, the long axes of which are directed parallel with the course of the fibers.

The innermost of the coats of the hair follicle is a hyaline basement membrane, in immediate contact with the cylindrical layer of epithelial cells belonging to the external root sheath of the hair. It varies greatly in thickness. In the lanugo hairs the connective-tissue envelope of the hair is absent, the root sheaths being derived from the epidermis forming the hair follicle.

The Hair Sheaths.—The root of the hair proper is in the greater portion of its extent covered by an envelope, which consists of several layers of cells very adherent to it. It constitutes the inner root sheath of the hair, and lies in contact with the external root sheath, by which it is separated from the connective-tissue envelope of the hair follicle.

The Hair Proper.—A fully developed hair is composed of three tissues, the cuticula, the cortex, and the medulla. Each of these can be easily recognized in the shaft of the hair, but not so readily at the bulb. Still, if the hair is treated with picrocarmine, the cuticula can be traced here, and it can be seen that it starts from the neck of the hair papilla (Unna). By the same method, it is also found that the cortex develops from the lateral portions of the papilla, and the medulla from the apex.

The Cortex.—The most voluminous portion of the shaft of the hair is constituted by the cortex, a transparent fibrillar mass of varying color. In it are seen dark spots and longitudinal streaks, which are situated between the horny elements of the hair, and are caused by the presence of air. Pigment granules are also present in greater or lesser quantities.

When the hair is treated with sulphuric acid the cortex breaks up into the fibers of which it is composed, and, if the action of the acid has been long continued, it may even separate into long, narrow, spindle-shaped plates. In the centers of these latter an indistinct linear figure is oftentimes traceable. It represents the remains of the nucleus of the cell from which the plate was derived.

The development of the hair from cells is very distinctly seen at the papilla. The portion of the hair in immediate contact with this body is hollowed out or concave in shape, and it is composed of a row of cylindrical epithelial cells entirely similar to those forming the basic layer of the epidermis. This layer of cells is termed the matrix of the hair, and it is upon it that the growth of the hair depends. From this point the cells and their nuclei grow longer, become finely

fibrillated and granular, and finally, when entirely horny, appear as small plates. The cells of which the cortex of the hair root is formed have been found by Waldeyer to be composed of small fibers. Each cell is united to the contiguous ones by short spines, in a manner analogous to the cells composing the epidermis.

The pigment varies greatly in quantity, and in proportion to its abundance or comparative absence the hair is dark or light in color. It occurs both in a diffuse form and also in granules. The elements of the cortex are diffusely pigmented by the former, but the pigment granules are distributed here and there, and are situated in and between the cells composing the cortex (Waldeyer). This deposition of the pigment granules in the cells is most clearly seen in the root of the hair.

The Medulla.—The medulla is situated in the axis of the hair but terminates at some distance from the free end. It is marked in the stronger hairs, but is usually absent in the lanugo hairs, and often also in those of the scalp. The presence of the medulla is shown by a more or less broad, longitudinal band of a dark color, which is due to the air situated between its composing elements. These latter are cells which are shrunken into irregular shapes, possess no nuclei, and are furnished with spines and prongs (Waldeyer).

At the bulb of the hair, the medulla differs very slightly from the cortex. Over the apex of the papilla and above the cylindrical cells situated there, which represent the matrix of the medulla, large nucleated cells are seen, and in their protoplasm are large drops of keratohyalin. In proportion as the shaft is ascended, these cells become shrunken, harder, lose their nuclei, and the keratohyalin disappears. They are bound together by means of the spines and prongs on their surface, between which are left spaces—intercellular spaces. Below the external surface these spaces serve as channels through which nourishment is furnished to the young cells of the medulla, but where the hair is exposed to the external atmosphere this fluid evaporates, and the spaces become filled with air.

The Cuticula.—The hair is also furnished with a cuticula, which surrounds the greater part of the portion which lies in the follicle. It is formed by a layer of horny plates, arranged like tiles on a roof, and they are closely bound together. The cuticula originates from the neck of the papilla of the hair, between the matrix of the cortex and that of the inner root sheath. At this point it consists of several rows of cylindrical nucleated cells, which divide soon after leaving the matrix into two layers. One of these goes to form the cuticula of the hair, the other the cuticula of the inner root sheath. The cells of the former are at the middle of the hair papilla, directed perpendicularly to the circumference of the hair, but gradually become more and more inclined toward it. At the upper portion of the hair follicle the cuticula is no longer distinguishable and becomes a constituent portion of the cortex. At the matrix the cells are epithelial in character, but they become transformed into solid transparent horn plates without nuclei.

The Root Sheaths.—The hair root is further enveloped by two coats—the root sheaths—which are closely adherent to it. They are known as the inner and the outer root sheath. The former is immediately around and in contact with the hair, and ends within the hair follicle; the latter, more external, passes up to the orifice of the follicle, where it becomes continuous with the spiny layer of the epidermis.

The inner root sheath is composed of three layers—the cuticula, the one nearest the hair, Henle's layer, the most external, and between these two Huxley's layer. The cuticula arises from the same matrix at the neck of the hair papilla as the cuticula of the hair. The cells composing it are so arranged that their long axes are parallel to the circumference of the hair, that is, in an opposite direction to the cells forming the cuticula of the cortex. They undergo transformation in a manner entirely analogous to the one which has been already described for the cuticula of the cortex. The cuticula of the inner root sheath is lost sight of within the follicle, becoming a part of the sheath.

Two layers known as those of Huxley and of Henle, also take their origin from the neck of the papilla, and at that point appear as a layer of three or more cylindrical epithelial cells. Drops of keratohyalin, however, appear very soon in these cells, and this substance increases rapidly in quantity. The change in their appearance due to the presence of the keratohyalin is very marked on a level with the apex of the papilla, and the cells are seen here to have attained a much larger size. The cells forming the layer of

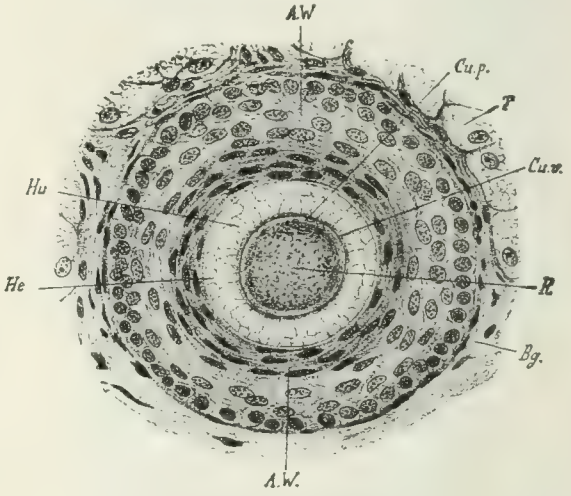


Fig. 4518.—Cross Section of a Hair and its Sheath, from the Scalp. The cut was made at the level of the region in which lie the sebaceous glands. Magnified 250 diameters. (After Rabl.) *R*, Cortical portion of the hair shaft (the medullary substance is lacking in this specimen); *Cu.p.*, cuticula of the hair; *Cu.r.*, cuticula of the sheath of the root; *Hu*, Huxley's layer; *He*, Henle's layer; *A.W.*, outer sheath of the root; *Bg.*, connective tissue; *T*, sebaceous glands.

Henle—the most external—contain, however, a greater amount of keratohyalin, and undergo cornification much more rapidly than those in the layer of Huxley. Huxley's layer is composed at the papilla of cells which contain a smaller amount of keratohyalin. Keratogenesis in them is not so rapid as in the cells of Henle's layer, the nuclei do not disappear so early, and the complete transformation of the elements into horny masses occurs at a higher level.

In describing the embryology of the hair, it was stated that the first changes consist in a proliferation and prolongation downward into the cutis of a portion of the cells forming the stratum spinosum of the epidermis. The further steps result in the formation of the shaft of the hair, but the remaining portion also serves an important purpose. It represents the external root sheath, or envelope, of the hair, and is separated by it from the connective tissue composing the follicle.

The outer root sheath is not uniform throughout its entire extent, but is lined on the surface next to the hair shaft, and as far down as the opening of the duct of the sebaceous gland, by the stratum corneum and stratum granulosum. From here to the level of the hair papilla the stratum spinosum descends in its entirety, but then narrows, and at the neck of the papilla is reduced to a layer of two or three cylindrical cells. It lies at this point in close contact with the cells from which the inner root sheath is formed.

George T. Elliot.

Skin, Physiology of the.—The functions of the human skin are those of protection, heat regulation, secretion, absorption, respiration, sensation, and as a secondary sexual organ.

Protection.—The epidermis is a poor conductor of electricity and of light. As is well known the natives of those countries where the light is most intense have the greatest amount of pigment in the skin and hair. It has been claimed that whites do badly in the tropics because of a deficiency in protective pigment. Under ordinary circumstances the Caucasian is fair skinned but when exposed to an excessive amount of sunlight he becomes more deeply pigmented, either generally when tanned, or locally when freckled. In both instances the formation of pigment is undoubtedly protective in object. Hyde considers that skin cancer is more frequent in those exposed to much light, an observation that has found general acceptance. As bearing on this point it is interesting to note that the negro does not frequently suffer from either cancer of the skin or from precancerous keratoses.

The fatty material secreted by the sebaceous glands serves to keep the skin soft and pliable, and also to check the evaporation of the bodily fluids, for water, of course, will not pass through an oiled membrane. When the oil is removed by too frequent applications of soap and water the condition known as "chapping" results, chapping being simply an abnormally dry skin due to the extraction of water by the atmosphere.

The keratin of the horny layer forms an excellent armor plating against all of the small traumas of life. It is very resistant to chemicals of all kinds, although fairly readily dissolved by strong alkalis. In like manner the skin is resistant to bacterial invasion, but there are a number of open ports through which bacteria can gain entrance, namely, the hair follicles, and possibly the openings of the sweat ducts. Skin infections usually begin in or around a hair follicle, and are much more frequent when there is friction over the opening, the friction probably mechanically rubbing in the organisms.

In the lower animals the hair serves as an excellent organ of protection, but this is true in man only to a limited extent.

Heat Regulation.—As Howell states: "Experiments show that the mechanism of heat regulation is very complex and two-sided, that is, the body possesses means of combating the loss of heat as well as the production of heat." The skin causes heat to be lost in two ways, by evaporation of the sweat and by direct conduction and radiation. Vierordt estimates that 14.5 per cent. or 364 calories are daily lost by evaporation and seventy-three per cent. or 1792 calories by radiation and conduction. Rubner as quoted by Lusk has shown that these factors vary greatly according to the external temperature. Man largely controls the loss of heat by the wearing of suitable clothing, clothing preventing excessive loss by any means.

The control through the vasomotor nerves is more important because more fundamental. The cutaneous capillaries bring the blood to the surface where it loses its heat as already stated. In warm weather more blood is brought to the surface due to the dilatation of the small peripheral vessels, more oxidation takes place at the surface, and more heat is lost by conduction and radiation. As there is also more sweat more heat is lost by evaporation. On the other hand in cold weather when the peripheral vessels are contracted there is less blood at the surface, hence less heat is lost by conduction and radiation. As there is also less perspiration there is also less loss of heat by evaporation. Substances which cause a dilatation of the peripheral vessels, such as alcohol, cause an increased loss of heat. In humid atmospheres, evaporation takes place much more slowly, so less heat is lost. A breeze or draught will increase the rapidity of evaporation. The evaporating surface can be increased by means of applying insoluble powders.

Excretion.—The organs of excretion in the skin are the sweat and the sebaceous glands. The former are found over the entire cutaneous surface except in the deeper portions of the external auditory meatus, the prepuce and the glans penis. They are especially abundant upon the palms and soles, and are less numerous upon the back than elsewhere. Krause estimates their total number at two millions. Pembrey notes that they are most numerous where sensation is best developed. Excretion takes place into the coil glands proper and not into the ducts. The amount of excretion varies according to temperature. According to Schierbeck the average in a clothed person is between two and three liters. Willebrand has shown that at a temperature of 18.2° C. (64.8° F.) a man will discharge 13.19 grams of water per hour, while at 31.5° C. (88.7° F.) he will discharge 34.04 grams per hour. As the temperature becomes higher the discharge becomes much more rapid. Schierbeck has demonstrated that at 31.9° C. (89.4° F.) 50.3 grams is given off per hour, while at 38.4° C. (101.1° F.) 158.8 grams is given off in the same time.

According to Charles the composition of sweat is as follows:

Water	98.88
Solids	1.12
Salts	0.57
Sodium chloride	0.22 to 0.33
Alkaline sulphates, phosphates, lactates and potassium chloride	0.18
Fats, fatty acids and cholesterol	0.41
Epithelium	0.17
Urea	0.08

Sweat is a colorless fluid of a salty taste and acid reaction in man, with a specific gravity of 10.01 to 10.10. Estimations of sweat should be made only from material collected from the palms and soles, so that there shall be no admixture of sebaceous secretion.

Pembrey draws a sharp distinction between perspiration and sweat, maintaining that the former is a transudation of water through the skin, and the latter an active outpouring of water from the glands, and that it does not begin until an external temperature of 32° C. is reached. Perspiration is due to vascularity and the temperature of the skin, while sweating is an active secretory process controlled by the nervous system.

Under abnormal conditions, as in uremia, a very considerable amount of urea may occur in the sweat. A number of drugs are excreted through the skin. After exercise lactic acid has been found. Sweat taken from healthy persons and sterilized is probably not toxic. The presence of protein in some analyses is undoubtedly due to an admixture of epithelial cells.

The secretion of sweat is often invoked by the emotions, fear and pain particularly inducing such a flow, even if the skin contains much less blood than normally. Stimulation of the majority of the afferent nerves will produce sweating by reflex action. The secretion is not entirely due to the blood flow, for if a cat be killed, the pads of its feet examined and found to be dry, the sciatic nerve of the right side exposed and electrically stimulated, sweat will appear upon the pad of the right foot but none upon the left. In man in early paralysis of the cervical sympathetic nerve sweating occurs on the paralyzed side, but later the same parts will not sweat. After a plastic operation has been performed the skin does not sweat until it has gained its sensitiveness. There

seems to be no doubt that the sweat nerves are general secretory fibers, and that sweating is directly due to stimulation and consequent action of the cells of the coil glands. Arnstein has shown that special nerve fibers are supplied to the glandular epithelium. In addition to the emotions, disease and artificial stimulation, the sweat glands may be made to secrete by the application of external heat, dyspnea, muscular exercise, and by the action of various drugs, of which pilocarpine is the most notable example; in all instances the action is probably through the central nervous system. There are probably physiological centers controlling the secretory fibers but their exact location has not as yet been definitely established. There is some evidence to show that there may be some centers in the cord, but analogy with the vasoconstrictor fibers would seem to indicate that the medulla is their real site.

The sebaceous glands are usually located in connection with the hairs, although they may be found independently, as on the lip, and on the prepuce and glans penis. Secretion is supposed to take place by a complete casting off of the layer of cells next the lumen, their detritus forming the secretion. New cells are formed from the basal layer, and the glands produce a slow but constant secretion. The sebum is an oily material that forms a cheesy mass when exposed to the air. Its exact composition is not known, but it does contain fats and soaps, some cholesterin, albuminous material, remnants of epithelial cells and inorganic salts. The composition upon different portions of the body undoubtedly varies, for instance that from the ear (wax) and that from the prepuce (smegma) being very unlike. Hoppe Seyler states that the composition of a distended sebaceous gland in man was as follows:

Water	317.0
Epithelium and albumin	617.5
Fat	41.6
Fatty acids	12.1
Ash	11.8

The sebaceous glands are not known to possess any special secretory nerves.

The vernix caseosa of the new-born babe consists of sebaceous matter together with epithelial cells. The sebaceous glands undoubtedly become much more active at puberty, and menstruation may be accompanied by a hypersecretion from them. This explains why acne begins at puberty and is worse during the menses. In old age the secretion usually diminishes. It is possible that a true secretion takes place as in the case of the mammary gland. Pembrey dilates upon this possibility to a considerable extent. The cells of the glands appear to absorb fat from the blood, and to slightly alter its composition before secretion. The kind of food given to animals influences both the quantity and quality of the secretion. In man the total amount secreted in twenty-four hours is about ten to thirty grams. The function of the secretion is to supply the skin with a fatty material, which, in conjunction with the cholesterol and cholesterolesters formed from the horny layer of the skin, protects the skin from a drying-out process or from becoming water soaked. The secretion also gives gloss to the hairs.

Absorption.—At the present time it is generally conceded that we are amazingly ignorant regarding absorption of various materials through the skin. It is believed that no substance in either aqueous or alcoholic suspension is absorbed. However, when a substance is put up in a greasy medium, as lanolin or goose grease, especially if well rubbed in, some is absorbed. When the surface of the skin is abraded absorption may take place with avidity. A number of years ago it was generally considered that mercury was well absorbed when rubbed into the skin in the form of an ointment, but within the past few years a number of observers have claimed that the heat of the body volatilized the substance and that it was then absorbed through the lungs. Much more experimental work upon the whole question is urgently needed.

Respiration.—In some of the lower animals, as the frog, the skin has a very considerable respiratory function, but in man there is practically none.

Sensation.—The efferent cutaneous nerves convey at least four different qualities of sensation, pressure, warmth, cold, and pain. The so-called touch sensations are frequently compound, consisting of pressure and temperature components and also of an element of muscle sense. The nerve endings for these four senses are present over the entire cutaneous surface and also in the adjacent mucous membranes. Head and Rivers have carefully studied the question of cutaneous sensibility and have found in skin areas made anesthetic by division of the cutaneous nerves there is still present a deep sensibility to pressure and movements which must be conveyed to the spinal cord by efferent nerves from the muscles. In the skin itself there are present two systems of sensory fibers which regenerate at different times in a nerve that has been divided. One system conveys sensations of pain and extreme changes in temperature without sharp localization, and is called protopathic sensibility. The other system of fibers responds to stimulation from light pressure and to small differences in temperature and gives sharp localization. This is called the epicritic system. Blix first clearly showed that the cutaneous senses are present in discrete points. One can easily demonstrate the warm or cold spots upon his skin by means of a metal point that is either warm or cold. The pressure or tactile sense and the pain sense are distributed in the same way as has been shown by von Frey. It is possible that the endings for pain lie most superficially in the skin, and the endings for warmth most deeply. It is also possible that the different endings have likewise separate fibers, although this point is not as yet entirely clear.

The cold spots are more numerous than are the warm ones, and also react more promptly. In addition to temperature, either mechanical or electrical stimulation will cause the sensation of cold. Certain chemicals such as menthol will produce the same results. If a very warm object be applied to a cold spot the sensation of cold is produced.

The pressure points are smaller and more numerous than are the temperature points. They lie over the hair follicles, so that movement of the hair will stimulate them. It is stated that there are about five hundred thousand of them on the body. They are most numerous on the tongue and on the fingers.

The pain sense is present not alone in the skin, but in many of the bodily organs as well, although it has been best studied in the first named. It is generally agreed that the endings are distributed in a punctiform manner and that they are very numerous. The threshold stimulus is fairly high. There is probably no special end organ, the stimulus affecting the free endings of the nerve fibers. Artificial stimulation may be produced by any of the usual experimental methods. The pain sensations are usually referred accurately to the irritated spot, but when the skin has lost the sense of pressure and of temperature localization may be faulty.

Secondary Sexual Organ.—The value of the skin and its appendages as a secondary sexual characteristic was first emphasized by Darwin in his classical book "The Descent of Man." By secondary sexual characteristics are meant the numerous

distinctions in size, color, and the like which signalize either sex. In the animals and birds they are supposed to render the individual more desirable or conspicuous as a mate, or to render the conquest more certain. In the male of the human species the beard is probably the best developed of the secondary sexual characteristics of the skin, although now it is of very doubtful utility from this standpoint. In woman the round contour of the body, due to the subcutaneous fat, is an undoubted sexual attraction. In addition the presence of regular features and of a clear skin also undoubtedly aids in attracting many men. The breasts, whose glands are modifications of those of the skin, furnish milk for the nourishment of the offspring.

In writing this article much help has been derived from Howell's "Text Book of Physiology," 6th Edition, Pembrey's articles on "The Functions of the Skin" in the British Journal of Dermatology for 1910, and Kreidl's "Physiologie der Haut in the first volume of Mracek's "Handbuch der Hautkrankheiten." These articles give a very full bibliography.

H. H. Hazen.

Skin, Tuberculosis of the.—Tuberculosis Cutis.—Under this heading are to be placed those dermatoses known to be caused by the tubercle bacillus. Among these, the most important are: tuberculosis ulcerosa, tuberculosis verrucosa, tuberculosis disseminata, scrofuloderma, and lupus vulgaris. This list may in the very near future be further increased by the addition of one or more members of a group of cutaneous manifestations, now believed to be probably due to toxins produced by the tubercle bacillus, and which after further investigation may frankly reveal themselves as true tuberculous processes. Erythema induratum, lichen scrofulosorum, the tuberculides, and the benign sarcoid tumors, are representative of this class of dermatoses. It may be that in this latter group, an attenuated or different form of tubercle bacillus may be the etiological factor; this might account for the difficulty of demonstrating the presence of tubercle bacilli in these particular lesions. Some work along these lines has been done by Much; he believes that there is a granular form of the tubercle bacillus, which is not demonstrable with the Ziehl stain. The organism of Much is non-acid-fast, and may appear as solid bacilli, rows of granules, or isolated granules. Like the acid-fast bacilli, it has the power of resisting antiformin. So far as known it is confined to tuberculous conditions. The various manifestations of tuberculosis cutis present enough clinical differences to warrant a brief separate description.

Tuberculosis ulcerosa, also termed tuberculosis cutis orificialis, is an extremely rare form of the disease, and was the first of the group of integumentary tuberculosis to be recognized as such. It occurs almost exclusively about the mucous orifices of patients suffering from pulmonary or visceral tuberculosis, with development of tubercles in the adjacent mucous tract. It is really an extension of a pre-existing process. The ulcers are usually small, rounded or oval, with softish edges, and covered with a thin crust which upon removal reveals an uneven, indolently granulating floor, which is bathed in a thin purulent secretion. Occasionally they coalesce, with resulting serpiginous configuration. As a rule they are painless. Almost invariably the cutaneous manifestation is the end result of a far advanced visceral tuberculosis, which rapidly goes on to a fatal issue.

Tuberculosis verrucosa, usually appears in one or two forms: verruca necrogenica (anatomical tubercle) and tuberculosis verrucosa cutis.

Verruca necrogenica is characterized by a single, small, red, pustular lesion, which slowly enlarging forms an inflammatory, elevated warty growth, with an infiltrated base, and a surrounding reddish areola. Upon lateral pressure a few drops of purulent secretion can be expressed, which frequently contains tubercle bacilli. Contiguous lymphatic glands are usually enlarged. Its favorite location is over one of the metacarpophalangeal joints. It is most often found in those who come into frequent contact with decomposing animal matter; therefore butchers, dissecting-room and morgue attendants, medical students, and physicians are most often affected.

Tuberculosis verrucosa cutis usually begins similarly to verruca necrogenica, but soon becomes very much more extensive. Several patches may be present, which sooner or later coalesce, forming an irregular serpiginous area. A characteristic patch is irregularly rounded or ovoid in shape, and is frequently markedly serpiginous. It is elevated, greatly infiltrated, and covered with a warty overgrowth. Isolated or grouped purplish-red nodules are often present. The whole lesion is usually surrounded by a purplish-red area. It spreads peripherally, healing going on in its central portion. It very closely resembles blastomycosis, and frequently a histological examination is the only means of clearly differentiating between the two.

Tuberculosis disseminata (miliary tuberculosis of the skin) is a very rare affection occurring almost invariably in children, and frequently after some severe illness. It consists of a number of widely scattered small papules and vesicopapules, some of which may go on to ulcer formation. Guinea-pig inoculation and the tuberculin tests are positive. Microscopically a tuberculous structure can be demonstrated. The disease is frequently associated with a general miliary tuberculosis

Scrofuloderma is a term now entirely restricted to that form of cutaneous tuberculosis which is secondary to tuberculous foci beneath the skin, usually tuberculous glands. It most frequently begins as a subcutaneous painless swelling, in the immediate vicinity of a chronically enlarged lymphatic gland. The skin is of a purplish-red color, and, becoming thinned, undergoes central necrosis and ulcer formation. The floor of the ulcer is covered with pale, flabby, unhealthy granulation tissue, and is filled with a watery pus. Fistulous tracts, from which a seropurulent fluid is constantly exuding, extend from one lesion to another, undermining the healthy skin. The tubercle bacillus may be found in the discharge.

Lupus Vulgaris.—See the article with this title in vol. vi.

Etiology and Pathology.—In all the various manifestations of tuberculosis cutis, the tubercle bacillus, either of the human or bovine type is the causative factor. The "soil" must of course be a suitable one, hence poverty, with its frequent companions, filth, depravity, and insufficient food, with consequent lowered resistance, are predisposing factors the importance of which are only now sufficiently recognized. There is no doubt that the presence of a tuberculous individual in a family, in which common hygienic precautions are neglected, may result in the propagation of the disease in the skin as well as the lungs of those exposed, and this is particularly true of children. While the histological picture of the various forms of tuberculosis cutis varies in minor details, the most important features evidence sufficient similarity to enable the observer to recognize the common cause. Each variety presents a cellular new growth, blood-vessel changes, hypertrophy or destruction of the collagen, and alteration or destruction of the sebaceous and sweat glands. The epidermal changes are secondary.

Treatment.—The treatment in all essential details is exactly similar to that described for lupus vulgaris.

Tuberculin, phototherapy, the Röntgen rays, excision, curettage, galvanocauterization, and caustics are among some of the measures which bring about improvement or cure. Fresh air, good food, plenty of sunshine, and outdoor exercise are of the greatest importance. Cod-liver oil, the syrup of the iodide of iron, and other similar tonics, frequently prove beneficial. PAUL E. BECHET.

Skin-grafting.—See *Tissues, Transplantation of.*

Skippers.—A name given to the larvæ of the cheese-fly, *Piophila casei*, which may cause intestinal myiasis. A. S. P.

Skoda, Joseph.—Born at Pilsen, Bohemia, Dec. 10, 1805. He studied medicine in Vienna, and received his doctor's degree in 1831. During the period from 1833 to 1840 he devoted himself chiefly to pathologico-anatomical work, under Rokitansky, and to investigations in the domain of physical diagnosis. In 1841 he was given exclusive charge, as First Physician, of a section in the Allgemeines Krankenhaus—a section devoted to diseases of the chest. In 1846 he was made a full Professor of Physical Diagnosis, a field in which he soon gained a world-wide celebrity. His lectures were attended by large crowds, composed of practitioners as well as of students, and the benefit derived from his teaching was admitted by all to be great. In 1871, after a service that had lasted twenty-five years, he felt compelled by the impaired state of his health to give up all active professional work. He died June 13, 1881.

Of his very few published writings that entitled "Abhandlung ueber Percussion und Auscultation" (Vienna, 1839; sixth edition in 1864) is the only one that calls for special mention. It is a work, however, that marks one of the great epochs in the history of medicine. A. H. B.

Skull, The.—The characters that may be noted in the skull are very numerous. They can be divided into *descriptive*, which gives an account of the conformation of the bony structure of the skull and its parts; *topographical*, which is of special importance in practical medicine; *craniometrical*, which gives the dimensions of the various parts of the skull by exact measurements taken by means of special instruments; and *comparative*, in which the human skull is contrasted more particularly with those of the anthropoids.

The skull may also be investigated from the points of view of embryology and general morphology.

This article will deal especially with the applied anatomical and the craniometrical characters of the skull, though presenting very briefly such descriptive and comparative matter as is necessary for an adequate treatment of the subject.

THE EXTERIOR OF THE SKULL.—The skull in a general way is spheroidal in shape. It is flattened and uneven below, compressed from side to side, and smooth above. It presents, externally, six regions for investigation, viz., an inferior region or base (*norma basilaris*), two lateral regions (*norma lateralis*), a posterior or occipital region (*norma occipitalis*), an anterior or frontal region (*norma frontalis*), and a superior region or vertex (*norma verticalis*).

Many *sutures* can be noted. The sutures are the lines of union of the facial (excluding the mandible) and cranial bones.

The uneven edges of the bones form closely fitted articulations (*synarthroses*) and are separated only by a fibrous membrane continuous with the dura mater and periosteum. The only places where cartilage intervenes, forming *synchondroses*, are the basilar and jugular portions of the occipital bone at the base of the skull. These cartilages are ossified in the adult. The sutures bind the bones so firmly together, by being bevelled alternately on each side, that dislocations are practically impossible. They diminish shocks, and during early life permit a rapid growth of the skull. The sutures, with the exception of the coronal (frontoparietal), sagittal (interparietal), and lambdoid (occipitoparietal), are best named from the bones which form them.

THE INTERIOR OF THE SKULL.—In order that the interior of the skull may be investigated to the greatest advantage it is necessary to make sections in three different planes—horizontal, sagittal, and coronal. These sections not only facilitate the study of the numerous points on the interior of the skull, but also reveal the great preponderance in size of the cranial cavity over those situated in other parts of the skull.

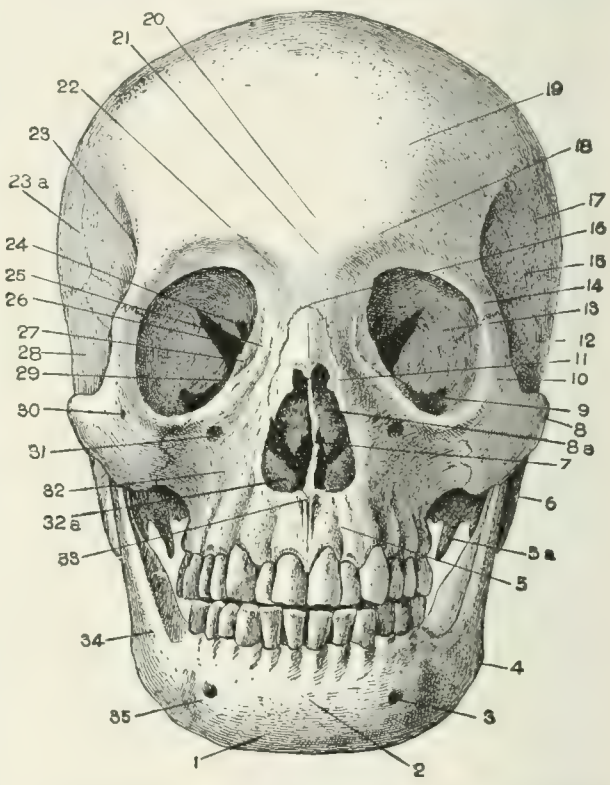


FIG. 4518.—Norma Frontalis. 1, Mental tubercle; 2, symphysis menti; 3, mental foramen; 4, angle of jaw (gonion); 5, incisor fossa; 5*a*, styloid process; 6, mastoid process; 7, nasal septum in middle of anterior nasal aperture; 8*a*, middle turbinated bone of ethmoid; 8, zygomatic arch; 9, sphenomaxillary fissure; 10, malar bone; 11, nasal bone; 12, 15, 17, temporal fossa, the sutures of which are obliterated; 13, orbital surface of great wing of sphenoid; orbital sutures are obliterated; 14, external angular process of the frontal bone; 16, nasion; 18, superciliary ridge; 19, site of frontal eminence; 20, ophryon,; 21, glabella; 22, supraorbital margin; 23, temporal crest of frontal bone; 23*a*, anteroinferior angle of parietal bone, articulating with frontal, great wing of sphenoid, and squamous portion of temporal; 24, optic foramen; 25, nasal process of superior maxilla; 26, sphenoid fissure; 27, lacrymal groove bounded posteriorly by lacrymal crest; 28, squamous portion of temporal bone; 29, lacrymal tubercle; 30, malar foramen; 31, infraorbital foramen; 32, canine fossa; 32*a*, inferior turbinated bone; 33, subnasal point at root of anterior nasal spine; 34, ramus of mandible; 35, mental foramen.

The walls of the skull consist of an outer and inner table of compact bone and an intervening cancellous diploë. The spaces of the diploë contain veins com-

municating in the interior of the cranium with the meningeal veins and the sinuses of the dura mater, and on the exterior of the skull with the veins of the pericranium. There are other apertures in the cranial wall through which *emissary veins* pass that also establish communication between the sinuses of the dura mater inside the skull and the veins external to it.

These veins pass through the mastoid, parietal, the posterior and anterior condyloid foramina; others pass through the foramen ovale, the foramen lacerum medium, and through the foramen of Vesalius, Through these diploic and emissary veins pyogenic infection may extend from the outside of the skull, leading to osteophlebitis of the diploë and inflammation of the membranes of the brain. By means of the emissary veins blood may be abstracted almost directly from the sinuses of the dura mater, as, for instance, where leeches are applied over the mastoid process to abstract blood from the lateral sinus.

The cranial wall is very thick at the external occipital protuberance, and along the ridges bounding the grooves for the lateral, longitudinal, and occipital sinuses, the mastoid process, and the lower part of the frontal bone. It is comparatively thin and translucent in the cerebellar fossæ, the squamous portion of the temporal bone, and the anteroinferior angle of the parietal. The average thickness of the bones of the cranial vault is five millimeters. In *trephining*, the pin of the trephine should not penetrate over three millimeters.

A Horizontal Section of the Skull.—This section of the skull should be made to traverse the ophryon and the maximum occipital point, passing one or two millimeters above the pterion.

The removal of the calvarium or vaulted skull cap by a horizontal section (Fig. 4524) shows the floor of the cranial cavity, consisting of three irregular depressions, viz., the anterior, middle, and posterior fossæ.

The weak areas of the floor of the cranial cavity through which fractures are liable to extend are: The horizontal plates of the ethmoid and frontal bones in the anterior cranial fossa; the region of the foramen ovale of the sphenoid bone, and of the glenoid fossa of the temporal, in the middle cranial fossa; the cerebellar fossæ of the occipital bone in the posterior cranial fossæ. The internal auditory canal and the tympanum weaken the otherwise strong petrous portion of the temporal bone.

A Sagittal Section of the Skull.—A sagittal section should be made a little to one or the other side of the mesial plane so that one-half will reveal the nasal septum in position while the other half will display the lateral wall of the nasal fossa (Fig. 4521).

upon or close to its superior surface. The hiatus serves as a direct and only communication between the meatus and the important *infundibulum*, and is a deficiency in the mesial wall of the latter. The infundibulum is a small gutter-like channel immediately external to the hiatus. It corresponds in direction and length to the border of the uncinate process. In the majority of cases the infundibulum continues up, as the *nasofrontal duct*, to the *ostium frontale*. Sometimes the superoanterior end of the infundibulum terminates in a bony lamina; in these cases the nasofrontal duct opens into the middle meatus in front and independently of the infundibulum.

The opening of the maxillary sinus (*ostium maxillare*) is situated in the most depressed part of the infundibulum beneath the bulla. It is concealed from view by the uncinate process. The size of the opening varies from two to eighteen millimeters. There may be one or more accessory maxillary openings in the membranous portion of the outer wall of the middle

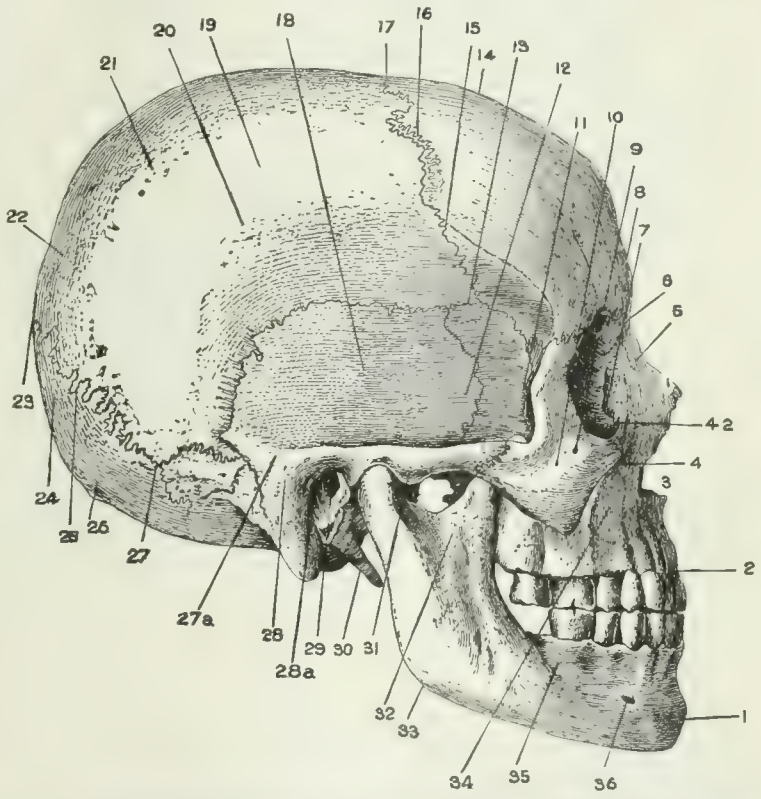


Fig. 4520.—Norma Lateralis. 1, Mental tubercle; 2, alveolar point; 3, anterior nasal spine; 4, infraorbital foramen; 4*a*, lacrymal tubercle; 5, nasal bone; 6, nasion; 7, lacrymal groove for nasal sac; 8, glabella; 9, malar foramen; 10, malar bone; 11, great wing of sphenoid; 12, temporal fossa; 13, pterion; 14, frontal bone; 15, stephanion; 16, coronal suture; 17, bregma; 18, squamous portion of temporal bone; 19, site of upper temporal ridge; 20, site of lower temporal ridge; 21, parietal bone; 22, obelion; 23, lambda; 24, occipital bone; 25, lambdoid suture; 26, inion (or external occipital protuberance); 27, asterion; 27*a*, supramastoid crest; 28, mastoid process; 28*a*, suprameatal spine with the suprameatal fossa immediately back of it; 29, aperture of external auditory canal; 30, styloid process; 31, zygomatic arch; 32, ramus of mandible; 33, gonion; 34, superior maxilla; 35, body of mandible; 36, mental foramen.

Removal of the middle turbinated bone shows two prominent objects on the lateral wall of the middle meatus, viz., a bulging of one of the ethmoidal cells (*bulla ethmoidalis*), and immediately below it the well-defined curvilinear border of the uncinate process (*processus uncinatus*) of the ethmoid bone. A narrow semilunar opening (*hiatus semilunaris*) occurs between the two projections. The air cell in the bulla communicates directly with the meatus by an opening meatus, varying in size from one to eight millimeters. They do not open into the infundibulum but directly into the meatus at the posterior part of the infundibulum. The middle ethmoidal cell, when present, opens into the meatus above the bulla. The anterior ethmoidal cells open into the superior part of the infundibulum.

A Coronal Section of the Skull.—The most instructive coronal section of the cranium is through the basio-

bregmatic axis (Fig. 4525). Such a section of the skull facilitates the examination of the parts about the posterior nares; it divides the parietal bones slightly in front of the parietal eminences, and thus makes it possible to indicate the greatest transverse measurement of the cranial cavity by a line drawn transversely across the cavity. The section will traverse the petrous portion of the temporal bone in such a way as to pass through the external auditory canal and expose the tympanum proper (atrium) and its attic, as also the vestibule. It will also pass through a part of the internal auditory canal

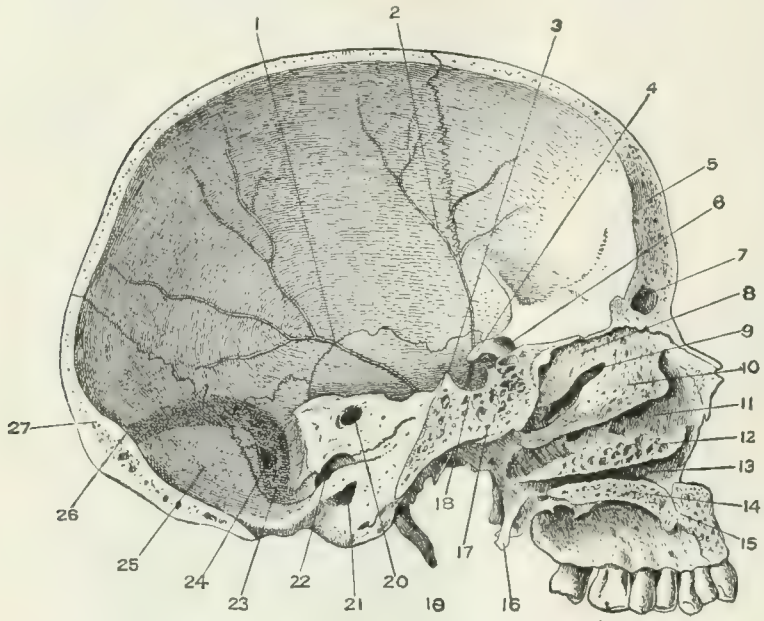


Fig. 4521.—Sagittal Sections of Human Skull. 1, Posterior division of middle meningeal artery, 2 anterior division of the artery; 3, dorsum sellæ; 4, anterior clinoid process; 5, diploë of frontal bone; 6, optic foramen; 7, frontal sinus; 8, superior turbinated bone of the ethmoid; 9, superior meatus; 10, middle turbinated bone of the ethmoid; 11, middle meatus, showing antral openings; 12, inferior turbinated bone; 13, inferior meatus; 14, hard palate; 15, anterior palatine canal; 16, hamular process of the internal pterygoid plate; 17, body of sphenoid (diploetic instead of pneumatic); 18, pituitary fossa; 19, styloid process; 20, internal auditory canal; 21, anterior condyloid foramen; 22, jugular foramen; 23, groove for lateral sinus; 24, mastoid foramen, 25, cerebellar fossa; 26, internal occipital protuberance (site of torcular Herophili); 27, diploë of occipital bone.

The inner surface of the cranial wall shows certain grooves and depressions, viz., for (1) the meningeal arteries (especially the middle meningeal), (2) the dural sinuses, (3) the Pacchionian bodies, and (4) the cerebral convolutions. In trephining, these facts should be borne in mind.

It may be stated here that in studying the macerated skull, through which no sections have been made, *transillumination* with a small electric bulb, such as that used in laryngological work, will be found very instructive. Especially is this the case in studying the nasal fossa, the grooves for the lateral sinuses, the maxillary sinus, the tympanum, the relations of the carotid canal and jugular fossa to the tympanum, etc.

The skull presents certain *buttresses* where the bones are thicker and stronger than the intervening thinner and weaker regions. The latter regions are the more readily fractured. These buttresses pass from the vertex to the foramen magnum. The *anterior buttress* is represented by the median portion of the frontal, the ethmoid, the body of the sphenoid, and the basilar portion of the occipital. The *posterior buttress* passes through the external occipital protuberance and crest to the foramen magnum. On either side there are two *lateral buttresses*—an anterolateral one which extends from the vertex to the external angular process of the frontal and thence through the great wing to the body of the sphenoid; and a posterolateral one which runs through the parietal eminence, the mastoid process, the posterior part of the petrous portion of the temporal bone, the jugular process and condyle of the occipital bone.

There are several factors that lessen the liability of the cranial wall to fracture: (1) The elasticity of the wall due to its shape and its formation of a number of elastic bones separated by sutures and suture membranes which act slightly as buffers; (2) a rounded form favoring glancing blows; (3) the mobility of the head on the spinal column; (4) the mobility and density of the scalp.

From the fact that there is much membrane and cartilage between the bones the skull of the infant is much more elastic than that of the adult. The yielding character of the infant's skull is shown during delivery, when frequently the parietal bone may be flattened by pressure against the sacral promontory or by the forceps without producing fracture.

Craniology.—The races of mankind display great variations in their physical attributes, and these differences are more or less characteristic of the stock to which they belong. For instance, the various races manifest great differences in the size and form of the cranial cavity and of the face. Variations are observed in the prominence of the chin, and in the form of the dental arch, the palate, the nasal aperture, the orbit, etc. Craniology deals with these variations to the extent that they affect the skull. In order that the differences between skulls may be recorded, it is necessary that accurate measurements, in many details, should be made. Some craniologists have multiplied the measurements to more than a hundred, but those worth mentioning are comparatively few. These measurements constitute Craniometry. In order to make the various measurements required, many complicated instruments have been invented, but for all practical purposes the calipers designed by Fowler are sufficient.

While there is a great difference of opinion as to the value of the various measurements, all anatomists endeavor to select such fixed *anatomical points* on the skull as may be easily located. Some of these "anatomical points" are as follows (Figs. 4519, 4520, 4521, 4522, 4524, 4525):

Nasion.—The middle of the nasofrontal suture.

Glabella.—The midpoint between the two superciliary ridges.

Ophryon.—The midpoint of the narrowest transverse diameter of the forehead.

Bregma.—The point of junction of the sagittal and coronal sutures.

Vertex.—Highest point of the cranial vault.

Obelion.—A point in the sagittal suture on a line extending between the parietal foramina.

Lambda.—The point of junction of the sagittal and lambdoid sutures.

Maximum Occipital Point.—That point on the squamous portion of the occipital bone and in the sagittal plane that is most removed from the glabella.

Inion.—The external occipital protuberance.

Opisthion.—The midpoint of the posterior margin of the foramen magnum.

Basion.—The midpoint of the anterior margin of the foramen magnum.

Mental Tubercle.—The tubercle of the chin.

Alveolar Point.—The midpoint of the anterior margin of the alveolar border of the upper jaw.

Subnasal Point.—The midpoint of the inferior margin of the anterior nasal aperture at the base of the nasal spine.

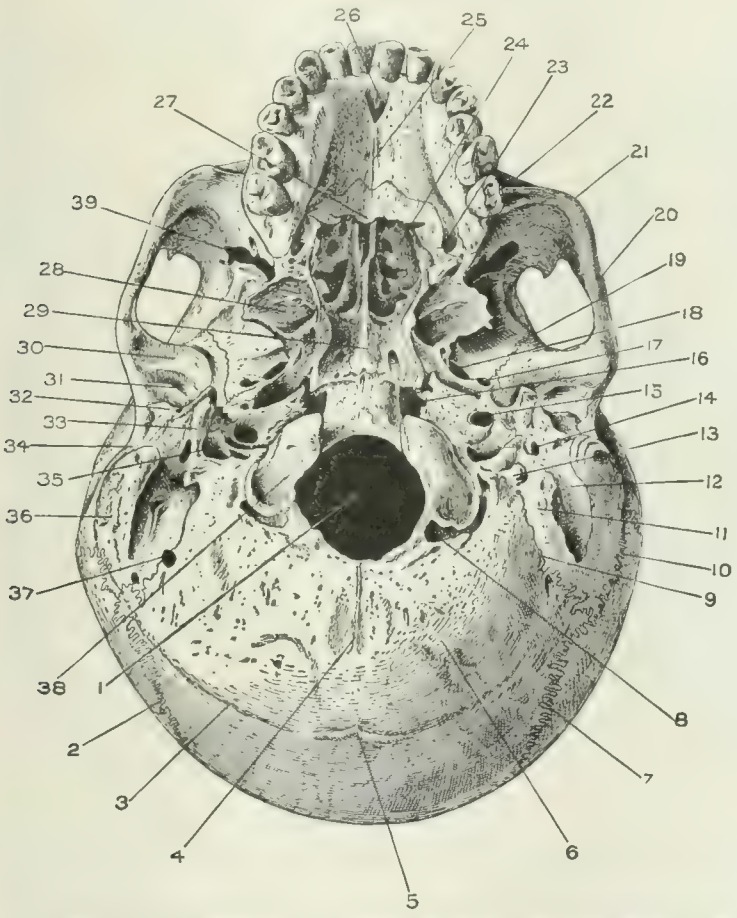


FIG. 4522.—Norma Basilaris. 1, Foramen magnum; 2, lambdoid suture; 3, superior curved line of the occipital bone; 4, external occipital crest; 5, inion; 6, site of inferior curved line; 7, lambdoid suture; 8, posterior condyloid foramen; 9, occipitomastoid suture; 10, parietomastoid suture; 11, groove for occipital artery; 12, digastric fossa; 13, jugular process of occipital bone; 14, stylomastoid foramen; 15, carotid canal; 16, foramen lacerum medium; 17, foramen spinosum; 18, foramen ovale; 19, sphenosquamous suture; 20, zygoma; 21, malar bone; 22, superior maxilla; 23, posterior palatine canal; 24, lateral mass of ethmoid in nasal fossa; 25, intermaxillary suture between the palate processes of the superior maxillæ; 26, anterior palatine canal or fossa; 27, posterior nasal spine on palate bones; 28, pterygoid fossa; 29, part of nasal septum (vomer); 30, eminentia articularis (anterior root of zygoma); 31, glenoid fossa; 32, auditory process flooring the external auditory canal; 33, styloid process; 34, supramastoid crest (posterior root of zygoma); 35, jugular foramen; 36, mastoid process; 37, mastoid foramen; 38, condyle of occipital bone; 39, sphenomaxillary fissure.

Stephanion.—The point where the temporal crest crosses the coronal suture.

Pterion.—The region of the anteroinferior angle of the parietal bone. As a rule there is a *sphenoparietal suture* so that the squamous portion of the temporal bone is separated from the frontal.

Asterion.—The region of the posteroinferior angle of the parietal bone.

Jugal Point.—Located at the angle between the upper border of the zygomatic process and the posterior border of the frontal process of the malar bone.

Gonion.—The outer surface of the angle of the mandible.

Auricular Point.—The center of the aperture of the external auditory canal.

Preauricular Point.—That point which lies immediately in front of the upper end of the tragus on the posterior root of the zygoma.

Postauricular Point.—That point on the supramastoid crest which lies immediately behind and eighteen millimeters (a finger's breadth) below the upper attachment of the auricle.

Dacryon.—That point at the superointernal angle of the orbit where the frontonasal suture meets the lacrymomaxillary suture.

Another anatomical point used in craniometry is the *midpoint* of the *spheno-ethmoidal suture* (called by some anatomists the gonion).

The Temporal Crest (*linea temporalis*).—Curving in a longitudinal direction over the lateral region of the calvarium is the temporal crest. It is often double. The upper ridge marks the limit of attachment of the temporal fascia, while the lower line defines the attachment of the temporal muscle. It commences in front on the external angular process of the frontal bone at the frontomalar suture and sweeps backward and upward across the lower part of the frontal bone, and then crossing the coronal suture at the stephanion, passes to the parietal bone. Curving over this toward the posteroinferior angle of the parietal, it is continued on to the temporal bone to form the supramastoid crest.

The Supramastoid Crest.—The upper edge of the zygomatic process of the temporal bone passes back over the external auditory canal and becomes confluent with a ridge (posterior part of the temporal ridge or crest) that separates the mastoid from the squamous portion of the temporal bone; this ridge is the supramastoid crest or posterior root of the zygoma.

The *basicranial axis* is represented by a line drawn from the basion to the midpoint of the sphenoethmoidal suture, and is formed by the basioccipital, the basisphenoid, and the presphenoid bones.

The *basifacial axis* is indicated by a line drawn from the midpoint of the sphenoethmoidal suture to the subnasal point.

The *craniofacial axis* comprises the basioccipital, basisphenoid, presphenoid, and mesethmoid bones.

The *basibregmatic axis* extends from the basion to the bregma.

The *craniofacial angle* is the one formed by the basicranial and basifacial axes. It is useful in making comparative measurements of crania.

The *longitudinal arc* of the cranium is measured from the nasion along the vertex to the opisthion, and may be subdivided by measuring the lengths of its frontal, parietal, and occipital portions so that the relative proportions of these bones may be noted.

The *basinasal length* is the distance from the basion to the nasion.

The *basialveolar length* is the distance from the basion to the alveolar point.

The *dental length* is the distance, in the upper jaw, from the anterior surface of the first premolar to the posterior surface of the third molar.

The *total circumference of the cranium*, in the sagittal plane, may be obtained by adding together the longitudinal arc, the distance between the opisthion and the basion, and the basinasal length.

Reid's Base Line.—This is a line drawn from the auricular point to the lower margin of the orbit.

The *horizontal circumference* of the cranium is measured around a plane cutting the glabella anteriorly, and the maximum occipital point posteriorly.

In ascertaining the *maximum breadth of the cranium*, which is very variable in its position, it should be noted whether it is above or below the squamoparietal suture.

The *length of the cranium* may be measured between a number of different points, as between the nasion, glabella, or ophryon anteriorly, and the maximum occipital point, or the inion posteriorly.

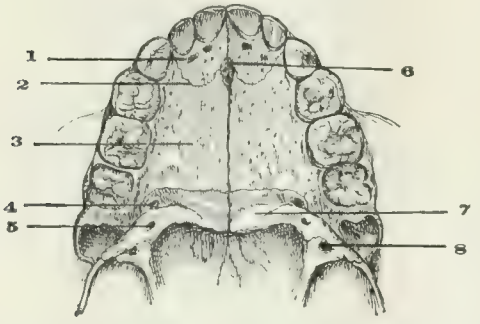


FIG. 4523.—Hard Palate of a Child (about the sixth year). 1, Premaxilla; 2, maxillo-premaxillary suture; 3, palate process of maxilla; 4, posterior palatine canal; 5 and 8, accessory palatine foramina; 6, anterior palatine fossa; 7, horizontal plate of palate bone.

The *bistephanic width* of the cranium is the distance from one stephanion to the other in the horizontal plane.

The *biasterionic diameter* of the cranium is the distance, in the horizontal plane, from one asterion to the other. The opisthion and the floor of the posterior cranial fossa occupy the same horizontal plane as the hard palate. The basion is a little higher than the opisthion. By consequence the plane of the foramen magnum in the higher races is oblique, being directed downward and slightly forward.

In order to describe the cranial peculiarities correctly and to have fixed coordinates to which the measurements can be referred, the skull should be placed, when studied, in the horizontal plane. Anthropologists are not agreed as to this initial plane. In Germany the plane in favor is one passing through the center or top of the contour of the osseous external auditory canal and the inferior border of the orbit. In France and England Broca's alveolocondylean plane is adopted; this plane passes through the alveolar border of the superior maxilla and the condyles of the occipital bone.

Cranial Capacity.—The size of the brain cavity or the cranial capacity is estimated in various ways. Were it not for the fact that the brain cavity of the skull contains so many foramina which it is difficult to close, fluids would be the most accurate agents to use in ascertaining cranial capacity. But practically leaden shot, or seeds, or glass beads are the most serviceable. Cranial capacity is intimately correlated with the development of the brain, and, apart from individual variations and the proportion of head size to stature, it may be stated that the size of the cranium in highly civilized races is greatly in excess of that observed in the lower races.

For the purposes of comparison skulls are grouped according to their cranial capacity as follows: *megacephalic*, with a brain capacity over 1,450 c.c. (mixed Europeans, Japanese, Eskimaux); *mesocephalic*, with a capacity varying from 1,350 c.c. to 1,450 c.c. (some African Negroes, American Indians, Chinese); *microcephalic*, with a capacity below 1,350 c.c. (Veddahs, Australians, Andamanese, Bushmen).

The Cephalic Index.—Comparisons between crania may be made by *indexes*. An index is the ratio between two dimensions that have a natural relation; the normally greater dimension is employed as a base and is assumed to be 100. The ratio is expressed as follows:

Greater dimension : lesser dimension :: 100 : index.

Or,

$$\frac{\text{Lesser dimension} \times 100}{\text{Greater dimension}} = \text{Index.}$$

The cephalic index expresses the relation of the breadth to the length of the cranium and records the proportion of its maximum breadth to its maximum length (the latter being assumed to be equal to 100) in the following formula:

$$\frac{\text{Maximum breadth} \times 100}{\text{Maximum length}} = \text{Cephalic index.}$$

According to the amount of the cephalic index skulls are classified as follows: *Brachycephalic*, index over 80 (American Indians, Malays, Andamanese); *mesaticephalic*, index varying from 75 to 80 (mixed Europeans, mixed Polynesians, Chinese); *dolichocephalic*, with an index below 75 (Australians, Zulus, Fijians, Kaffirs, Eskimaux).

The dolichocephalic skull is more primitive than the brachycephalic one. Generally tall men have long heads, while short men have short or rounded ones. The Norwegians are the tallest men as well as the largest-skulled nation in Europe; the Auvergnats are the shortest of European whites and possess the roundest heads.

The Height Index.—This index expresses the proportion of the height to the length of the cranium and is obtained by the following fromula:

$$\frac{\text{Basiobregmatic height} \times 100}{\text{Maximum length}} = \text{Height or vertical index.}$$

According to the index skulls are divided into *hypsicephalic*, index 75.1 and upward; *orthocephalic*, index from 70.1 to 75; and *chamæcephalic*, index below 70.1.

The Nasal Index.—This index expresses the proportion of the maximum nasal width to the nasal height (measured from the subnasal point to the nasion) and is obtained by the following formula:

$$\frac{\text{Maximum nasal width} \times 100}{\text{Nasal height}} = \text{Nasal index.}$$

The form of the nasal aperture is of great value from an ethnic point of view, since it is so intimately associated with the shape of the nose in the living. According to the nasal index skulls are classified as follows: *Platyrhine*, with index above 53 (Australians, Negroes, etc.); *mesorhine*, index varying from 48 to 53 (Japanese, Chinese); and *leptorphine*, index below 48 (mixed Europeans, American Indians, ancient Egyptians).

The Orbital Index.—This index, though varying considerably in different races, is of much less value for purposes of classification than the nasal index. It expresses the proportion of the height to the width of the orbit. The orbital height is the distance, at its middle, between the lower and upper margins, while the width is measured from the dacryon to the most distant point on the anterior edge of the outer border of the orbit.

The orbital index is obtained by the following formula: $\frac{\text{Orbital height} \times 100}{\text{Orbital width}} = \text{Orbital index}$. Skulls are divided, according to the index, into *megaseme*, index above 89; *mesoseme*, index between 89 and 84; and *microseme*, index below 84.

The Palatomaxillary Index.—This index is used to record the variations occurring in the form of the palate and dental arch. The width is measured between the outer surfaces of the alveolar borders immediately above the second molar tooth of each side, while the length is taken from the alveolar point to the midpoint of a line drawn from the posterior border of one superior maxilla to that of the other. The index is obtained by the following formula: $\frac{\text{Palatomaxillary width} \times 100}{\text{Palatomaxillary length}} = \text{Palatomaxillary index}$. According to the index skulls are classified as follows: *Brachyuranic*, index above 115; *mesuranic*, index between 110 and 115; and *dolichuranic*, index below 110.

The Dental Index.—From an ethnic point of view the proportion of the space occupied by the premolar and molar teeth (dental length), on one side, to the length of the basinasal line has been found to be a character of much value. The dental index is obtained by the following formula: $\frac{\text{Dental length} \times 100}{\text{Basinasal length}} = \text{Dental index}$. According to the index skulls are divided into *megadont*, index above 44 (Australians, Negroes); *mesodont*, index between 42 and 44 (Mongolians); *microdont*, index below 42 (Caucasians).

The Facial Index.—The characteristic features of the race are most readily noted in the face, and measurements of the skeleton of the face are of more value than those of the cranium, though more complex. As a general rule, to which there are many exceptions, it may be stated that a long or dolichocephalic cranium is associated with a long face, and a brachycephalic one with a shorter and rounder face.

There are two varieties of facial index, according to whether the mandible is included in the measurements or not. With the mandible present the measurement is taken from the nasion above to the mental tubercle below, and compared with the greatest bizygomatic diameter. This constitutes the *total facial index*, and is obtained by the following formula: $\frac{\text{Naso-mental length} \times 100}{\text{Bizygomatic diameter}} = \text{Total facial index}$. Since the mandible is frequently missing in skulls it is important to express the relation of length to the breadth of the face by the *superior facial index*, which can be obtained by the following formula: $\frac{\text{Naso-alveolar length} \times 100}{\text{Bizygomatic diameter}} = \text{Superior facial index}$. According to the facial index the following types of face are noted: *chamæprosopic* (broad or low face), *mesoprosopic* (medium-size face), and *leptoprosopic* (high or narrow face). The terms *brachyfacial* and *dolichofacial* have also been employed to record the different faces observed. The proportion of the width of the face to that of the cranium is expressed by terms which indicate that the zygomatic arches are either concealed or observed when the skull is inspected from its norma verticalis. In the former case skulls are roughly described as *cryptozygous;* in the latter as *phænozygous.*

The Alveolar Index.—The degree of projection of the superior maxillæ, so characteristic of certain races, is most readily ascertained by the *alveolar index.* This expresses the proportion of the basialveolar to the basinasal length, the latter being equal to 100. The index is secured by the following formula:

$$\frac{\text{Basialveolar length} \times 100}{\text{Basinasal length}} = \text{Alveolar index.}$$

According to the index races are classified into three groups: *prognathous,* index above 103 (Australians, various African Negroes, Melanesians, Tasmanians);

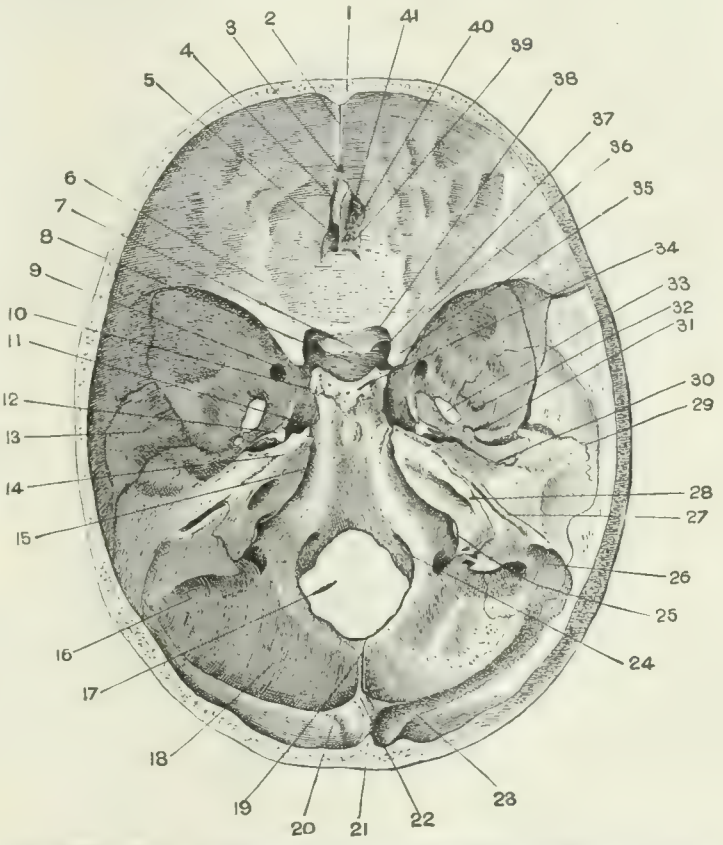


Fig. 4524.—Floor of the Cranial Cavity. 1, Diploë of frontal bone; 2, crest of attachment of the falx cerebri; 3, foramen cecum 4, crista galli of ethmoid; 5, cribriform plate of ethmoid; 6, anterior cranial fossa for lodgment of frontal lobe of cerebrum; 7, olivary eminence (optic groove immediately in front of it); 8, pituitary fossa; 9, foramen rotundum; 10, posterior clinoid process, 11, cavernous groove; 12, foramen lacerum medium; 13, middle cranial fossa for lodgment of temporal lobe of cerebrum; 14, depression for the ganglion of Gasser; 15, groove along the petrooccipital suture for the inferior petrosal sinus; 16, groove for lateral (sigmoid) sinus terminating at jugular foramen; 17, foramen magnum; 18, fossa (posterior cranial) for lodgment of left cerebellar hemisphere; 19, internal occipital crest for attachment of falx cerebelli; 20, fossa for lodgment of occipital lobe of cerebrum; 21, crest for attachment of falx cerebri; 22, internal occipital protuberance; 23, groove for lateral sinus continued from that for the superior longitudinal sinus; 24, anterior condyloid foramen; 25, jugular foramen; 26, groove for sigmoid part of the lateral sinus; 27, groove for the superior petrosal sinus; 28, internal auditory canal; 29, petrosquamous suture; 30, hiatus Fallopii; 31, foramen spinosum; 32, middle cranial fossa; 33, foramen ovale; 34, dorsum sellæ; 35, anterior clinoid process; 36, lesser wing of sphenoid; 37, cavernous groove; 38, optic foramen; 39, 40, cribriform plate of ethmoid; 41, slit for nasal nerve.

mesognathous, index from 98 to 103 (Chinese, Eskimaux, Japanese, mixed Polynesians;) *orthognathous*, index below 98 (ancient Egyptians, mixed Europeans).

In calculating indices the *index calculator*, invented by Dr. Waterston, will be found of great service in saving time.

The amount of projection of the face may be measured by certain angles, the two most important of which are the following, viz., the facial and the maxillary.

The *facial angle* is that subtended by a line drawn from the most prominent part of the forehead above to the most projecting portion of the upper jaw and a second line drawn horizontally from the first through the center of the aperture of the external auditory canal. The more acute this angle is, the smaller is the cranial capacity. The angle is 40° in the orang-outang, 70° to 75° in the African Negro, and 80° in the European whites.

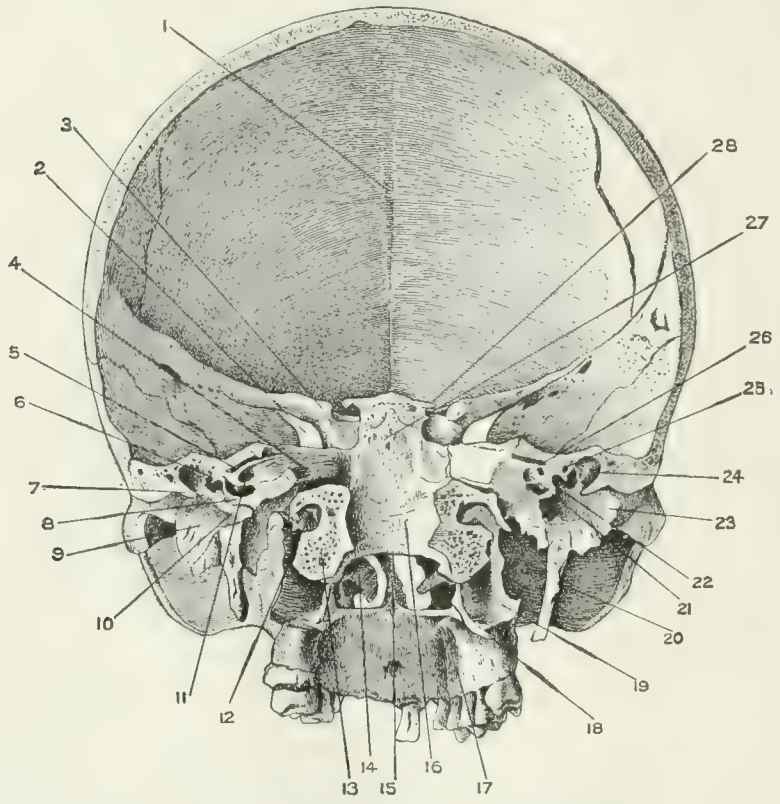


Fig. 4525.—Coronal Section of the Skull through Middle of Occipital Condyle, the Posterior Part of the External Auditory Canal, the Tympanum, Vestibule, Internal Auditory Canal, on each Side, and the Bregma. Front portion tilted forward and viewed from behind. 1, Groove for superior longitudinal sinus; 2, sphenoid fissure; 3, anterior clinoid process; 4, commencement of internal auditory canal; 5, commencement of aqueductus Fallopii at bottom of internal auditory canal; 6, aqueductus Fallopii; 7, floor of attic and roof of external auditory canal; 8, promontory bounding canal of cochlea; 9, auditory process separating external auditory canal from the glenoid fossa in front of it; 10, groove for the membrana tympani; 11, spiral cribriform tract at bottom of internal auditory canal; between 11 and 5 is seen the falciform crest; 12, anterior condyloid foramen; 13, condyle of occipital bone; 14, inferior turbinated bone; 15, vomer; 16, basilar portion of occipital bone; 17, hard palate; 18, hamular process of the internal pterygoid plate; 19, external pterygoid plate; 20, styloid process; 21, spiral cribriform tract; 22, atrium; 23, external auditory canal; 24, attic; 25, aqueductus Fallopii; 26, commencement of aqueductus Fallopii; 27, dorsum sellæ; 28, posterior clinoid process.

The *maxillary angle* is subtended by lines drawn from the most projecting portion of the chin below and the forehead above. The more acute this angle, the more prognathic is the face and the less the chin. The angle is 110° in the orang-outang, 140° in the African Negro, and 160° in the European whites.

Sutures.—The lines of union or sutures between the several bones of the skull also give indications of great value in differentiating races. They are much simpler in the lower races than in the higher, and become obliterated earlier in life. Through this means the bones of the cranium unite into a compact mass and prevent the continued expansion of the brain cavity. Occasionally, in some races more frequently than in others, small distinct bones (Wormian bones) are observed in these sutures. One of these occurs so frequently in certain tribes of American Indians that it has been named the *Inca* bone. It is situated toward the back of the head.

The presence of inferior physical traits in certain races of men is either the perpetuation of the ape-like (pithecoid) characters of the lower animal, which was man's immediate ancestor, or they are atavistic.

As a very brief summary we may say that some of these inferior traits are a wide nasal aperture with synostosis of the nasal bones; simplicity and early union of the cranial sutures, with retarded union of the facial sutures; recession of the chin; prominence of the jaws; articulation of the temporal with the frontal bone; early appearance, large size, and permanence of the wisdom teeth.

In nearly all the black people (Soudanese, Australians, Melanesians, etc.) the wisdom teeth are ordinarily furnished with three separate fangs, while among the whites they decay early and have only two fangs.

It has been justly objected that ethnologists who are mere anatomists have claimed too much for craniology, and that they have given it a prominence which it does not deserve, too often applying it to the exclusion of other elements. The shape of the skull is no indication of race in the individual; only in the average of large numbers has it importance. Within the limits of the same race, as the Slavonians, the greatest variations in skulls are observed. Again the cranial indices were found to vary from seventy to eighty-three among the pure-blooded natives of one of the small islands of the Pacific Ocean.

Nevertheless, employed with a due regard for all the ethnic elements, and in large averages, craniometry is extremely useful as furnishing additional data for comparison.

The cranial characters not only vary according to *race*, but also in each race there are other variations due to *age* and *sex*.

Age Differences in the Skull.—The skull of a new-born infant presents two striking peculiarities, viz., the great predominance of the cranial over the facial portion (eight to one) and its relatively large size in comparison with the body. The diminutive facial portion is due to the small size of the maxillary antrum, the undeveloped condition of the mandible and max-

illæ, and the small size of the nasal fossæ which are as broad as they are high and almost filled with the turbinals. The parietal and frontal eminences are large and conspicuous, but the frontal sinuses and superciliary ridges are wanting. The bones of the vault are without any diploë, and therefore consist of a single layer. The sutures are absent in the cranium.

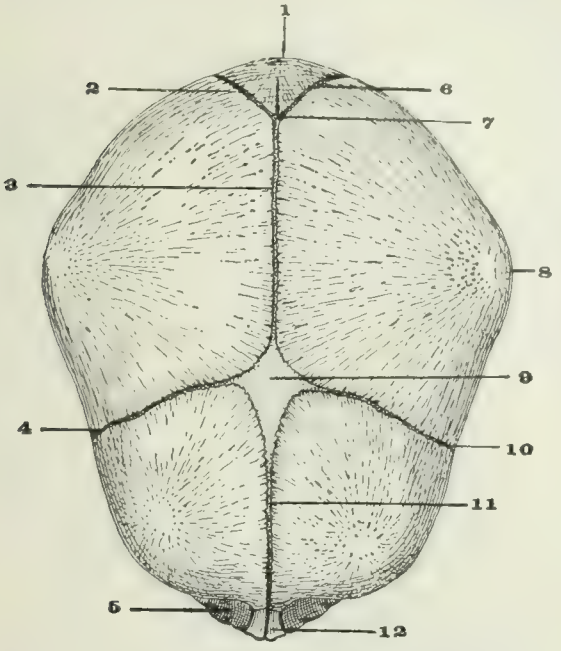


Fig. 4526.—Norma Verticalis of Infant. 1, Interparietal; 2 and 6, lambdoid suture; 7, posterior fontanel; 3, sagittal suture; 8, parietal eminence; 9, anterior fontanel; 4 and 10, coronal suture; 11, interfrontal metopic suture; 5, upper jaw; 12, nasal bone.

Each angle of the parietal bone is undeveloped and in relation with a fontanel. The anterior fontanel is large and lozenge-shaped, the posterior small and triangular, and the lateral ones irregular in shape (Figs. 4526 and 4527).

The most striking facts about the base of the skull are the absence of the mastoid processes, the large angle formed by the pterygoid processes with the base, and the existence of the occipital condyles on the same level with the lower border of the symphysis menti. The frontal bones consist of two elements separated by a *metopic suture*.

The temporal bone consists of three parts, viz., the *squamosal, tympanic,* and *petrosal.* The squamosal has its posteroinferior angle prolonged downward into a *postauditory process*, which forms the outer wall of the mastoid antrum. Its glenoid fossa is very shallow and has a relatively large postglenoid tubercle.

The horseshoe-shaped tympanic bone is attached to the inferior border of the squamosal by its anterior and posterior extremities. A striking feature of the norma lateralis is the absence of the bony external auditory canal. The petrosal presents a cartilaginous styloid process except for a minute nodule of bone (*tympano-hyal*) in its base. There are no mastoid sinuses, but a relatively large mastoid antrum; there is a large and conspicuous floccular fossa. The ossicles of the middle ear are about as large as in the adult. The processus gracilis may reach two centimeters in length.

The occipital bone consists of four elements at birth, viz., *basioccipital, exoccipitals,* and *squamo-occipital.* There are two deep fissures in the latter, separating it partially into a *supraoccipital* portion and an *interparietal* portion (the latter being a membrane bone). There is no jugular process or pharyngeal tubercle. The grooves for the lateral sinuses are lacking.

The maxilla presents on the oral surface of its palatine process the maxillo-premaxillary suture (Fig. 4523). The mandible at birth consists of two parts united by fibrous tissue in the line of the future symphysis menti.

The ethmoid presents three elements, viz., two lateral portions (*ectethmoids*) and a median portion (*ethmovomerine* plate). The uncinate process is undeveloped and the ethmoidal sinuses are represented by shallow depressions.

The sphenoid at birth consists of two lateral segments (*alisphenoids* with their pterygoid processes) and a composite median portion. This median portion is composed of the body of the sphenoid (ankylosed *presphenoid* and *postsphenoid*), the lesser wings of the sphenoid (*orbitosphenoids*), and the *lingulæ*. There is no foramen spinosum, and the future foramen ovale is merely a deep notch in the posterior border of the alisphenoid. The presphenoid is solid and gives no evidence of the sphenoidal sinuses which occupy this region in the adult. The Vidian canal of the adult occurs in the skull at birth as a *groove* between the lingula, the alisphenoid, and the internal plate of its pterygoid process. The sphenoidal turbinals lie in the perichondrium on either side of the ethmovomerine cartilage near its union with the presphenoid. They are two small triangular pieces of bone. The palate bones have their horizontal and vertical portions of the same length.

The vomer presents quite a different appearance from that in the adult.

The lacrymals are thin, delicate lamellæ. The inferior turbinal and the malar are relatively large. The nasals are broad and short.

From the above hasty survey of the skull of the newborn child it will be observed that there are many more bones than are present in the adult. At various periods in intrauterine life the bones are still more numerous. With increasing age the bones are reduced in number through the ankylosis of two or more adjacent bony segments into composite bones. The child

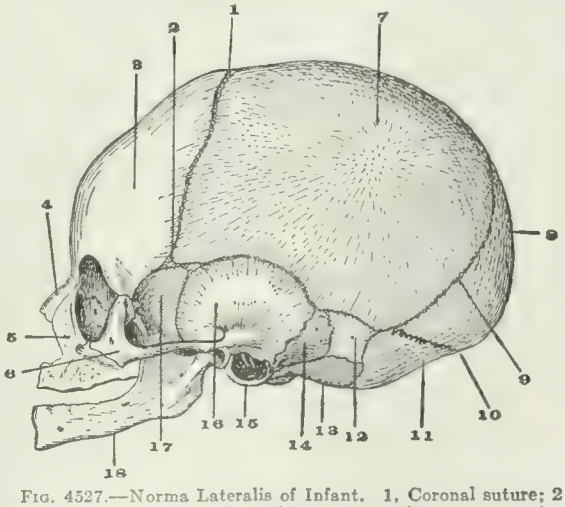


Fig. 4527.—Norma Lateralis of Infant. 1, Coronal suture; 2 anterolateral fontanel; 3, frontal bone; 4, nasal bone; 5, superior maxilla; 6, malar; 7, parietal eminence; 8, interparietal portion of occipital bone; 9, lambdoid suture; 10, fissure between inter- and supraoccipital portions of occipital bone 11, supraoccipital portion of occipital bone; 12, posterolateral fontanel; 13, exoccipital; 14, petrosal; 15, tympanic plate; 16, squamosal; 17, alisphenoid; 18, mandible.

has fewer separate bones in his skull than the infant, the adult fewer than the child, and so on, more or less, until old age. These facts are the explanation of the

occurrence of blood-vascular and nerve foramina in various parts of the adult skull.

The foramina and canals which transmit nerves have been subdivided into primary and secondary groups. *Primary foramina* occur at the points where the nerves leave the general cavity of the dura mater. In a morphological sense a nerve becomes extracranial where it perforates the dura mater, since this membrane largely represents the primitive connective-tissue cranium. Two illustrations of primary foramina are the *foramen magnum* and the *optic foramen*. The former is formed by four bones (the exoccipitals, the basioccipital, and the supraoccipital) ankylosing around the medulla oblongata. The optic foramen is formed by the presphenoid and the orbitosphenoid ankylosing around the optic nerve.

Owing to the fact that human and other high vertebrate adult skulls have undergone, during the evolutionary process, complicated modifications, resulting in highly composite bones, it is observed that elaborate bony canals occur in these adult skulls that are not represented in the adult skulls of more primitive vertebrates, as the Elasmobranchs. In similar manner the adult skulls of high vertebrates contain foramina and elaborate tunnels that are not found in their embryonic condition. Such channels come under the category of *secondary foramina*. A few illustrations are as follows, viz., the Vidian canal, to which reference has already been made; the anterior ethmoidal canal formed by bony ankylosis of the ectoethmoidal and the frontal bones around the nasal branch of the ophthalmic nerve; the *iter chordæ posterius* is a passageway for the chorda tympani nerve to enter the tympanum, and is formed by the ankylosis of the squamosal and tympanic bones around the nerve. The inferior dental canal of the mandible is formed by the ankylosis of several bony embryonic elements around a portion of the inferior dental nerve.

In the adult the face is at least one-half the size of the cranium. About the age of puberty the air sinuses, especially the frontal sinus, expand and develop, leading to characteristic alterations in face and head form. The age of the skull may be approximately estimated by several factors; for instance the eruption of the teeth in infancy and adolescence. When permanent dentition is completed the wear of the teeth may assist in hazarding an approximation. Complete bony union between the sphenoid and occipital bones is an indication of maturity. In old age the cranial bones become thinner and the whole skull lighter; also the condition of the sutures may guide us, since the sagittal and coronal sutures do not undergo synostosis until late in life; also at this period the obtuseness of the mandibular angle increases on account of the flattening of the vault of the hard palate, which is induced by changes in the alveolar borders of the mandible and maxillæ; for owing to the loss of the teeth in the aged, these borders become absorbed. Through this means is induced also a change in the relative position of the mental foramina.

Sexual Differences in the Skull.—The cranial capacity of the female skull is about a tenth less than the male of the same race; it is smaller and lighter; it has less prominent mastoid processes; it is smoother in consequence of the inferior development of the muscular ridges. The supraorbital margin of the frontal bone is sharper and thinner in consequence of the less pronounced character of the superciliary ridges. For the same reason the frontal eminences are more conspicuous and the forehead more vertical. The parietal eminences are more prominent and the glabella less so in the female than in the male.

The edge of the tympanic plate of bone is more rounded and tubercular, whereas in the male it is sharp and divides to ensheath the styloid process. In the female the height of the skull is reduced in consequence of a more flattened vertex. No one of these sexual differences is characteristic, but taken together they enable us to arrive at a fairly accurate conclusion. It may be interesting to recall in this connection that Broca taught that if a skull rests on its mastoid processes it is almost certainly a man's.

Pneumatic Spaces in Connection with the Nasal Fossæ and the Nasopharynx.—Connected either with the nasal fossæ or with the nasopharynx are the following air sinuses or pneumatic spaces: maxillary, frontal, ethmoidal, orbital, sphenoidal, and tubotympanic (Figs. 4528, 4529, 4530, and 4531).

The *maxillary sinus* or *antrum of Highmore* (Fig. 4828) occupies the body of the superior maxilla, and therefore is situated to the outer side of the nasal fossa on either side. It is a pyramidal cavity with its apex directed toward the malar bone and its base formed by the outer wall of the nose. Its walls are relatively thin and are directed forward to the face, inward to the nose, upward to the orbit, backward to the spheno-

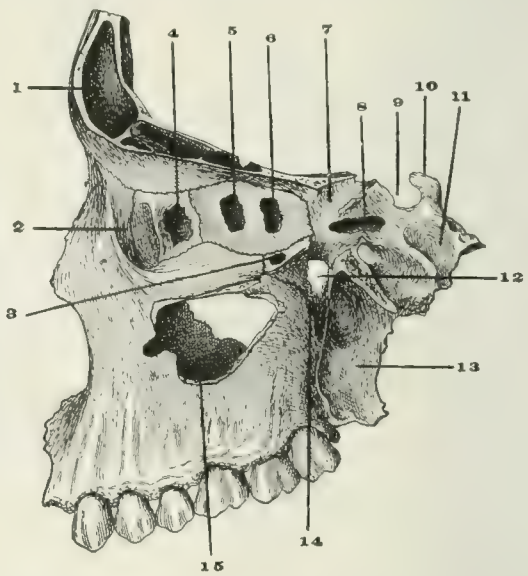


Fig. 4528.—A Section of the Skull showing the Inner Wall of the Orbit and the Air Sinuses. 1, Frontal sinus; 2, lacrymal groove for the nasal sac; 3, orbital sinus; 4, infundibulum shown through opening in lacrymal bone; 5 and 6, anterior and posterior ethmoidal sinuses seen through openings in os planum of ethmoid; 7, optic foramen; 8, opening through body of sphenoid to show sphenoidal sinus; 9, pituitary fossa; 10, dorsum sellæ; 11, cavernous groove; 12, sphenopalatine foramen; 13, external pterygoid plate; 14, sphenomaxillary fossa; 15, maxillary sinus or antrum of Highmore revealed by removal of malar process.

maxillary and zygomatic fossæ, and downward to the alveolar border. Portions of several bones assist in the formation of the thin osseous partition, which nearly, save for the small antral orifices, separates it from the nasal fossa. These bones are the uncinate process of the ethmoid bone, the ethmoidal process of the inferior turbinated bone, a portion of the lacrymal, and the vertical plate of the palate bone. The floor of the antrum is separated from the roots of the molar and bicuspid teeth by bone of varying thickness. Ordinarily the floor of the antrum is on a level with the floor of the nasal fossa. But sometimes the floor of the antrum, when it is thin and devoid of spongiosa, sinks below the level of the fossa; under these circumstances suppuration at the roots of one or more of the teeth in this locality is very prone to extend to the antrum. Wide variations are noted in the size of the maxillary sinus. The cavity may be represented by a narrow cleft; more rarely it is entirely absent.

A large adult antrum will hold 32 c.c. The aver-

age capacity is 14.5 c.c. In a sinus of average dimensions the line of junction of its facial and nasal walls is indicated externally by the outer edge of the canine ridge.

Small recesses and pockets are frequently found on the inner surface of the walls of the sinus, thus favoring the collection of abnormal secretions. The sinus may rarely be completely subdivided into two compartments by a horizontal or vertical partition. In these circumstances both cavities may communicate with the middle meatus; or the superior or posterior compartment may communicate with the superior meatus, while the inferior or anterior one opens into the infundibulum. In the event of this anomaly, the surgeon might fail to find the source of suppuration in the superior or posterior compartment.

The antral orifice is unfavorably situated for natural drainage, since it is at the highest part of the antrum. It opens into the middle meatus of the nose through the posterior extremity of the hiatus semilunaris.

Ordinarily the antrum of Highmore is separated from the neighboring pneumatic spaces by thin bony partitions, and it communicates only with the nasal fossa. Occasionally I have seen a direct, non-pathological channel of communication between the antrum and the anterior ethmoidal cells. In other specimens I have seen a direct channel of communication between the antrum, the orbital, the posterior ethmoidal, and the sphenoidal sinuses.

At birth the maxillary sinus exists in a very rudimentary form, but reaches its full development about twelve years of age.

The *frontal sinus*, one on either side, lies between the outer and inner tables of the frontal bone over the root of the nose and extends outward under the superciliary ridges (Fig. 4528, 1). The septum of bone which separates them is very seldom in the mesial plane. It may be so far removed from this plane that an opening made on one side of it may expose the sinus on the opposite side of the body. The sinus, on either side, communicates, through the infundibulum and front part of the hiatus semilunaris, with the fore part of the middle meatus of the nasal fossa. The sinus is smaller in young people and in women than in men. While there is no necessary correlation between a capacious frontal sinus and a prominent superciliary ridge, it may be stated as a general rule that there is a greater probability of the presence of a well-developed sinus where there is a prominent supraorbital area (including a prominent superciliary ridge and nasal eminence). The outer table of the sinus is the thickest, but varies considerably in different skulls. Its average thickness is about five millimeters. It has a large amount of diploic tissue, which accounts for the possibility of septic infection when it is opened, and also for the hemorrhage that occurs from it. The inner table is thin and brittle. The floor of the cavity overlies the orbit, as well as the upper border of the lacrymal and the anterior part of the superior border of the lateral mass of the ethmoid. The floor is the thinnest wall, especially at the superointernal angle of the orbit. Accordingly when there is empyema of the sinus the pus tends to point at the upper and inner angle of the orbit. This pneumatic chamber may extend upward on the forehead for forty millimeters; laterally as far as the external angle of the orbit; backward as far as the lesser wing of the sphenoid, on either side, thus separating the horizontal portion of the frontal bone (the roof of either orbit) into two tables, viz., orbital table and cerebral table. It may communicate by a large opening with a well-marked sinus in the crista galli.

The cavities are very unsymmetrical and irregular. They may be very small or altogether absent. The sinus may be present on one side and absent on the other. The sinus becomes funnel-shaped as it passes downward to the ethmoidal infundibulum. The ostium of the frontal sinus is found at a short distance from the septum and at the most dependent part of the cavity. It may be situated twenty-eight millimeters behind the outer table of the frontal bone. Incomplete trabeculæ of bone often divide the sinus into recesses of various sizes and shapes.

The frontal sinus is absent at birth. It appears about the seventh year and develops only slightly up to puberty, when it increases rapidly in size, reaching its maximum growth about the twentieth year.

The *ethmoidal sinuses* (Fig. 4528, 5 and 6) are placed between the cavities of the orbit and the superolateral part of the nasal fossæ, being separated from them by thin and papery walls. These pneumatic spaces are completed by the ethmoids articulating with the sphenoidal turbinate, palate, frontal, lacrymal, and superior maxillary bones.

The thin partitions are frequently absent at various points. For instance, some of the ethmomaxillary septa may be absent, thus permitting the ethmoid cells to communicate directly with the maxillary sinus, as already mentioned; again the ethmofrontal (orbital plate) partitions may be deficient so that a direct communication may exist between the ethmoid cells and a large sinus which is sometimes present between the two walls of the orbital plate and extends well back toward the optic foramen.

The sinuses are separated into two groups by thin bony septa—an anterior and a posterior group. The anterior and sometimes a middle group of cells open either independently or through the ethmoidal infundibulum into the upper part of the hiatus semilunaris, and therefore into the middle meatus of the nasal fossa; the posterior ones open into the superior meatus. Ordinarily the ethmoidal cells are separated from the orbital cavity by the thin plate of bone called the *os planum*. Occasionally, as a result of arrest of development and in old people, the os planum may be defective in parts and the sinuses are then separated from the orbit only by membrane. A study of horizontal and coronal sections will disclose the fact that the pneumatic spaces increase in size from above downward, and from before backward.

The anterior ethmoidal cells ordinarily communicate, through the infundibulum, with the frontal sinus; occasionally they communicate directly with the maxillary sinus. The posterior ethmoidal cells occasionally communicate with the orbital sinus, and may through the latter communicate with the sphenoidal sinus or the antrum of Highmore, or with both the latter.

The ethmoidal cells are usually absent in infant skulls. They appear about the fourth year, and reach their full development about the twentieth year.

The *orbital sinus* is situated in the orbital process of the vertical plate of the palate bone (Fig. 4528, 3). The orbital process, therefore, from an ophthalmological and rhinological point of view, is a very important structure, whose relative anatomy should be carefully studied. It presents five surfaces, three of which are *articular*, and two free or *non-articular*. The maxillary surface looks forward, outward, and downward, and articulates with the superior maxilla; the ethmoidal surface looks inward, forward, and upward, and articulates with the lateral mass of the ethmoid, helping to close in the posterior ethmoidal cells; the sphenoidal surface looks backward, inward, and upward, and articulates with the vertical portion of the sphenoidal turbinated bone. The zygomatic surface lies in the sphenomaxillary fossa, looking toward the zygomatic fossa. The orbital surface helps to form the floor of the orbital fossa at its apex. Ordinarily the orbital pneumatic space or sinus communicates with the sphenoidal sinus. Sometimes it communicates with the posterior ethmoidal cells. On several occasions I have seen it communicate not only with both of the above-mentioned pneumatic spaces, but also with the antrum of Highmore, so that there has been a direct continuity between the maxillary,

orbital, posterior ethmoidal, and sphenoidal sinuses. Under these circumstances a severe empyema of these sinuses, leading to caries of bone, could produce grave complications, jeopardizing life through extension to the brain, or vision through extension to the orbit and its contents.

The *sphenoidal sinuses* (Fig. 4528, 8), very variable in shape and size, are usually separated from one another by a sagittally placed bony septum. This septum is frequently displaced to one or other side, and may be more or less oblique. The sinuses are situated in the body of the sphenoid and often extend well down into the pterygoid processes and out into the bases of the great wings of the sphenoid.

In front and below they are bounded, in part, by the sphenoidal turbinated bone. Above the latter an irregular opening is left by which the sphenoidal sinuses communicate with the upper and back part of the nose in the region of the sphenoethmoidal recess. Occasionally they communicate with the posterior ethmoidal cells.

One or both of the sinuses may be absent or replaced by diploë. The sphenoidal sinus is not present at birth. The time of its appearance is stated to be the third year (Steiner), seventh year (Laurent), or the twentieth year (Tillaux).

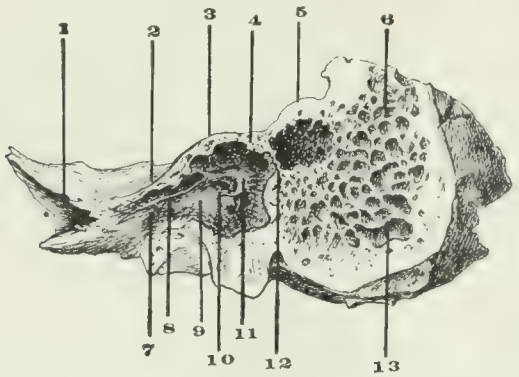


Fig. 4529.—Tubotympanic Pneumatic Cavity and Mastoid Sinuses, shown by removal of outer boundaries of the petromastoid portion of the temporal bone. 1, Carotid canal; 2, tegmen tympani over tube for tensor tympani muscle; 3, tegmen tympani over attic; 4, part of external wall of antrum; 5, tegmen tympani over antrum; 6, mastoid cells; 7, Eustachian tube; 8, processus cochleariformis; 9, promontory in atrium; 10, foramen ovale; 11, external horizontal semicircular canal; 12, part of external wall of antrum; 13, mastoid cells.

The location of the nasal opening into the sphenoidal sinus varies very much. In empyema of the sinus a probe, or the long, slender nozzle of a syringe, can sometimes be made to enter the cavity by passing it directly backward along the inferior margin of the middle turbinal. In other cases the sphenoidal opening is more laterally placed and on a higher level. Under these circumstances the probe must cross the posterior third of the turbinal and curve outward. Certain diseases of the sinus require that it should be freely opened. The distance of the anterior wall of the body of the sphenoid from the end of the nose should be ascertained and indicated on the drill. The anterior wall should then be drilled carefully and, sufficient allowance for the penetration of the wall being made, the surgeon knows precisely the distance beyond which the drill should not be passed. A sufficient opening having been made by the drill, the cavity is cleansed by curetting.

The Tubotympanic Cavity or Pneumatic Chamber.—This cavity, though varying much in its dimensions in individual cases, is practically of full size at birth. From an anatomical and pathological point of view it is well to remember that the tympanum consists of three very important divisions, viz., the *mastoid antrum*, the recessus epitympanicus or *attic*, and the tympanum proper or *atrium* (Fig. 4529). The recessus hypotympanicus is an arbitrary subdivision of the atrium, interesting because of its relation to the jugular fossa. At birth the mastoid cells do not exist.

The *mastoid antrum*, like the other subdivisions of the tympanum, is practically of the same size at birth as in the adult. Its roof is formed by the thin *tegmen tympani*, and extends forward as the roof of the attic and tensor tympani canal. It communicates in front with the attic. In the rest of its course it is bounded by the diploëtic and pneumatic tissue of the bone. Its vertical measurement is about seven millimeters; the transverse measurement is about nine millimeters. At birth the outer wall is bounded by a thin plate of bone belonging to the squamous portion of the temporal bone (squamosal) and is only about one or two millimeters thick, but it increases to about ten millimeters at the ninth year. Coincidently with the development of the mastoid process (which begins at the second year and reaches its maximum growth after puberty) the mastoid cells (Fig. 4529, 6 and 13) develop backward and downward as radiate or racemose diverticula from the tubotympanic pneumatic space, especially from the antrum, and show in different skulls the greatest possible variations. Up to the second year the tiny mastoid contains only diploëtic structure, and in the developed bone this may never be wholly displaced. Randall states that in his study of 1,000 bones he found scarcely two per cent. which could be classed as diploëtic, and only about ten per cent. revealed a notable amount of diploë combined with the pneumatic spaces. No mastoid is entirely pneumatic, though we may meet with a large, thin-walled, single pneumatic space occupying the greater part of the process in senile bones.

Through osteosclerosis a solid mastoid process may occasionally be seen. The pneumatic cells, when present, are not limited to the mastoid process, but extend upward toward the squama, forward over the roof of the external auditory canal, and may extend into the zygomatic process; some generally extend into the floor of the Eustachian tube lying in close relation with the carotid artery; others may extend inward toward the temporooccipital suture, sometimes invading the pars jugularis of the occipital bone. While a dolichocephalic skull is more likely to present a pneumatic mastoid than a brachycephalic one, and while a prominent, large mastoid is more liable to be pneumatic than a small, ill-developed one, there is no method of determining beforehand the condition of the interior of the bone.

The antrum merges, anteriorly, almost imperceptibly into the attic through a triangular-shaped, hourglass contraction called the *aditus*, made by the outward bulging, from the inner wall of the tympanum, of the horizontal semicircular and facial-nerve canals. The boundaries of the *aditus* are very important surgically and are as follows: *above*, the base of the triangle is formed by the tegmen tympani; the *inner boundary* is formed by a prominence of compact bone containing the external semiciruclar canal, and below and in front of this is the portion of the aquæductus Fallopii winding above and behind the fenestra ovalis. The bony wall of the aqueduct at this point is very thin, and at times entirely lacking, so that an inflammation of the tympanum can readily extend to the facial nerve. The *outer wall* of the aditus is formed by the deepest part of the posterosuperior wall (squamosal) of the bony external auditory canal. The *apex* of the triangular aditus is formed by the junction of the outer and inner walls in this region. Ordinarily the aditus will admit an instrument about five millimeters in diameter.

The *attic* (Figs. 4529, 3; 4525, 24) is broadest above where it has as its roof the *tegmen tympani*, the latter extending backward as the roof of the antrum and

forward as the roof of the canal for the tensor tympani muscle. It is about seven millimeters in its anteroposterior direction, about five millimeters vertically, and four millimeters in breadth. The roof, sometimes deficient to a varying degree, separates the tympanic cavity from the cranial cavity; it is limited externally by the *petrosquamous suture.* This suture may remain unossified for several years after birth or even permanently and thus afford a channel by which pyogenic infection may spread from the tympanum to the meninges and brain.

The attic overhangs markedly the inner end of the external auditory canal (Fig. 4525, 7, 24). It opens backward into the antrum and downward and inward into the *atrium* or tympanum proper. In the rest of its course it is surrounded by the diploëtic tissue of the bone. It contains, enveloped by mucous membrane, the head of the malleus, the body and the short process of the incus, the latter projecting into the aditus.

The *atrium* or tympanum proper (Fig. 4529, 9) is that portion of the general tympanic cavity which is below the attic and internal to the membrana tympani. It is bounded externally by the tympanic bone or annulus and the membrana tympani, which is fixed in the tympanic groove of the bony ring.

On a level with the upper edge of the membrana tympani

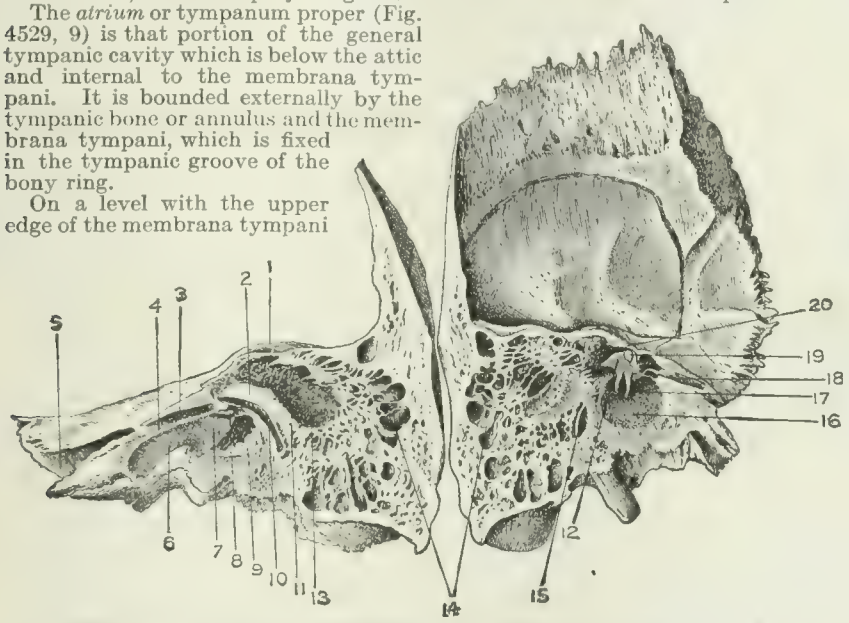


Fig. 4530.—Section through Temporal Bone showing Tubotympanic Air Chamber and Mastoid Cells; also Membrana Tympani and Auditory Ossicles. 1, Tegmen tympani over antrum; 2, external semicircular canal and aquæductus Fallopii; 3, tegmen over tube for tensor tympani muscle; 4, process cochleariformis; 5, carotid canal; 6, Eustachian tube; 7, promontory; 8, crosses fossula rotunda to the stapes; 9, recessus hypotympanicus; 10, aquæductus Fallopii; 11, diploetic tissue at posterior part of atrium with the aquæductus Fallopii descending through it; 12, body and short ramus of incus in the attic; 13, antrum; 14, mastoid cells; 15, aquæductus Fallopii; 16, membrana tympani; 17, manubrium of malleus; 18, tensor tympani muscle; 19, head of malleus in the attic; 20, tegmen tympani roofing attic.

in front of the annulus is the tympanic end of the *Glaserian fissure* (remnant of the fissura petrotympanica). Close to the inner end of this fissure, and forming a division of it, is the commencement of the *iter chordæ anterius,* which transmits the chorda tympani from the tympanum.

It is bounded internally by the outer surface of the labyrinth or internal ear. It presents, in the macerated bone, (1) a reniform opening (*fenestra ovalis*) which leads into the vestibule of the labyrinth, but in the recent state of the bone this opening is closed by the foot of the stapes, surrounded by its *ligamentum annulare.* Below this is (2) a rounded eminence (*promontory*) due to the first turn of the cochlea. (3) Above and behind the fenestra ovalis is a portion of the *aqueduct of Fallopius* or canalis facialis. (4) In front of the fenestra ovalis is the *processus cochleariformis,* which here makes a sharp turn outward, and forms a pulley over which the tendon of the tensor tympani muscle plays. (5) A funnel-shaped recess (*fossula fenestræ cochleæ*) is situated at the posteroinferior part of the promontory, and is directed toward the *fenestra rotunda,* which in the macerated bone leads into the cochlea, but in the recent state is closed by a membrane (*secondary membrana tympani*).

The anterior wall of the atrium is narrowed vertically by the ascent of the floor and descent of the roof, and transversely by the approximation of the inner and outer boundaries of the cavity. At this point are two bony parallel canals separated by the bony *processus cochleariformis* and placed one above the other. The upper is the canal for the tensor tympani muscle, while the lower is the osseous Eustachian tube. The latter communicates with the nasopharynx through the membranocartilaginous Eustachian tube.

The posterior wall of the atrium presents from above downward the following: 1. A minute conical bony eminence (*pyramid*). The pyramid is hollow and contains the stapedius muscle. The tendon of the stapedius perforates the apex of the pyramid, and is inserted into the posterior surface of the neck of the stapes. The base of the pyramid communicates with the aqueduct of Fallopius by one or two small foramina for the passage of the nerve and vessels to the stapedius. 2. Immediately below the pyramid is the minute aperture of the *iter chordæ posterius,* which communicates with the aqueductus Fallopii and transmits the *chorda tympani nerve* from the facial nerve to the tympanic cavity. The chorda tympani, covered by mucous membrane, passes along the upper border of the drumhead between the handle of the malleus and the vertical ramus of the incus to enter the iter chordæ anterius. 3. There is sometimes seen below the aperture of the iter chordæ posterius a rounded eminence (*prominentia styloidea*) which is caused by the forward and upward prolongation of the styloid process. The aqueduct of Fallopius continues down from the posterior part of the fenestra ovalis through the diploëtic tissue of the posterior wall of the atrium to the stylomastoid foramen.

The front part of the *floor* of the atrium is in relation with the first bend or convexity of the carotid canal. At this point the bony septum may be absent and the artery separated from the tympanum only by membrane.

It may be well to state at this point that the outer wall of the carotid canal is in very close proximity to the bony Eustachian tube, and since dehiscence of the bony septum is here more frequent, the aural surgeon should always exercise great care in bougieing this passage.

The back part of the floor of the tympanum is in relation with the jugular fossa and presents small depressions separated by slight bony trabeculæ, thus producing an irregular region that has been called the *recessus hypotympanicus.* It is important because it is often quite encroached upon by the bulb of the internal jugular vein in the jugular fossa.

At times the lateral sinus is unusually large and arches far forward. Under these circumstances the bulb of the internal jugular is unduly large, and the jugular fossa which contains it may arch well up into the floor of the tympanum and be separated from the cavity by a thin and translucent septum of bone, or even the bone may be dehiscent. In such cases as this the bulb of the internal jugular has been wounded in performing a paracentesis of the tympanic membrane or drumhead.

In the anteroposterior direction the atrium measures about twelve millimeters, of which nine millimeters is bounded by the membrana tympani; from the floor of the atrium to the commencement of the attic is about ten millimeters; the narrowest part of the atrium, 2.5 millimeters, is caused by the outward projection of the promontory and the inward traction of the center of the membrana tympani (*umbo*). Owing to the great obliquity of the drumhead the handle of the malleus is very obliquely placed in the drum; also the long ramus of the incus is quite oblique. The stapes, since it is placed at a right angle to the tip of the long ramus of the incus, passes upward and inward very obliquely toward

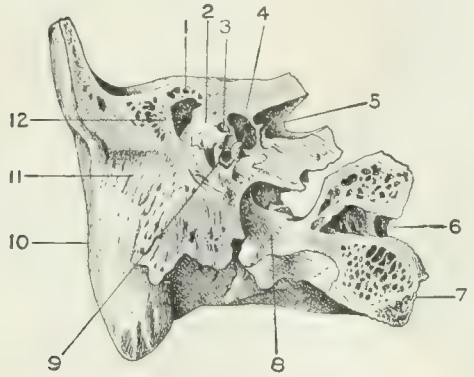


Fig. 4531.—Transverse Section through Temporal Bone and Condyle of Occipital Bone, showing especially the *Aditus*. 1, Tegmen tympani roofing in the aditus; 2, inner wall (external semicircular canal) of the aditus; 12, outer (squamosal) wall of aditus; 3, aquæductus Fallopii; 4, vestibule; 5, internal auditory canal; 6, part of anterior condyloid foramen; 7, condyle of occipital bone; 8, jugular foramen; 9, pyramid with foramen at apex for exit of tendon of the stapedius muscle; 10, mastoid portion of temporal bone; 11, external auditory canal.

the fenestra ovalis. The atrium is placed in the midst of the temporal bone, about twenty to thirty-five millimeters from the entrance of the external auditory canal.

Bony Landmarks of the Skull (Figs. 4519, 4520, 4521).—Among the many landmarks of the skull the following can readily be palpated, viz., the inion, lambda, glabella, nasion, mastoid process, the supramastoid crest, suprameatal spine, nasal spine, osseous anterior nares, the bridge of the nose, the superciliary ridges, the external and internal angular processes of the frontal bone, the infra- and supraorbital margins, the supraorbital notch, the malar bone, the anterior part of the temporal crest, the region of the canine fossa of the superior maxilla, the lower portions of the borders of the ramus, the angle and mental tubercle of the mandible, and the zygomatic arch.

The *inion* is about fifty millimeters above the spine of the axis or second cervical vertebra and twenty-five millimeters below the posterior pole of the cranium. The inion not being developed in the child, its position is defined by taking a point at the junction of the middle and upper thirds of a line drawn from the spine of the axis to the posterior pole of the cranium.

The *lambda* can generally be felt through the scalp and is situated about sixty-three millimeters above the inion. The parietooccipital fissure, in the adult, lies opposite, or a few millimeters in front of, the lambda; in the child the fissure may be as much as twenty-five in front of it.

The *bregma*, in the child, is occupied by the anterior fontanel; in the adult it is about a third of the distance from the nasion to the inion.

The *zygomatic arch* is a very important landmark. In the natural position of the head it is horizontal, and is on the same level as the inion and the infraorbital margin. Its upper border about indicates the level of the lower lateral margin of the cerebral hemisphere. By tracing the upper border of the zygoma backward we shall find that it passes immediately above the tragus and the external auditory canal to become continuous with the *supramastoid crest* or posterior root of the zygoma (posterior portion of the temporal crest).

If a line is carried in a vertical coronal plane from the *preauricular point* on one side to that on the other, it will pass through the bregma. The *lower end* of the fissure of Rolando is situated 50 millimeters vertically above the preauricular point.

The *pterion* cannot be felt, but may be located two fingers' breadth (37 millimeters) vertically above the middle of the zygomatic arch. It locates the *Sylvian point*—the point where the fissure of Sylvius divides into its three branches; it overlies also the anterior branch of the middle meningeal artery.

The posterior extremity of the *left* inferior frontal convolution (*Broca's convolution*) is situated about three fingers' breadth (56 millimeters) above the middle of the left zygomatic arch.

The junction of the motor areas for the face and arm is situated at the junction of the lower and middle thirds of the Rolandic area, which is indicated by the highest part of the *temporal crest*.

The *parietal eminence* overlies the supramarginal convolution of the brain, and therefore also the terminal part of the posterior horizontal limb of the fissure of Sylvius.

The *frontal eminence* overlies the middle frontal convolution of the cerebrum.

Slightly above the outer canthus of the eyelids is located the *frontomalar suture*, directly above which is the *external angular process* of the frontal bone. The lower lateral margin of the frontal lobe of the cerebrum is situated 12 millimeters above the tip of the external angular process. About 12 millimeters below the process is a small *tubercle* on the posterior border of the malar bone; a line drawn from this tubercle to the lambda overlies the superior temporosphenoidal fissure (*parallel fissure*) and corresponds to the descending horn of the lateral ventricle. That part of the temporal crest which extends between the external angular process and the coronal suture is located a little above the level of the inferior frontal fissure.

Situated at the junction of the inner and middle thirds of the supraorbital margin is the *supraorbital notch*. A line carried downward from this notch to the lower border of the mandible and crossing the interval between the lower bicuspid teeth will pass over the *infraorbital* and *mental* foramina, the latter being situated about midway between the upper and lower borders of the mandible, while the former is about 12 millimeters below the infraorbital margin. These foramina furnish the guides for the operation of neurectomy to relieve neuralgia of the trifacial nerve.

On a level with the crown of the last molar tooth and midway between the posterior and anterior borders of the ramus of the mandible the inferior dental nerve enters the inferior dental canal on the inner surface of the ramus of the mandible. Consequently neurectomy of this nerve can be performed by trephining the corresponding outer surface of the ramus. Since the lingual nerve lies a little anterior to the in-

ferior dental nerve, it can be exposed through the same opening.

A landmark of interest to ophthalmic surgeons is the *lacrymal tubercle*, which is situated at the junction of the infraorbital margin belonging to the body of the superior maxilla, and the anterior border of the lacrymal groove on the nasal process of the superior maxilla. In the operation for lacrymal fistula it serves as a guide to the position of the lacrymal sac.

The lacrymal groove is a bony groove situated between the crest of the lacrymal bone and the nasal process of the superior maxillary bone. It contains the lacrymal sac, which is the most important part of the lacrymal apparatus, since it is the seat of very disfiguring diseases. The lacrymal groove is directly continuous with the nasal duct. The latter passes downward and slightly backward and outward to open, under cover of the anterior extremity of the inferior turbinated bone, into the inferior meatus of the nose, at the junction of its anterior fourth with its posterior three-fourths, at a distance of from 30 to 35 millimeters from the posterior boundary of the nostril.

The general direction of the duct is best expressed by a line extending from the inner canthus of the eye to the interval between the premolar and the first molar tooth of the upper jaw.

The sac measures from 12 to 15 millimeters in length, from 4 to 5 millimeters in breadth, and about 7 millimeters anteroposteriorly. It is narrowest at its termination in the nasal duct.

The nasal duct has a diameter of 3 or 4 millimeters, and averages about 18 millimeters in length. The duct is somewhat narrower near its middle than at its lower or its upper extremity.

On the living subject by drawing the lids outward, the *internal palpebral ligament* (tendo oculi) is made tense, and can be felt as a narrow tense band passing inward transversely, and in front of the lacrymal sac, to be attached to the nasal process of the superior maxillary bone. The ligament passes a little above the center of the lacrymal sac, and is a guide to its position. Spontaneous rupture of an abscess of the lacrymal sac almost invariably takes place just below the internal palpebral ligament. In opening a lacrymal abscess in this the best location, the incision should be made a little external to the angular artery.

The position of the mastoid antrum is represented by Macewen's *suprameatal triangle*, situated a little behind and above the bony external auditory canal. This triangle is bounded by the posterosuperior segment of the bony external auditory canal below, by the supramastoid crest above, and by an imaginary line joining the above boundaries. Accoridng to Macewen, if the aperture of the bony external auditory canal be bisected horizontally, the upper half would approximately be on a level with the mastoid antrum. On bisecting this upper segment vertically its posterior half would correspond roughly to the junction of the antrum and the attic, and immediately behind this is the suprameatal triangle. Macewen states that the level of the base of the brain will be 1 or 2 millimeters above the supramastoid crest and about 5 or 6 millimeters above the roof of the osseous external auditory canal.

The supramastoid crest, which indicates the roof of the antrum as well as the floor of the middle cranial fossa, may vary as much as 20 millimeters down or up. Measurements on large numbers of skulls show that the middle cranial fossa is never 10 millimeters below the supramastoid crest. But the crest is sometimes imperfectly developed and cannot be relied upon as a landmark.

The *suprameatal spine* is situated at the posterosuperior portion of the aperture of the bony external auditory canal, and has the suprameatal triangle or fossa back of it (Fig. 4520, 28*a*). This spine can almost invariably be recognized as indicating the posterosuperior portion of the opening of the bony meatus. Randall states that he has found the floor of the middle cranial fossa as low as this spine only five times in 1,000 bones. It averages about 6 millimeters above the spine. The suprameatal spine is a safer guide for avoiding the middle fossa of the cranium than is the supramastoid crest.

In opening the mastoid sinuses it should be borne in mind that the *mastoid foramen*, extending from that portion of the groove for the lateral sinus called the *sigmoid fossa*, and terminating on the exterior at or near the occipitotemporal suture, is very variable in size. It usually transmits a small emissary vein from the lateral sinus to the occipital vein. Sometimes the foramen may be so large as to transmit all the blood from the lateral sinus to the external jugular vein.

The sigmoid fossa, and consequently the lateral sinus, varies very much in its outward curving; it may even project to the external cortex or table of the mastoid process.

On account of the non-development of the mastoid process and the tympanic plate in the infant the stylomastoid foramen is situated upon the *lateral surface of the skull* instead of at its base. Hence the facial nerve emerges from the foramen immediately behind the annulus, and is unprotected. Therefore in infants the incision through the integument and subjacent soft parts, for the purpose of reaching the cranial wall, should not extend too far forward and downward, otherwise the facial nerve will be severed.

DANIEL KERFOOT SHUTE.

Skullcap.—See *Scutellaria*.

Sleep, and Its Disorders.—From the earliest times the phenomenon of sleep has been a matter of mystery and consequently has excited all sorts of conjecture. The theories in vogue in the infancy of our race may be surmised from those existent among savage tribes to-day. The natives of Africa, for example, believe that when a man sleeps a spirit leaves the body and wanders about, undergoing experiences which are dimly recalled on awakening and are called dreams. These latter gave origin to the supposition of a double personality. For the savage, after a vivid dream of an exciting hunt, wakes to find his body in the same spot where he fell asleep a half-hour since and can only reconcile these apparently contradictory experiences by supposing that he has two individualities.

The history of what might be called the scientific knowledge of sleep seems to be that of a procession of theories, presented by one set of investigators only to be superseded by entirely opposite views from the next set. Even to-day our knowledge of this state is extremely nebulous. Certain isolated facts to be sure are in our possession. A few definite facts have been determined, most of which are objective phenomena, and upon this flimsy foundation many speculations have been reared. Naturally a great amount of literature has arisen about the subject. Much of it is merely in the nature of theorizing, or the criticizing of theories, a little of it consists of attempts to accumulate data, and a very small part of it adds definitely to our knowledge of the sleep state. Among the prominent workers in this field must be mentioned Mosso, Hartley, Howell, Manacéine, Heubel, Sidis, and Shepard.

The theories of sleep may be roughly divided into the physiological, the pathological, and the psychological. The physiological theories have been the most popular, the most widely held being the one that sleep is due to cerebral anemia. Ideas which have much in common with the cerebral anemia theory suppose a stasis of blood in some part of the body with a consequent withdrawal of blood from the brain. Thus Forneris thought that a stasis of blood occurred in the thyroid gland, while Osborne favored the arach-

noid plexus. Purkinje thought that the basal ganglia, becoming engorged, compressed the bundles of the corona radiata.

The favorite physiological theory of the eighteenth century was that the sleeping state was due to congestion of the brain. Among the exponents of this theory may be mentioned Haller, Müller, Hartley, and Cappie, and later, Cabanis, Marshall Hall, Macnish, W. B. Carpenter, G. H. Lewes, Holland, and Sieveking. The congestion theory was thus expressed by Hartley, "It appears then that during sleep the blood is accumulated in the veins and particularly in the venal sinuses which surround the brain and spinal marrow. It follows therefore that the brain and spinal marrow will be particularly compressed during sleep, since the blood then takes up more space, is particularly accumulated within the cavities of the skull and vertebræ, and the hardness of these bones will not suffer them to yield or make more room. In short this compression will result in sleep."

The idea of cerebral anemia has been a popular one. It was originated probably by Blumenbach who supposed the anemia to be under vasomotor control. Among the prominent supporters of this view have been Durham, Claude Bernard, Hammond, Howell, Viziolo, Kussmaul, Lehman, de Fleury, Krauss, Patrizi, Tarchanoff, and Leonard Hill. Of course the great objection to this idea is the circumstance that, so far as we know, there is no vasomotor system controlling the brain itself.

Mosso, in 1881, published a study of sleep which he had made in three trephined cases. (Kreislauf des Blutes in Menschlichen Gehirn.) His conclusions were that in sleep there was a relaxation of the vessels of the limbs and a decrease of blood supply to the brain, but he did not believe that cerebral anemia was the cause of sleep. Mays, in 1882, published a few records from two subjects which seemed to show a fall of the brain volume, but his results were somewhat uncertain.

Leonard Hill's investigations were made almost entirely on dogs. He found that the amount of blood in the brain must be the same in all physiological conditions (Monro-Kellie doctrine). He called attention to the fact that the studying of the blood supply to the brain with an open cranium changes the physical condition of the cerebral circulation, exposes the cerebral capillaries to the air pressure, and permits alteration of brain volume. He could find no evidence of vasomotor control within the brain circulation. Instead, the cerebral venous pressure always varied absolutely with general venous pressure and proportionately with arterial pressure. Sleep, with its lowered blood pressure, he concludes, is always due to cerebral anemia, accompanied perhaps by venous congestion; and the blood pressure, in this process is, controlled by the degree of splanchnic constriction maintained by the vasomotor center.

Two theories which are not susceptible of direct proof, but which are ingenious and fit the facts, as far as we know them, are those of cell fatigue (Rabl Rückardt, Lepine and Duval) and the supposition that sleep is due to a sort of ameboid movement of the neuroglia (Ramon y Cajal).

Another kind of theory, based on the assumption that sleep is a pathological process, has been presented in many forms. Sommer's view was that during the day there arose an impoverishment of oxygen in the brain which resulted in a sort of stuporous state during which the supply of oxygen was replenished. A similar theory was that evolved by Pflüger who believed that during sleep the formation of carbonic acid was arrested; Dubois had a similar theory. This idea has its adherents even to-day. We find in a symposium on sleep, published in the *British Medical Journal* in 1913, a statement by W. H. B. Stoddart that a supply of carbon dioxide is essential to sleep and in support of this statement he alleges that patients with heart disease and anemia sleep very soundly. Leo Errera thought that sleep was due to an accumulation of leucomaines in the tissues. A view put forth by Marshall Hall in the early part of the nineteenth century was that sleep was a sort of epilepsy. The autotoxemia theory of course had its vogue—attempts were made to explain the sleeping state on the theory that poisonous substances collected in the body during the day and were responsible for an autointoxication which took the form of sleep during which the body ridded itself of the noxious material. This theory seems to have had its inception from Obersteiner and Preyer and variations of it were furnished by Binz, Bouchard, Breisacker, and others.

The theory of sleep which is perhaps most widely known is the one generally referred to as Howell's theory. He believed that sleep was brought on by a vascular dilatation of the skin and a concomitant anemia of the cortex cerebri. According to him the periodicity of sleep is due to a rhythmic loss and resumption of tone in the vasomotor center. He found that the arm expanded in volume during the first hour or more of sleep, remained stationary for some time and then gradually contracted. This contraction became rapid about half an hour or so before waking. His theory is then that during the waking hours the cortical cells and the vasomotor center become fatigued. When the stimuli are withdrawn the vasomotor center relaxes and this relaxation affects primarily the vessels of the skin, lowering the blood pressure, thus leading to a lessened flow through the brain and bringing on sleep.

Maria de Manacéine, who has made extensive researches into the subject of sleep, summarizes her results by saying that "sleep is the resting time of consciousness" which brings the subject around to where she started from although she has contributed a great deal of data valuable on account of its detail and fidelity. Concerning the objective phenomena of sleep, she says, "The eyelids are lowered, the eyeballs are turned upward, and the pupils are contracted. The amount of inspired air is considerably diminished (Mosso) and thoracic or costal breathing predominates. There is a weakening of the action of the diaphragm (Mosso) and inspiration is more prolonged, being to expiration as 5 : 1 instead of as 2 : 1 as in the waking state. There is less carbonic acid eliminated, forty-two per cent. instead of fifty-eight per cent. (Pettenkoffer and Voit). The cardiac action is modified and the pulse is less frequent. The peripheral vessels dilate and the body temperature falls somewhat. The volume of various parts of the body increases during the waking state and decreases during sleep. The sweat glands act more freely during sleep and it is probable that metabolism is somewhat enfeebled (Busch).

In regard to the intensity of sleep Manacéine quotes the familiar curve of Kohlschütter where a sleeper was awakened after being asleep for varying periods by a metallic ball falling from varying heights. "These experiments," she says, "Show that the first two or three hours sleep are the most important, for it is during these hours that sleep reaches its culminating point." It might be mentioned that this deduction, which is one frequently made, is open to serious objections. Carrying it out to its logical conclusions we would reason that one hour of a deep sleep produced by a narcotic was equal to three hours of ordinary sleep because a ball might have to be dropped from three times the height to awaken the sleeper in the former case than in the latter. Also, we would be justified in assuming that the first three hours sleep were all that were necessary for the curve approaches so near the level at the end of three hours that the remaining quantity of sleep, estimated diagrammatically, is practically negligible. But we all know that three hours sleep have never been known to be sufficient. Later observations, too, have tended to show

that there is a secondary increase of sleep at approximately from the fourth to the sixth hours. Moreover, in this experiment no allowance is made for the friction of the weight against the clasps holding it which alone is enough to vitiate the results.

Boris Sidis, in 1908, published an experimental study of sleep which is remarkable for thoroughness and original viewpoint. The chief point he makes is that from the waking state the organism passes into a subwaking or hypnoidal state from which two pathways diverge, one leads to hypnosis, the other to sleep. He says, "There is one fact that is especially worth while noticing in the process of falling asleep, and that is, the circumstance that we do not tumble into it in spite of ourselves, that we go about it in a deliberate, may be cold-blooded fashion. The whole affair is not the after-effects of some narcotic, toxic, antitoxic bodies, not the result of some involuntary automatic mechanism—it is a voluntary act—the result of decision." The chief difference between the conditions which bring about hypnosis and those which produce sleep are that in the former we have a fixation of the attention, in the latter a relaxation. Sidis' experiments were carried out on frogs, guinea-pigs, cats, dogs, infants, and adults. He produced sleep in all of these subjects by causing three main conditions, the removal of sensory impressions, the limitation of voluntary movements and the exhibition of a monotonous stimulus of some sort.

Briefly expressed, Sidis' hypothesis of the causation of sleep is as follows: The degree of intensity of a stimulus at which it begins to act upon an organism, or part of an organism, may be called the threshold of stimulation. Now, keeping in mind Sherrington's views that there is a surface of separation between neuron and neuron and a connection between them which he calls synapse. At each synapse the transmitted energy must surmount a barrier. If the stimulations are continued indefinitely they fail to cross the barrier because the threshold rises. This is not so much due to the exhaustion of the cell as to the exhaustion of the stimulus. The cell no longer reacts to the stimuli, in other words, is asleep. Extending this conception to a group of cells, or organism, we say that the organism is asleep. Sleep is produced by monotony. Sidis has formulated this as follows: "Stimuli which have exhausted themselves by their monotony drop out and are replaced by new ones until the whole round of stimuli is gone through and the organism ceases to respond to its external environment—falls asleep."

Sidis dismisses the theories of sleep based on circulation, engorgement, anemia or hyperemia, narcosis and autointoxication by saying that sleep is not pathological, it is essentially physiological in character. He mentioned the well-known facts that mothers watching infants and nurses with patients may be sound asleep to loud noises and wide awake to the slightest change in their charges. Their thresholds are high for certain stimuli and low for others.

"Putting the matter again in teleological terms we may say that we go to sleep when we relinquish our hold on the relations of our external environments. We fall asleep when our consciousness is fagged, when we wish no longer to enter into communication with the outside world, when we lose interest in our surroundings.

"Biologically regarded, sleep is as much as instinct as hunger or sex."

"Phylogenetically and ontogenetically, the sleep states of higher animals are developed out of undifferentiated, intermediary, subwaking, hypnoidal-like states found in the resting states of the lower representatives of animal life. The hypnoidal state is the primitive rest state out of which sleep arises. Briefly put, the hypnoidal state is the germ of sleep."

(Manacéine's remarks about the hypnoidal state, which she calls the hypnagogic, or half-awakening, may be interjected here. She thinks that it is due to lack of tonicity of the blood-vessels of the brain rather than a normal preliminary to sleep, as Sidis claims. She says that it is hardly ever present after a sleep of from six to eight hours, and if it is prolonged, say over ten or fifteen seconds, is a bad sign. She speaks of the suggestibility present in the hypnagogic state, especially to emotional ideas rather than to intellectual ones or to judgments and says further, "In persons who presented a long, profound half-awakening I remarked nearly always a marked predisposition to a cataleptic condition of different muscular groups; it was comparatively easy to bring the extremities of such a person into any position without waking up the subject experimented upon, and then the limbs remained in these often very tiresome positions for a more or less long time, and it happened sometimes that they remained in such positions the whole time of the half-awakening. Even in cases when no attempt was made to place the extremities in other positions, they showed of themselves a cataleptic condition, and were sometimes fixed by it in the most unnatural positions.")

Sidis' definition of sleep is then this: "Physiologically and psychologically regarded, sleep is an actively induced passive state in relation to the external environment; the psycho-physiological systems have their thresholds raised in relation to external stimulation; the rise of the threshold is induced by a mass of impressions possessing little or no variability, or what is the same, by monotony of stimulations and by limitations of voluntary movements."

The most important work on sleep which remains to be mentioned is that of J. F. Shepard, published in 1914. After reviewing the various circulatory theories of sleep, he says, "All things considered, it is impossible to draw any definite conclusion from the literature as to anemia or hyperemia during sleep. Brodmann's curves suggest an increased blood supply to the brain and Mosso's results do not conflict with that. But Hill believes that the cerebral vessels are merely passive and, if this is true, the work of Howell and others would make probable a reduced brain circulation."

Shepard states that none of the curves reported by previous investigators as representing circulatory changes in the brain have been long enough to be suitable for generalizations. From his series of experiments, which he describes in detail, together with a collection of his curves in a separate volume, he concludes:

"The vessels of the brain are under the quite definite control of a system of vasoconstrictors, and the center of this control is probably a portion of the general constrictor center in the medulla. His reasons for so thinking are: First, in sleep there is a sustained and marked increase in volume of the brain accompanying a fall of general arterial pressure, and the reverse changes with awakening. Now this cannot be venous congestion for the following reasons: There is no analogous change in the jugular curve. This result is attained with a pressure (from rubber) far greater than venous congestion could attain. The rise of volume with sleep is accompanied by an increase in the size of the arterial pulse in the brain; the fall of volume with awakening is accompanied by a decreased size of the pulse in the brain, the rise of brain volume due to compression of the jugulars is accompanied by a decreased arterial pulse in the brain. The pressure of the jugulars was insufficient to give any trace of venous pulse while sitting, or leaning forward, but the brain showed the same reactions as when lying down.

Second. The brain vessels relax on going to sleep and constrict on awakening with relatively great activity. There is a fall even when the subject is awakened with a start by a strong stimulus, and in spite of a large rise of blood pressure. Correspondingly, few

reactions while awake even compare with the rise with going to sleep.

Third. The ordinary stimuli of the waking condition seem sufficient to the brain to constrict nearly to its limit, and to remain in that condition; so that the tendency to further constriction with stimuli while awake is relatively powerless and is overcome with the rise of pressure due to constriction of other regions which do not show such a limit of constriction.

Shepard also found that the respiratory wave in the brain volume was greater during sleep than during the waking condition, and greater with snoring than with freer breathing. Vasomotor changes played an appreciable part in the respiratory wave, notwithstanding the usual assumption to the contrary. The center for vasomotor control in the brain is a part of the general center in the medulla, and these activities of the breathing and vasomotor center influence each other and also the inhibitory center of the heart. Activity of the vasomotor center perhaps stimulates both the others. Activity (inspiratory) of the breathing center inhibits both the others.

In conclusion he says: "*We certainly cannot adopt an anemia theory of sleep.* The change in the cerebral vessels should be looked upon as an effect rather than a cause of the sleep process." J. M. Granville said the same thing in the *Lancet*, Aug. 28, 1880.

What then do we find if we attempt to analyze it introspectively? Various people describe it in terms that mean essentially the same thing. We experience a "yielding to the force of gravity," "yielding to a heaviness," "becoming lost in rest sensations or feelings." These sensations seem to come from muscles all over the body. The sensations which we receive from the tired muscles are undoubtedly of different character from the strain sensations we receive from the acting muscles. Whether the two are due to different terminals, or different ways of acting of the same terminals, we do not know. The fatigue sensations seem to result from chemical stimuli (waste products) given off by the tissues. They often appear to be more intense after the muscle has relaxed than before. Whether the removal of the self-massage and the greater or less cessation of the strain sensations actually allows a more intense stimulation of fatigue sensation then, or whether they are merely more noticed then, it is as yet difficult to say. Yoakum points out that they develop sooner in the acting rigid muscle than in the periodically contracting muscle. Although the nerve terminals are only in the muscles, apparently, they may probably be excited also by substances thrown into the circulation from other tissues.

"As we go to sleep, we become absorbed in a mass of fatigue sensations. Motor impulses dwindle, then skin sensations, then auditory. The sleep process is the dominance of an organized group of rest sensations. After two or three hours sufficient waste products are thrown off so that there is less actual stimulation of fatigue sensations, and less resistance to disturbances by other processes."

It will be seen from the above theories that a marked difference of opinion exists among students of sleep and this is so fundamental in nature that it will not be easily adjusted. Hence the meager and stereotyped description of sleep in the physiological textbooks which content themselves with publishing Kohlschütter's curve together with a few remarks anent cerebral anemia. To our mind the explanation of Sidis seems to fit most accurately with the known phenomena of this condition and we are of the opinion that the circulatory conditions observed during sleep are effects, not causes.

Hygiene of Sleep.—When we come to the question of the hygiene of sleep we find authorities more in accord. It is pretty generally agreed that the newborn infant spends all his time in sleep except such time as is actually occupied in nursing. As the child grows older, the waking time occupies a greater part of the twenty-four hours until in mature adult life seven hours seems to be the normal amount. Of course here the question of idiosyncrasy comes in. Some individuals do very well on five or six hours while others require eight or nine hours. In general it may be said that strongly intellectual persons, those with dominating characters, do not require so much sleep as those of opposite qualities. Thus mental defectives sleep a great deal. One of the requisites for sleep being relaxation of the attention it follows that persons having a diversity of interests or who are intensely interested in one field of thought get along with very little sleep. Repute has it that the American inventor, Edison, when engaged in working out a problem, goes for long periods of time with only three or four hours sleep in the twenty-four.

Examples of the varying periods of sleep required by well-known men are the hours ascribed to the following: Jeremy Taylor, the divine, three hours; Napoleon Bonaparte, four or five hours; Richard Baxter, the divine, four hours; John Wesley, the divine, six hours; Lord Coke, the lawyer, Kant, the philosopher and Sir William Jones, the jurist, each seven hours; Sir John Sinclair, the author, Elliotson, the physician, and the statesmen Bismarck and Gladstone, each eight hours. The time of sleep in human beings corresponds more or less closely to the hours during which the part of the world they inhabit is in darkness, but this arrangement seems to be for the sake of convenience and not a physiological necessity. It has been found that men may reverse this procedure for a great many years, even a whole life-time, with no bad results. The experience of night workers confirms this.

The time given to sleep should be uninterrupted, but in this too, habit can cause a revision of the rule. Thus nurses, physicians, sailors, and others whose occupation accustoms them to taking their sleep in "broken doses" find they can get along very comfortably if they can average the proper amount in twenty-four hours.

Manacéine does not believe that we should be too regular in our sleeping habits because the man who retires and rises at stated hours the year round may find it necessary to attend to important business at the hour when he is usually asleep and may find this efficiency impaired by drowsiness. She does not believe that children should be dragged out of bed in winter before daylight and made to dress by artificial light. The period of sleep should correspond somewhat, she says, with the sun. Thus children should be allowed to arise early in the summer mornings and enjoy the freshness of that time of the day.

The ordinary hygienic requirements of the bedroom such as good ventilation need hardly be dwelt upon here, except to emphasize that the more completely external sensory stimuli are excluded, the more favorable will be the conditions for sleep. Quiet and darkness are the two chief attributes.

In regard to position during sleep Sidis says that most people fall asleep on the right side if they are right-handed, on the left side if they are left-handed. By actual count of a number of normal persons he found that seventy-five per cent. of right-handed persons fall asleep on the right side and ninety per cent. of left-handed persons on the left side. This he thinks is due to the instinctive desire to limit voluntary movements as much as possible. The position flat on the back has for years borne a bad reputation, it being believed that distressing dreams were due to this position, also nocturnal emissions. The evidence adduced in support of these theories is largely fanciful, but it seems to be true that most persons in falling asleep instinctively choose one side or the other, probably for the reason given above. Manacéine

believes that the position should be changed frequently during sleep.

Disorders of Sleep.—*Excessive Sleep.*—Individuals will be found who spend a disproportionate part of the twenty-four hours in sleep, perhaps anywhere from ten to fourteen hours. This is usually found to be due to one of two things, lack of resources or habit. The habit of indulging in more sleep than is necessary should be discouraged, Manaceine thinks, not only because of waste of time it implies, but because she believes that the retention of the urine for such long periods may give rise to weakening of the vessel walls, albuminuria and biliary calculi. Excessive sleep may also be due to anemia, especially chlorosis.

Paroxysmal sleep is sometimes referred to by the older writers, the condition described appears to have been nocturnal epilepsy.

Morbid Somnolence.—Medical literature is replete with cases of prolonged sleep, or narcolepsy as it has been called although the term is now falling into disuse. Periods of sleep lasting thirty-six or forty-eight hours are fairly common, those lasting a week or more less so. Well authenticated cases have been recorded of sleep lasting several months or even years. It was doubtless a case of this kind which gave rise to the Rip van Winkle legend. Prolonged sleep may follow exhaustion, either mental or physical. Thus we may have this condition following hemorrhage or accompanying fatigue after exertion and also as an aftermath of great emotional strain. Napoleon, whose hours of sleep were notoriously brief, is said to have slept thirty-six hours after the battle of Aspern.

Metabolism appears to be greatly decreased in prolonged sleep, dreams are usually absent. Occasionally the sleeper takes nourishment or attends to his evacuations in an automatic way suggestive of somnambulism and then relapses into sleep. In some cases it appears to be impossible to awaken the sleeper by any stimuli, no matter how intense, in other cases they can be roused for a moment, but immediately fall asleep again. Cataleptic symptoms are sometimes observed in these cases of prolonged sleep. This and other circumstances lead us to suspect that many of these cases have been catatonic.

Somewhat allied to prolonged sleep is the phenomenon of hibernation which, strictly speaking, is confined to animals, although in parts of the Arctic regions the inhabitants spend the winter in a somewhat similar manner. The exact nature of hibernation is as yet unexplained; Liebault and Forel have offered the explanation that it is a sort of autohypnosis. Blaudet offers the phylogenetic explanation that it is a custom remaining from the severe winters which obtained in the earth's infancy. It is noteworthy that some cold-blooded animals in hot countries exhibit a similar phenomenon during the summer which has been called "summer sleep." (Pflüger.)

Sleeping sickness is not strictly speaking a disorder of sleep, but rather an infectious disease, the chief symptom of which is a morbid somnolence. It was at first supposed that this disorder was in reality a constitutional tendency toward excessive sleep much as the effects of the ancylostoma were supposed to be only manifestations of the laziness of the inhabitants of certain regions of the South. The infection of animals by the tsetse fly was first described to Europeans by Livingstone and later it was found that human beings were susceptible and that the disease was by no means confined to negroes. As the name indicates, the nervous system seems to be chiefly affected and a lethargy, growing more profound, and terminating in death, is the characteristic course of the disease. See article on *Trypanosomiasis.*

Somnambulism or sleep-walking resembles somewhat the hypnotic state. It appears to be due to the persistence of an idea from the waking into the sleeping state. Thus an idea associated with a marked emotional affect may be repressed out of the immediate field of consciousness during the day, but during sleep it may appear in motor consciousness. A man who has hidden a bag of money during the day may visit the spot at night and handle the money or transfer it to another spot; if he has neglected to write a letter he may arise during the night and repair his omission. The body during somnambulism seems to be under the influence of the subconscious mind. The state may be said to be the acting out of a dream.

It is certain that in sleep-walking all sensory stimuli are not excluded. Lielut and Guy indeed have held that somnambulists could see. Smell and taste may be quite active. There is some perception of auditory stimuli, but these must have especial claims to recognition, *e.g.* a loud noise may fail to attract the sleeper, but his name spoken in a conversational tone will cause him to turn his head. The sense of touch is said by Manacéine to be hyperesthetic, but she, as well as other observers, seem to draw this conclusion from the accuracy with which a somnambulist acts in spite of the fact that his eyes may be closed. It seems more probable that the sleep-walker is governed by a visual impression of his environment and thus moves about with the same security with which a blind man does in a familiar locale. The experiment has been tried for instance of substituting a blank sheet of paper for the one on which the somnambulist has been writing. If this is done so deftly that it does not startle him, and the change made for example at the completion of a word he will dot his i's and cross his t's on the blank paper and continue writing along a line corresponding with the one on the sheet of paper which was removed.

A connection between somnambulism and hypnosis is suggested by the fact that somnambulists will often be found to be quite suggestible and the means of cure may be found in this. D. Hack Tuke, in his Dictionary of Psychological Medicine, relates the case of a boy sleep-walker who was cured when his schoolmaster told him firmly that it must not happen again or he would have to take the consequences. Another suggestive fact is that the circumstances known to be favorable to sleep-wakling, that is, the fixation of the attention on one point, resemble the requisite for hypnosis, fixation of the attention, rather than relaxation which produces sleep.

Minor Disturbances of Sleep.—A phenomenon which appears to be universally experienced is that of waking up suddenly with the feeling that one has fallen from a great height. These awakenings which have been termed "psychic jumpings" are accompanied by a momentary emotional disturbance sometimes quite disagreeable. Numerous theories have been advanced to account for them none of which is susceptible of proof. One of the most ingenious is that they are psychological remnants, vestigial memories of remote ancestors who flew or perhaps of comparatively recent ones who swung from tree to tree in long leaps simulating flight. Another explanation is that a man's usual posture during his conscious hours being the erect one, there occurs at night a redistribution of weight and when he wakes suddenly he gets a sensation of nothing being under him which he translates as a sense of falling, but the pressure of the bed being felt immediately afterward it seems as if his fall were thus arrested. An allied phenomenon which is, however, not so common is the experience of waking with the feeling of apprehension. These "distressed awakenings" may occur periodically in certain individuals, say every seventh or eighth day. The discussion of these experiences probably belongs rather in the domain of psychopathology. They are usually found associated with neurasthenia, a classical symptom of which was formerly given as morning malaise. The most obvious suggestion is that these individuals, having made a faulty adjustment to reality, find refuge in their

troubles in sleep and dreams. With the morning they feel again the claims of the external world and their first reaction is a feeling of distress and apprehension.

Insomnia.—Insomnia has always been recognized as pernicious in its effects. It is all very well to say blandly that it is only a symptom, find the cause and remove it, but this is not so easily done always. Manacéine found by actual experiments on animals that the deprivation of sleep had a much more deleterious influence than the deprivation of food. She found that animals could not live from three to five days without sleep while the same animals went from ten to twenty days without food. Examining these animals postmortem, it was found that the ones which had been kept awake showed atrophy of the brain and degenerative changes in its cells while in the animals starved to death the brain appeared to be the last organ to suffer. She also experimented on a group of intelligent persons, mostly college professors, to see how long they could stand loss of sleep. Three nights seemed to be the limit of endurance in this regard. Exhaustion was quite profound; some of the subjects suffered hallucinations. Memory became very defective and the power of concentrating the attention was lost. It was found that even if an individual had lost three nights sleep, say from twenty to twenty-four hours, a sleep of half that time seemed to repair the damage; this sleep was apparently much deeper than normal.

Complete insomnia is very rare and very dangerous, and although it is not uncommon to have patients report that they do not sleep at all, this should always be taken *cum grano salis.* Insufficient sleep, according to Bouchut, occurs in persons with unstable nervous system and may be more or less chronic in such individuals.

The causes which may produce insomnia are legion, but they may be divided roughly into physical and psychical. It should be kept in mind that nearly all the so-called causes are operative only in predisposed individuals.

Under physical causes may be mentioned overwork, cold, circulatory disorders, especially anemia, valvular disease, and arteriosclerosis, drugs, especially tobacco, tea, coffee, and alcohol, pain, eyestrain, toxemia from any cause, but especially from the intestines and from carious teeth. Under psychical causes may be mentioned the psychoses, neuroses, and psychoneuroses, high altitudes, emotional stress, change of habits, and excessive intellectual work.

In the treatment of insomnia the first care should be to remedy the condition if possible without the exhibition of hypnotic drugs. If the cause can be definitely proved to be physical, the task is somewhat simpler. The treatment for any of the causes listed above as physical readily suggests itself to the physician. Thus eyestrain or dental caries means reference of the case to the ophthalmologist or the dentist. Harmful habits, such as overwork or indulgence in drugs, require regulation. Anemia calls for iron and arsenic, arteriosclerosis, the iodides, nitroglycerin, erythrol tetranitrate, or aconite and valvular disease or Bright's disease appropriate medication. Bleeding is a remedy seldom resorted to nowadays but it may often be valuable in the insomnia of plethoric individuals. The mention of cold in the production of insomnia may require a word or two of explanation. It sometimes happens that insufficient bedcovering is used by persons who are "health faddists" and believe that they are toughening themselves thereby. Sedentary individuals will often be found to have cold feet. In these cases an effectual treatment is to have them stand in cold water for a few minutes, then dry their feet by rubbing them briskly with a rough towel.

Intestinal toxemia is sometimes merely the result of constipation and disappears when that does. A treatment formulated by Brunton and Blaikie is said to cause a variation in the intestinal flora and thus remove a chronic toxemia. On the first day of the treatment a half pint of warmed, not boiled, milk with three grains of potassium citrate is given every two hours and one-sixteenth grain of calomel every two hours for six doses. On the second day two drams of sodium sulphate are given in a half a pint of warm water at 6 A.M. and 8 A.M. Every two hours beginning at 6 A.M. unless asleep at night, a half a pint of water with an ounce of grape sugar, the latter lessened if diarrhea appears. The third and fourth day the régime is the same as on the second, except that the sodium sulphate is omitted. On the fifth, sixth, and seventh days a half pint of an especially prepared solution of plasmon is given with a pinch of salt every two hours. Whatever effect this course of treatment may have on the intestinal flora, it probably has an intense moral effect on the patient, and many sufferers from insomnia are quite suggestible.

Insomnia due to psychical causes is much more difficult to treat. When the sleeplessness is due to excessive intellectual work a readjustment of the patient's method of work should be made. Sometimes his tasks are so arranged that the most intense strain comes in the evening and it is consequently hard to get the relaxation of the attention necessary for sleep. Sometimes the work can be so arranged that a comparatively monotonous part of it comes in the evening and this will be found conducive to sleep. Intellectual workers often will find the plan of ceasing work an hour or so before bedtime, then eating a light lunch, playing a frivolous game, or reading some ephemeral book works very well. In cases of emotional strain or that condition which might be termed "insomnophobia" hypnosis is sometimes indicated, or at least suggestion. So also in individuals who have changed from day to night work. The night-terrors of children (see *Pavor Nocturnus*) often yield quite readily to suggestion.

No general rules for the treatment of insomnia in the neuroses and psychoneuroses can be laid down. It is in these cases that psychoanalysis promises the most by solving their difficulties. The most important advice in regard to treatment is of a negative kind: these are the cases which should never receive drugs. In the psychoses insomnia is sometimes troublesome, particularly in the early stages. Psychotherapy and hydrotherapy are indicated. In the later stages, especially in the manic, complete insomnia may occur. The continuous bath is the remedy par excellence. Rarely it will be necessary to exhibit drugs. Paraldehyde is the hypnotic of choice.

A few general rules for the treatment of insomnia may not be amiss. The personal hygiene and the hygiene of the bedroom should be made as nearly perfect as possible. The patient's habits should be regulated, especially in regard to his bowels; the bedroom should be dark, but not too dark, and well ventilated; sedentary people should take a little exercise in the open air before retiring. Hydrotherapy may be tried in any form, particularly in the shape of a hot bath, a sheet pack, a warm foot-bath, or "Neptune's girdle." The evening meal should be light and a slight, easily digested meal may be taken at bedtime. If it is necessary for any reason to resort to drugs, the mildest and safest should be tried first. The bromides, veronal, and paraldehyde are the hypnotics of choice and when they or any other drugs are being used, an occasional placebo should be interjected, and the dose should be gradually diminished. The second set of drugs are such ones as sulphonal, trional, and chloral, the last named being used with especial care. The last resort in drugs for this purpose is opium and its alkaloids. It should be used only when nothing else will do, always excepting those cases where the sleeplessness is due to pain; the patient should not know what he is taking, and the drug should be discontinued as soon as possible. In some cases of what might be termed acute mental pain,

that is, where the conflict in the patient's mind is so acute that he is intensely depressed and suicide is threatened, the temporary use of opium is sometimes good therapy to tide him over to that time when he shall have adjusted himself to his difficulties.

JOHN E. LIND.

Sleeping Sickness.—See *Trypanosomiasis.*

Smallpox.—HISTORY.—It is claimed by some writers that the antiquity of smallpox dates back to the time of the Tsche-u dynasty in China, at a period not less remote than a thousand years before the Christian era. It is stated that temples were erected in honor of the disease, and the goddess of smallpox was thus glorified. Inoculation, or "sowing the smallpox," it would appear was practised in China at a very early period, the result being crudely attained by thrusting crusts into the nostrils.

Tradition has it also that smallpox existed among the Brahmin caste of India from time immemorial. Descriptions in some of the ancient sacred writings of spotted and pustular skin diseases are alleged to relate to smallpox. Like the Chinese, the inhabitants of Hindoostan are also said to have worshipped at smallpox shrines and to have offered sacrifices to the presiding goddess to grant them protection.

That the Greek physicians were acquainted with smallpox is open to most serious doubt. Some authors have labored diligently to prove that the great vesicular and pustular eruptions and "anthrakes" which Hippocrates (460–377 B. C.) speaks of relate to smallpox. While the descriptions are somewhat suggestive of this disease, they are far from constituting satisfactory evidence.

The first writings of the Roman period bearing upon the subject are those of the Jewish philosopher of Alexandria, Philo, who lived in the first century. His description of the Egyptian plague[1] might with greater reason be assumed to refer to smallpox than the writings of Hippocrates: "From the great suffering, natural to the fermentation of festers so extensive, their bodies were tortured and their minds filled with horror. The lesions thrown out soon merged into extensive blisters filled with pus, as if the parts had been burned. It extended over the whole body from head to foot." This description is, as Haeser contends, strongly suggestive of confluent smallpox.

Haeser[2] concludes, from a study of the Greek and Roman writings, "that knowledge of smallpox among the ancient Greeks and Romans probably existed, although we cannot with absolute certainty either affirm or deny this assertion."

The word "variola" is first mentioned by Bishop Marius, of Lausanne, who employed the term (et variola Italiam Galliamque affixit) in 570 A. D. in describing a devastating epidemic that swept through Italy and France. The same epidemic was doubtless referred to by Bishop Gregory of Tours who, in 582, under the name of "lues cum vesicis," described a disease characterized at the beginning by high fever, vomiting, and "back pains," followed by the appearance of a painful eruption of hard white vesicles which occurred most conspicuously over the face, hands, and feet; the vesicles became pustules, and in many cases death occurred on the twelfth or fourteenth day.

Procopius[3] described a dreadful pestilence which began in Pelusium, Egypt, in the year 544. It was accompanied by buboes and carbuncles (suggesting bubonic plague), but was widespread, raged independent of season, spared neither age nor sex, attacked pregnant women severely, and was a new disease but little understood by physicians.

A short time afterward, unequivocal traces of smallpox are met with in countries bordering on the Red Sea; for we read of caliphs and caliphs' daughter being pitted and having white spots in their eyes.

In 569 A. D. smallpox appears to have broken out in virulent form in the Abyssinian army of Abraha, which was besieging Mecca. The soldiers were decimated by the pestilence, necessitating the raising of the siege.

Reference to a lost treatise on smallpox (seventh century) by an Alexandrian physician, Aaron, is found in the writings of Rhazes. Edwardes[4] says: "The first clear description of smallpox by a physician, which has come down to us, is by Isaac, the Jew, who lived in the ninth century. A manuscript Latin translation of his work is in the town library of Mainz (Isaaci Israeliti . . . opera omnia)."

The most scientific and comprehensive description of smallpox handed down from these times, however, is from the pen of Rhazes, who wrote in about 910. The Bagdad physician was a prolific writer and a close observer, and has been called "the Arabian Galen." The following quotations are of interest:

"As soon as the symptoms of smallpox appear we must take especial care of the eyes, and then of the throat, and afterward of the nose, ears, and joints. . . . If a severe pain arises in the soles of the feet, then take care to anoint them with tepid oil and foment them with hot water and cotton, . . . for these and the like things soften and relax the skin, and thus facilitate the eruption of the pustules and lessen the pain."

"All those pustules that are very large should be pricked, and the fluid that drops from them be soaked up with a soft clean rag in which there is nothing that may hurt or excoriate the skin."

"When the desiccation of the pustules is effected, and scabs and dry eschars still remain upon the body, examine them well and upon those that are thin and perfectly dry, and under which there is no moisture, drop warm oil of sesamum every now and then until they are softened and fall off."

". . . and in order to efface the pock holes, and render them even with the surface of the body, let the patient endeavor to grow fat and fleshy, and use the bath frequently and have the body well rubbed."

The above therapeutic suggestions might be incorporated in a modern treatise on smallpox with but little revision. Rhazes credits Galen with a knowledge of the disease and also quotes from Hippocrates, Aaron, and Masawaih. The last-named writer is cited as saying ". . . your first care should be directed to the eye, for which you should use a collyrium made of sumach and rose-water, in order to prevent any pustules from coming out in it."

Avicenna (980–1037), an Arabian physician, was the first to distinguish smallpox from measles. In the Canon Medicinæ he states of measles "that in it more tears flow." He also conceded the possibility of second attacks of smallpox.

Franciscus de Pedemontium (1330) referred to red coverings and warm air as tending to expel the pustules to the surface, for, "according to Avicenna the sight of red bodies moves the blood."

Constantinus Africanus (1075 A. D.), a Carthaginian, who lectured at Salerno, the first European medical school, closely followed, as did his contemporaries, the Arabian doctrines. He restricted the term variola, which was at that time loosely employed, to small pox.

A tenth century Anglo-Saxon manuscript, in the Harleian collection in the British Museum, contains an exorcism and prayer in which the following words appear: ". . Geskyldath me vid de lathan Poccas," which, rendered into modern English reads: "Shield me against the hideous pocks."

A Cottonian manuscript, evidently written in the eleventh century, contains a prayer to Saint Nicaise who had the smallpox, and whose name was to be worn in an amulet to grant protection.

The term "pocca," which was the Anglo-Saxon equivalent of variola, is first encountered in a tenth century leech-book of the physician Bald. The death

of Baldwin (961), son of the Earl of Flanders, from "variolas sive poccas" is set forth in the Bertinian Chronicle.

Smallpox is supposed to have invaded England between the tenth and thirteenth centuries. Holinshed, describing an epidemic in the reign of Edward III, writes: "Also many died of small pokkes, both men, women, and children." According to Hirsch, Iceland suffered from smallpox in 1306, having received the infection from Denmark.

John of Gaddesden, physician of Edward II, and author of Rosa Anglica, followed the Arabian treatment of surrounding the patient with red bed-clothing and hangings, etc. He acquired a great reputation, but, according to Watson, was a "very sad knave."

During the epidemic of 1694, Queen Mary, the wife of William III, died at the age of thirty-three of hemorrhagic smallpox. Lord Macaulay, writing of the ravages of this disease says: "That disease over which science has achieved a succession of glorious and beneficent victories, was then the most terrible of all ministers of death. The havoc of the plague had been far more rapid; but the plague had visited our shores only once or twice within living memory; and the smallpox was always present, filling the churchyards with corpses, tormenting with constant fears all whom it had not yet stricken, leaving on those whose lives it spared the hideous traces of its power, turning the babe into a changeling at which the mother shuddered, and making the eyes and cheeks of the betrothed maiden objects of horror to the lover."

Smallpox was treated in diverse and various manners in different periods. In 1640 the hot or sweating treatment, by which the peccant humors were to be expelled, was the vogue. Diemerbroeck, a Dutch physician and professor, was an advocate of this method. Gregory remarks that when Sydenham began his medical reform, in 1667, "he had an Augean stable to cleanse." The "English Hippocrates," however, was equal to the task, and succeeded in completely changing the practice with regard to smallpox. He insisted upon fresh air, and substituted the cooling for the sweating treatment. He also described the disease admirably, and was the first to trenchantly distinguish between measles and smallpox. Boerhaave (1668–1738) was a warm admirer of Sydenham. He deserves the credit of having maintained that smallpox was contagious and due to a specific miasm.

Smallpox in America.—It is said that smallpox reached Mexico in 1518, having been brought by a negro slave who accompanied the troops of Cortez from Cuba. According to Toribio it swept the country, destroying the lives of three and a half millions of people. De la Condamine states that whole tribes of Indians were exterminated, and in some places no one was left to bury the dead. The disease then reappeared at regular intervals of seventeen or eighteen years. In 1663 the Indians of Massachusetts were attacked by smallpox and slain by the thousands. The disease first appeared in Boston in 1649.

Referring to the importation of smallpox into America, Gregory humorously remarks: "If America gave us, as people confidently say it did, the great pox, we have more than returned the compliment by introducing to her acquaintance the smallpox."

Period of Inoculation.—Inoculation was first practised in Constantinople about the year 1674. Dr. Timori (1714), Dr. Kennedy (1715), and Dr. Pylarini (1716) wrote on the subject of inoculation but the profession in England ignored the publications. It remained for the charming and accomplished Lady Mary Wortley Montague, wife of the British Ambassador to Turkey, to introduce inoculation to the European world. The now famous letter to her friend Miss Sarah Chiswell, written in 1717 is here appended. ". . . . Apropos of distempers, I am going to tell you a thing that will make you wish yourself here. The smallpox, so fatal and so general amongst us, is here entirely harmless by the invention of engrafting, which is the term they give it. There is a set of old women who make it their business to perform the operation, every autumn in the month of September, when the great heat is abated. People send to each other to know if any of their family has a mind to have the smallpox; they make parties for this purpose, and when they are met (commonly fifteen or sixteen together) the old woman comes in with a nutshell of the best sort of smallpox and asks what vein you please to have opened. She immediately rips open that you offer to her with a large needle (which gives no more pain than a common scratch) and puts into the vein as much matter as can lie upon the head of her needle, and after that binds up the little wound with a hollow bit of shell, and in this manner opens four or five veins. . . . The children or young patients play together all the rest of the day and are in perfect health to the eighth. Then the fever begins to seize them and they keep their beds two days, very seldom three. They have very rarely above twenty or thirty on their faces (*sic*) which never mark, and in eight days time they are all well as before their illness. Where they are wounded there remain running sores during the distemper, which I do not doubt is a great relief to it. Every year thousands undergo this operation, and the French Ambassador says, pleasantly, that they take the smallpox here by way of diversion, as they take the waters in other countries. There is no example of anyone that has died from it, and you may well believe that I am satisfied of the safety of this experiment, since I intend to try it on my dear little son. I am patriot enough to take pains to bring this useful invention into fashion in England, and I should not fail to write to some of our doctors very particularly about it, if I knew any one of them that I thought had virtue enough to destroy such a considerable branch of their revenue for the good of mankind. But that distemper is too beneficial to them, not to expose to all their resentment the hardy wight that should undertake to put an end to it. Perhaps if I live to return, I may, however, have courage to war upon them. Upon this occasion admire the heroism in the heart of

Your friend," etc.

The daughter of Lady Montague was the first person inoculated in England (1727) although her son had previously been inoculated in Constantinople. In the following year, after six condemned criminals had been successfully inoculated, the two daughters of the Princess of Wales submitted to the new process.

During the first ten years of its career inoculation met with great opposition. Later it became more firmly established, and was extensively practised in England up to 1800. It never, however, became popular on the Continent. The average death rate from inoculation was about one in three hundred cases, although it often rose above this. In 1798 Jenner announced his discovery of vaccination. In 1808 the inoculation of outdoor patients was discontinued at the London Smallpox Hospital, and fourteen years later inoculation of indoor patients was abandoned. In 1843 Gregory wrote: "In 1840 the practice of inoculation, the introduction of which has conferred immortality on the name of Lady Montague, which has been sanctioned by the College of Physicians, which had saved the lives of many kings, queens, and princes, and of thousands of their subjects during the greater part of the preceding century, was declared illegal by the English Parliament and all offenders were sent to prison with a good chance of the treadmill. . . . Such are the reverses of fortune to which all sublunary things are doomed."

Inoculation was first practised in America in 1721. It was introduced into this country at the suggestion of the Rev. Cotton Mather, by Dr. Zabdiel Boylston, of Boston, who first inoculated his only son and then

two negro servants. Before the practice was generally accepted, however, it was necessary to overcome here, as in England, much violent opposition.

The principal advantage claimed for inoculation was that smallpox thus produced was much milder in type than when the infection was received in the natural way; while the death rate from smallpox was one out of every three or four persons attacked, it was, at the highest from the inoculated disease, not greater than one out of fifty and sometimes as low as one out of three hundred, the average death rate being somewhere between the two. Not only the number of deaths, but the marred visages of persons in every community, testified to the frequency of smallpox before the days of inoculation. Indeed it was so prevalent in the Middle Ages as to lead to the common saying that "from smallpox and love but few remain free." The disadvantage of inoculation was that smallpox produced in this manner, although milder in type, was just as contagious as when contracted naturally; hence inoculation had the effect of keeping the disease almost constantly in existence.

Blindness from Smallpox.—During certain periods in England, a very large percentage of the people were pockmarked. Ben Johnson, the Elizabethan dramatist, wrote:

> Envious and foule disease, could there not be,
> One beautie in an age and free from thee.

Not only did the disease destroy life, disfigure, and maim, but it was at one time the most common cause of blindness. The early records of the London Asylum for the Indigent Blind, showed that two-thirds of the inmates had lost their sight as a result of smallpox.

Smallpox Ravages.—Smallpox was a great scourge before the introduction of vaccination. In London during the eighteenth century it caused one-twelfth of all deaths. Everyone felt that he had to pass through an attack of smallpox at some period of his life. One of Horace Walpole's correspondents (Wampole's Letters) wrote: "Poetry is as universally contagious as smallpox: Everyone catches it once in a lifetime at least, and the sooner the better." Most children in London contracted smallpox before the age of seven.

For official data concerning the disease in London in the seventeenth and eighteenth centuries we are largely indebted to the London "Bills of Mortality," which gave a weekly account of burials and christenings, and from 1629 to 1845 the specific cause of death, including smallpox.

It has been estimated that the population of London in 1685 was 530,000; in 1750 it was approximately 653,900; in 1801 it was determined by census to be 746,233.

The mortality from smallpox in London for an average of ten years, from 1681 to 1690, was over three per thousand of population (3,000 per 1,000,000); in the seventeenth and eighteenth centuries it frequently rose to 4.5 or more per thousand.

In the fifty-four years from 1647 to 1700, there was an average mortality from smallpox in London of 1,079 per year. The average yearly deaths by smallpox in the eighteenth century were 1,958. As it has been computed that about one in five died, it would appear that there were on an average over 5,000 cases of smallpox annually in the English capital in the seventeenth century, and almost 10,000 cases a year in the eighteenth century.

As will be readily comprehended, smallpox was a great scourge before the days of vaccination; but a small percentage of people escaped its ravages. At the end of certain epidemics in small towns, as many as eighty to ninety per cent. of the population represented survivors from attacks of smallpox.

Indeed smallpox was as prevalent in the eighteenth century as measles is at the present time. Haygarth gives an account of an epidemic of smallpox in Chester, England, in 1744, at which time, out of a population of 14,713, 1,202 persons took the disease and 202 died. At the termination of the epidemic there were but 1,060 persons or seven per cent. of the population who had never had smallpox.

In 1722 smallpox devastated the small English town of Ware, whose population numbered 2,515 souls; of this number, there were only 914 persons susceptible to smallpox, inasmuch as 1,601 had already passed through an attack of this disease. During the epidemic referred to, 612 persons were attacked, leaving but 302 individuals in the entire town who had never had smallpox. Eighty-five per cent. of the population, therefore, were smallpox survivors.

With these official figures in mind, we may be better able to appreciate the general estimate of the extent of smallpox given by writers of the day. In 1802 Admiral Berkeley in a speech before the House of Commons, said: "It is proved that in this United Kingdom alone 45,000 persons die annually from smallpox; but throughout the world what is it? Not a second is struck by the hand of time but a victim is sacrificed upon the altar of that most horrible of all disorders, the smallpox."

King Frederick William III, of Prussia, in a dispatch, dated Oct. 31, 1803, stated that 40,000 people succumbed annually to smallpox in his kingdom.

The French physician, De la Condamine,[5] stated that "every tenth death was due to smallpox, and that one-fourth of mankind was either killed by it or crippled or disfigured for life."

Juncker, professor of medicine in Halle in 1796–98, gathered statistics[6] indicating that 65,220 persons died of smallpox, in the German speaking countries in 1796.

Sarcone[7] estimated the number of persons in Italy who suffered from smallpox as nine-tenths of the population. He states that in Rome in 1754 smallpox destroyed more than 6,000 lives.

Smallpox was introduced into the western hemisphere by the Spaniards about fifteen years after the discovery of America; in Mexico within a short period 3,500,000 persons are said to have died of the disease.[8]

It is alleged that in Mexico smallpox exterminated whole tribes of Indians, sparing no one to tell the story of annihilation.

Robertson refers to smallpox among the South American Indians as follows:[9] "In consequence of this (various calamities) together with the introduction of the smallpox, a malady unknown in America, and extremely fatal to the natives, the number of the people both in New Spain and Peru was so much reduced that in a few years the accounts of their ancient population appeared almost incredible.

Catlin[10] states that of 12,000,000 American Indians, 6,000,000 fell victims to smallpox. Washington Irving's "Astoria" makes mention of the terrible epidemics of smallpox among the Indians in which "almost entire tribes were destroyed."

Lloyd, who translated Prince Maximilian's "Travels in the Interior of North America," states in the preface, in reference to a smallpox epidemic among the Indians in 1837: "The Big-bellied Indians and the Ricarees, lately amounting to 4,000 souls, were reduced to less than half. The Assiniboins, 9,000 in number . . . are, in the liberal sense of the expression, nearly exterminated.[11]

According to records published by the government of Denmark, a devastating epidemic of smallpox appeared in Iceland in 1707 which destroyed 18,000 out of the 50,000 inhabitants; thirty-six per cent. of the total population perished. It is stated on good authority that in the Danish colony of Greenland, in 1734, 6,000 to 7,000 persons perished from smallpox representing nearly two-thirds of the population. The disease was introduced by a Danish ship.

The natives of New England likewise suffered great losses from smallpox. Robertson writes: "At the same time, about 1631, the smallpox, a distemper fatal

to the people of the New World, swept away such multitudes of the natives that some whole tribes disappeared."

In 1752 Boston had a severe epidemic of this dread disease. The population of Boston at that time was 15,684; of this number 5,998 had previously had smallpox. During the epidemic 5,545 persons contracted the disease in the usual manner, and 2,124 took it by inoculation. Eighteen hundred and forty-three people escaped from the town to avoid the danger of infection.[12] There were, therefore, left in the city but 174 people who had never had smallpox. The population at the end of the epidemic practically consisted of persons who had survived an attack of this fear-inspiring malady.

Symptomatology.—*Period of Incubation.*—From the moment that the microparasite of smallpox is received into the system certain subtle and unknown processes begin which, in the course of a more or less constant period of time, culminate in active clinical manifestations. To this latent breeding stage the term "period of incubation" is applied. The time elapsing between the reception of the variolous poison and the outbreak of the disease can occasionally be determined with a considerable degree of accuracy. This is more easily accomplished in sporadic cases, where an individual has been exposed but once and for a brief period of time. Where the exposure is frequent or extends over a long period it is difficult to divine the exact moment when the infection is received. When the disease prevails in epidemic form it is not impossible for an unknown exposure to precede the one of which the individual has knowledge; in such cases the computed period of incubation would appear to be unusually short. Erroneous calculations of the duration of the period of incubation have doubtless arisen from failure to recognize this fact.

In the majority of cases in which we have had the opportunity of carefully studying the incubation stage, we have found it to be ten to twelve days, and we would, with other writers, regard this as the normal period. In a few instances it is true we have known persons to fall ill with smallpox after the raising of a two weeks' quarantine of the houses in which they were confined and in which smallpox had existed. We have also been able in a few cases to reckon with tolerable certainty a period of incubation of sixteen days, the eruption appearing on the eighteenth. Some writers have recorded instances in which the incubation period has been prolonged to twenty days. In the mild type of smallpox which has prevailed in the United States since 1896, the incubation period is longer and not infrequently extends from sixteen to twenty-one days. On the other hand, we have known a young physician exposed to smallpox, to develop the first symptoms at the end of five and a half days, and the eruption at the termination of ten and one-half days. Ordinarily, however, the period is seldom less than eight days or more than fourteen.

The incubation period is ordinarily not characterized by any active symptoms. Patients usually pursue their daily occupations ignorant of the fact that there is developing within them a dread disease. There are, however, frequent exceptions to this rule. It is not rare for patients to lose their appetite and complain of lassitude, chilliness, headache, gastric uneasiness, etc. These symptoms, when they occur, are commonly noted during the last few days of the incubation period. They may, however, develop as early as a week before the invasive chill. Now and then a patient will complain of slight sore throat during the last days of this stage.

The Stage of Invasion, or Initial Stage.—This stage is frequently ushered in with suddenness and with considerable violence. The earliest symptom is most frequently a chill. This may be severe enough to be accompanied by chattering of teeth, or it may consist of a succession of creepy sensations scarcely sufficient to attract the patient's attention. Synchronously with the chill or immediately following it the fever develops. The temperature on the first day often rises to 103° or 104° F., and on the second and third day, with perhaps the exception of slight morning remissions, it rises still higher, frequently reaching 105°, and in some cases even 107° F. The elevation of temperature is usually sudden; in but few diseases does it rise so quickly from the normal to a high degree. Even in varioloid the early symptoms are not infrequently equally severe, although occasionally they are so mild as to escape attention. But the eruption of unmodified smallpox seldom if ever appears without being preceded by a well-marked invasive stage.

During the continuance of the fever the skin is hot and sometimes dry. Profuse sweating, however, is by no means uncommon; this is apt to come on in the evening.

The pulse, as a rule, is full, tense and rapid, its frequency generally corresponding with the temperature curve. In adults it varies between 100 and 130, while in children it not infrequently reaches 160. In some cases the pulse during the initial stage will be found to be relatively slow and entirely disproportionate to the height of the fever. We have on a number of occasions noted a pulse of 90, 80, and even 70 with a temperature of 104° or 105° F. These cases were seen in the hospital on the first and second day of the eruption; consequently we were not able to state whether this pulse rate was present at the onset of the initial symptoms.

The respirations are almost always increased in frequency, especially when the temperature is excessively high. Prostration is often extreme, being out of all proportion to the length of the illness. Strong and robust patients are frequently unable to stand without support, and when in the upright position soon become pale and liable to be attacked by vertigo or syncope. Thirst is great, the lips and tongue are parched and dry, and there is complete loss of appetite.

Constipation is a common symptom and is apt to persist throughout the course of the disease. The tongue is usually coated with a thick, yellowish covering, and the breath is heavy and offensive. According to some authors, the odor from the body of a patient at this stage of the disease is so peculiar and distinctive as to make it possible for the diagnosis of smallpox to be made by this symptom alone. We must confess that our olfactories have not acquired the degree of acuteness to detect such an odor.

Irritability of the stomach is a very frequent manifestation. Occasionally the first symptom noted by the patient is severe and persistent vomiting. In such cases the disease has on more than one occasion been regarded as gastritis. The vomiting often continues for two or three days. It is apt to be accompanied by marked tenderness and pain in the pit of the stomach. The irritability usually ceases when the eruption appears. When it continues longer it should be viewed with some solicitude. Especially in hemorrhagic smallpox is this symptom, together with epigastric pain, apt to be distressing and prominent. Nausea and retching are present in some cases without actual emesis.

Headache is the most prominent among the early nervous symptoms. It usually follows shortly after a chill, but in a certain proportion of cases it precedes it, being not infrequently the earliest evidence of illness. Its intensity varies greatly, corresponding in a measure with the height of the febrile action. At times it in so excruciating as to cause even self-restrained individuals to cry aloud. The face is often flushed, the carotids visibly pulsating. Restlessness and sleeplessness are common symptoms during this stage. Children, on the contrary, are sometimes drowsy and sleepy. When the temperature is high, delirium is

prone to supervene. This usually takes the form of talkative incoherence, although some patients become quite violent. Coma, is rare in adults, but not uncommon in children. Convulsions are frequently seen in children, more so perhaps in this disease than in any other of the exanthemata. They may be severe and repeated, and may continue even after the appearance of the eruption.

Pain in the back is a symptom so commonly observed that it is believed to be of special diagnostic value. It is not as constant as some of the other symptoms, yet it occurs in more than one-half of the cases. In perhaps one-third of the cases it is sufficiently severe to cause the patient to volunteer information concerning it. Its diagnostic import, therefore, is due rather to its infrequency in the other acute infectious diseases than to its constancy in smallpox. The lumbar and sacral regions are the parts to which the pain is usually referred, although it may extend to the dorsal region. As a rule, it is more severe in unmodified smallpox than in varioloid, yet this rule is subject to many exceptions. In hemorrhagic cases the pain is often of an excruciating violence. Lumbar pain is more constantly seen among female than male patients, owing to the fact that the menstrual function is very liable to be excited by the initial illness of smallpox. In the vast majority of women who are stricken with smallpox the menses appear out of their regular period. This is true of mild as well as severe cases. The premature onset of the menstrual flow occurs with more striking frequency in this disease than in any other of the infectious maladies. Pregnant women are exceedingly liable to suffer from abortion or premature delivery. The pain in the back owing to these causes is given greater prominence in women.

General aches and pains are frequently complained of, appearing at the same time as the headache and backache. These may occur anywhere, but are usually referred to the lower extremities, particularly about the knees. The soreness of the general muscular system may lead to confusion of diagnosis with grippe. Vertigo, which is particularly manifest upon the patients assuming the erect position, is a common early symptom. It is often well marked, even in mild cases, for these patients are more apt to rise from their beds. Syncopal attacks may occur in weak individuals.

Trousseau records having seen during the initial stage patients who suffered from temporary loss of power in the lower extremities, associated in a few instances with retention of urine. When this condition occurs, it is, in our experience, most likely to be encountered at a later period of the disease.

There is a considerable degree of variation in the character and sequence of the symptoms constituting the initial stage of smallpox. This is shown in the following analysis of 100 cases occurring in the epidemic of 1901 and 1902: The patients who were taken without selection, were closely interrogated as to the nature and chronological development of the various symptoms. The number includes 28 cases of confluent smallpox, 15 with very profuse and semiconfluent eruptions, 29 with eruptions of moderate severity, and 29 cases of mild varioloid. Of this series of 100 patients, 22 died. Headache was the most constant of the initial symptoms. The various symptoms mentioned were present in the following percentages: Headache, 86 per cent.; chills or chilliness, 78 per cent.; backache, 70 per cent.; vertigo, 57 per cent.; vomiting 55 per cent.; nausea without emesis, 10 per cent.

In some of these cases the symptoms were of marked severity, while in others they were extremely mild. An effort was made to determine the earliest symptom observed by these patients. It is recognized that some inaccuracy must arise from an attempt to chronologically arrange the symptoms from histories thus obtained.

	Cases
Chilliness or a decided chill was the first symptom in	35
Headache was the first symptom in	26
Backache was the first symptom in	16
Vomiting was the first symptoms in	9
General aches and pains were the first symptoms in	7
Vertigo was the first symptom in	2

In but two patients out of the hundred was there complete absence of initial illness; one of these was a man aged twenty-six years, with a very mild varioloid, and the other a colored woman, aged twenty-seven years with an eruption of moderate severity. Upon close inquiry the latter patient admitted experiencing fatigue upon the day preceding the eruption. It is possible that some negative histories of this character may be due to poor memory or lack of intelligence on the part of the patients.

In the severe cases the initial illness was always well marked, although the classic symptoms were not invariably present. A man, aged fifty-five years, who had a fatal confluent attack had merely as prodromes a severe chill, fever and prostration; headache, backache, vertigo, and vomiting were absent. A male patient, aged twenty-nine with an eruption of moderate severity, experienced, during the initial stage, fever, repeated vomiting, and pain in the stomach without any other symptoms. On the other hand, quite a number of patients with very mild eruptions gave a perfect history of the classic initial syndrome. A young woman of twenty years, for instance, with only three or four lesions on the face and a few upon the arms and hands, experienced at the onset of the disease, headache, backache, repeated vomiting, severe chills, vertigo, and aching in the legs.

These observations are in accord with those of most writers, and seem to illustrate the impossibility of forecasting the extent of the eruption from the degree of severity of the initial symptoms. We have frequently seen the most aggravated febrile symptoms followed by a perfectly insignificant eruption. Mild initial manifestations are rarely succeeded by a severe cutaneous outbreak. In general terms it may be stated that severe initial symptoms may be followed either by a profuse or a sparse eruption, and that mild initial symptoms are nearly always followed by a sparse eruption.

The urine in the initial stage, is usually more or less diminished according to the degree of the fever. The solid constituents are not out of their normal proportion, except the chlorides, which are considerably diminished. In severe cases, especially those about to become hemorrhagic, albuminuria may be present. A high grade of fever might be responsible for a small quantity of albumin, but if it be present in great abundance a malignant type of the disease should be suspected. Before giving an unfavorable prognosis, however, care should be taken to exclude the possibility of preexisting disease of the kidneys.

The spleen may be found enlarged in the initial stage of severe smallpox. In mild cases no enlargement, as a rule, can be detected.

Peculiar *prodromal rashes* often make their appearance during the initial illness. When they develop it is usually upon the second day of the invasive fever. They disappear ordinarily in from twenty-four to forty-eight hours. They may, however, continue several days after the appearance of the eruption. The frequency of these rashes appears to vary in different epidemics. During the widespread and malignant epidemics of 1871 and 1872 they were very common. Osler noted these rashes during this period in thirteen per cent. of his cases. These eruptions are not apt to be observed in smallpox hospitals, inasmuch as they disappear commonly before the diagnosis is made and the patient conveyed to the hospital. The most common type is that resembling measles, with which disease, indeed, it is liable to be confounded. The eruption has an irregular distribution, being at

times generalized and at other times limited to certain regions of the body. It, moreover, differs from the eruption of measles in that the rash is not elevated above the level of the skin and therefore scarcely appreciable to the finger when passed over it. Its ephemeral character is also a differentiating feature. This roseola variolosa, as it has been designated, has a close analogue in the roseola vaccinosa which occasionally appears about the ninth to the eleventh day after vaccination.

The scarlatiniform rash is less common than the measles-like eruption. It may involve a large part of the cutaneous surface, but is more apt to affect certain areas as the thighs, inguinal regions, external surfaces of the extremities, and the trunk. Some authors refer to the appearance of an urticarial eruption in rare cases.

The petechial or hemorrhagic initial rash has a special predilection for certain regions of the body which were carefully studied by Simon, of Hamburg. This writer pointed out the frequent occurrence of the eruption in the lower abdominal, inguinal, and genital regions and inner aspects of the thighs, constituting a triangle whose base traverses the neighborhood of the umbilicus (the so-called crural triangle of Simon). The "axillary triangle," including the inner aspect of the arm, axilla, and pectoral region is also a commonly affected area. The petechial rash is also frequently seen along the lateral surface of the thorax and abdomen. The eruption consists of closely aggregated, pin-point to pin-head sized, purplish or clarety spots, which are in such intimate juxtaposition as to convey the impression of a diffuse redness. Being the result of a hemorrhagic extravasation into the skin, the discoloration does not disappear upon pressure. Occasionally an erythematopetechial rash is seen, the eruption partaking of the characters of both the erythematous and hemorrhagic rashes.

The petechial eruptions may occur in cases which later prove to be quite mild. More often, however, they are the harbingers of severe smallpox of the hemorrhagic type. The morbilliform eruptions in our experience are much more common in cases of varioloid and their occurrence, therefore, may be regarded as an auspicious sign. We are able to recall two cases of smallpox in vaccinated individuals in which the roseolous eruption was practically the only cutaneous manifestation. In one of these cases, it is true, about half a dozen small variolous papules appeared as the initial rash faded away, but they disappeared in two or three days without becoming in the slightest degree vesicular. These cases belong to the class commonly designated variola sine exanthemate, which is the most benignant form that smallpox may assume. That such cases are occasionally encountered is evident from the writings of both ancient and modern authors. Perhaps in every epidemic patients are seen who give a history of exposure to smallpox and who, in due course of time, are suddenly seized with chills, followed by headache, fever, vomiting, prostration, and pain in the back. These symptoms continue for three or four days and then subside without the development of any eruption except perhaps one of the prodromal rashes to which reference has been made. It is impossible to explain such cases on any other supposition than that the disease was variola without the eruption. Trousseau refers to cases observed by him in which the only symptoms characteristic of the disease were a "few pustules on the pharynx and the pendulous veil of the palate."

It may be of interest to record the histories of two patients under our observation upon whom but a single variolous lesion appeared:

B. H., aged twenty-six years, suffering from measles, was sent into the Municipal Hospital under the erroneous diagnosis of smallpox. He was immediately vaccinated but this and subsequent attempts failed. At the end of ten days he was seized with high fever (104° F.), headache, and vomiting. A few days later a single papule appeared in the right loin. This went on to vesicle formation, becoming characteristically umbilicated, but dried up within a few days. The patient claimed to have had smallpox at the age of eight years, but showed merely a single pit upon the face.

The following case shows a somewhat similar history:

W. G., a colored lad, aged fifteen years, was vaccinated four years prior to admission; he presents a good vaccination cicatrix. He was brought into the hospital from a house from which several patients with smallpox were removed. On admission he had a temperature of 102° F. and presented other well-marked initial symptoms. On the subsidence of these symptoms he developed a typical papule on the trunk.

These cases come almost within the definition of variola without an exanthem. If smallpox may occur with the appearance of but one lesion, there is no reason why it should not at times develop without any eruption whatsoever.

The duration of the initial stage is commonly forty-eight to seventy-two hours; it is rarely less, but it may be somewhat prolonged. Trousseau held that the longer the eruption was delayed in its appearance, the more favorable was the prognosis. This is scarcely borne out by experience. It is misleading to draw any prognostic conclusions from the duration of this stage.

It is commonly stated in text-books that upon the appearance of the eruption of smallpox the fever subsides and a general abatement of the systemic symptoms occurs. In our experience a decided remission of the temperature does not take place in unmodified smallpox until the second, third, or fourth day of the eruption. In very mild cases, more particularly in those modified by previous vaccination, the temperature may fall to normal as the exanthem makes its appearance. With the fall of the fever there is a cessation of the pains and a general improvement in the condition of the patient. In mild cases of varioloid the illness of the patient is terminated at this stage. In severe cases the improvement constitutes but a brief respite and then the grim struggle with the disease begins.

Stage of Eruption.—By carefully observing the early stage of the disease it will be found that the true eruption makes its appearance with remarkable regularity on the third day of the illness, calculating from the day on which the initial chill or rigor occurred. In modified smallpox deviations from this rule may be noted. The eruption almost always appears on the forehead and temples near the edge of the hair, and on the wrists. Not infrequently it is seen first on the upper lip and around the mouth. It rapidly spreads to the scalp, face, neck, ears, forearms, and hands, always showing a decided preference for the cutaneous surfaces habitually exposed to the atmosphere. In the course of twenty-four hours, sometimes somewhat earlier, it extends to the body and lower extremities. It does not simultaneously affect these regions, but attacks in succession the back, arms, breast, and finally the legs and feet. In rare cases the exanthem may be first noted on the trunk or extremities.

The full complement of lesions does not make its appearance at once in any given part; the eruption continues rather to multiply for two or three days before its definite limit is reached. In varioloid new lesions may continue to appear for a longer period of time. Upon carefully examining the eruption it is seen that many lesions develop at the sites of hair follicles or orifices of the sebaceous and sudorific glands.

The eruption begins as small red spots or macules some of which may be so small and faint as to be

scarcely visible, while others reach the size of a lentil seed. The color is at first pinkish red, later assuming a deeper tint. In many cases the lesions on the trunk and extremities present the appearance of flea bites. The lesions gradually increase in size and number, becoming more and more prominent, so that in twenty-four hours they assume the form of elevated papules with a characteristic feel. The early papules, particularly about the forehead and cheeks, may be more demonstrable to the sense of touch than to the eye. They possess a peculiar induration, and convey to the finger a sensation similar to that which would be produced by grains of shot imbedded in the skin. The "shotty" feel varies in degree in different cases. Some papules are extremely hard, while others possess comparatively little induration. They are at first always discrete, but they may rapidly increase in number and become confluent, even before the vesicular stage is reached.

On the third day of the eruption, or the fifth day of the disease, very many of the lesions which made their appearance first will be found to contain a little clear serum. Indeed in many patients, one will be able to note on the second day a lesion here and there which has become vesicular in advance of the general eruption. These precocious vesicles are frequently of diagnostic import, enabling one in doubtful cases to assert the variolous nature of the disease. By the fourth or fifth day all of the lesions are converted into vesicles. At this stage they commonly have the size and shape of a split pea. Small vesicles are apt to be conical or acuminate, while the larger lesions have a convexly flat or hemispherical appearance. The vesicle of smallpox is extremely firm; not infrequently it feels harder to the finger than the papule from which it developed. In no other disease do the vesicles acquire such a degree of induration and hardness. The color of the vesicle is at first pinkish, the tint extending to the areola surrounding it. Later, as the fluid exudation into it increases, it assumes a peculiar opaline or pearly hue. This, with the shining and glistening surface, imparts to the vesicle a most distinctive appearance. One of the most characteristic features of the smallpox vesicle is the so-called "umbilication." In the smaller acuminate vesicles this is seen as a minute central depression or invagination, representing in all probability the mouth of a hair follicle or sweat duct. This form of umbilication may occasionally be met with in other cutaneous diseases, when the lesions are situated at the mouths of the pilary or sudoriparous orifices. In the larger, pea-sized vesicles the umbilication is seen as a round, oval or slightly irregular indentation. In this case the depression is flatter and is probably due to the bulging of the periphery of the pock. This latter form of umbilication is of important diagnostic value, as but few other vesicular diseases produce quite the same appearance. The forearms and the backs of the hands are, perhaps, the regions upon which umbilication is most characteristically seen. Umbilication is observed only in a certain proportion of vesicles. It is by no means a constant feature of smallpox eruption and, indeed, is not frequently absent altogether. This is particularly true of cases of varioloid. A form of secondary umbilication is commonly seen during the stage of decline or desiccation, when the pustules as the result of rupture or drying, show a depression in the center.

If one observes closely the large, clear vesicles of about the fifth or sixth day, particularly those situated on the dorsal surfaces of the hands, one can frequently discern through the epidermal roof something of the interior construction of the lesions. They will be seen to be made up of compartments which are divided by vertical septa, very much like the divisions of an orange. The vertical partitions are formed by the spinning out and reticulation of the epithelial cells of the rete mucosum. This accounts for the multilocular character of the smallpox vesicle, and explains the inability to evacuate its contents completely by a single puncture. Large, fully developed vesicles frequently show at their central summit a disk of the color of yellowish serum, and around the periphery a whitish, puriform ring looking not unlike an arcus senilis.

The predominance of the eruption of smallpox on the face and terminal extremities is to be accounted for by the greater vascularity of the skin in these regions. That lesions are attracted by an overfilling of the cutaneous vessels is seen in the excessive development of the eruption wherever the skin has been irritated or congested. It is a common experience in the hospital to see in a discrete case of smallpox a profusion of lesions over a rectangular area in the lumbar or epigastric region where a mustard plaster had been applied during the initial stage for the relief of pain. We have seen marked confluence of the pustules in the form of a band on the wrist where the patient had applied iodine for a sprain received before his illness. An intense coalescence of the eruption upon the forearm was occasioned by the presence of a sunburn upon these parts.

It is only when mechanical or chemical irritation is applied to the skin before the appearance of the eruption that an increase in the number of lesions is produced. We have frequently applied tincture of iodine and similar applications to the skin in the early days of the eruption without augmenting the variolous crop in the region thus treated. Some of the older physicians purposely irritated the skin of certain portions of the body with the hope of deflecting the eruption from the face to the regions thus treated. Unfortunately, the eruption was increased in the manipulated areas without diminishing the number of lesions on the face.

Stage of Suppuration.—The contents of the vesicles gradually become more and more turbid, as the result of the increased exudation of leucocytes, until the lesions become frankly purulent. This condition is usually reached in unmodified smallpox about the sixth day of the eruption, and marks the beginning of the stage of suppuration. The pustules now in good part, become large and globular, and stand out prominently from the skin. This color varies somewhat in different cases. At times the pustules acquire a distinctly yellowish tone not unlike the color of ordinary pus. Frequently they retain until ruptured, a peculiar chalky or grayish-white hue. The reddish areola which is observed about the vesicles develops in this stage into a broader, deeper hued violaceous halo. Where the lesions are closely aggregated the entire interpustular integument becomes reddened and tumefied.

On the face and scalp, where the eruption is apt to be profuse, the redness and intumescence are so extreme as to render the features of the patients completely unrecognizable. The eyelids, as the result of edema of the loose areolar tissue, become enormously puffed and completely close the palpebral cleft, which is bathed in a puriform secretion. The patient for a time is unable to see, owing to a complete closure of the eyelids. The lips, nose, and ears are distorted, the normal contour of the face is lost, and the entire head swollen beyond human proportions. The patient presents a most revolting and loathsome appearance. One seeing the disease for the first time in this stage is apt to be appalled by the horrible spectacle. The patient is sorely distressed by the inflammation and swelling of the scalp, inasmuch as contact with the pillow is a source of unendurable pain.

As the eruption on the body and lower extremities is later in making its appearance than that on the face, so also is it later in maturation. When the lesions upon the face have become vesicular, it will be found that the efflorescence upon the trunk and extremities is still in the papular stage. In like man-

ner the facial lesions will have advanced to pustulation by the time that the eruption on the body has become vesicular. There is noticeable, therefore, this regular multiformity in the character of the lesions upon the different portions of the body. About the eighth day the pustules on the face have reached their greatest development, and the process of retrogression then begins. They become yellowish, present a shrunken or shrivelled appearance, and rupture or collapse. On rupturing the pustules give exit to a viscid, glairy, dirty yellow pus, which dries in the form of yellowish or brownish crusts. A gradual subsidence in the inflammation and swelling takes place, and the normal outlines of the face are once more restored.

During the stage of pustulation the lesions which exhibited umbilication become distended and globular, thus effacing the central depression. The epithelial bands holding down the center of the lesion, in all probability become dissolved away, permitting the roof of the pustule to assume an hemispherical form.

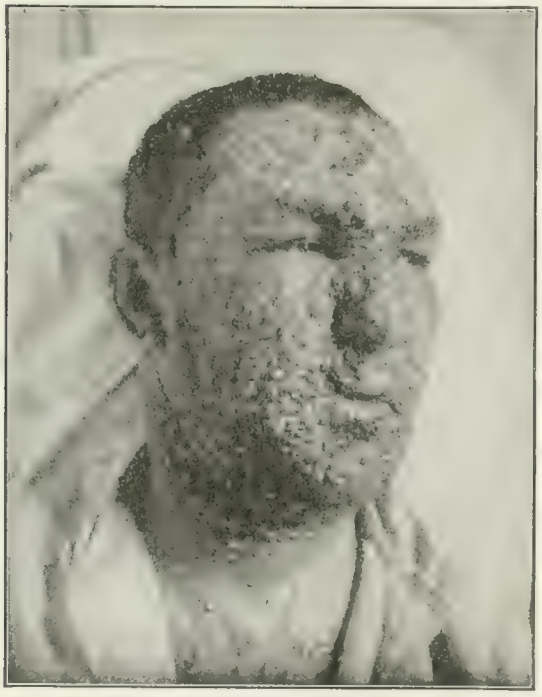


Fig. 4532.—Smallpox in an Unvaccinated Subject, about the Ninth Day of the Eruption.

The eruption on the trunk is almost always much less abundant than on other parts of the body. Not infrequently the hypogastrium is quite free from pustules, even when the face and hands show a marked degree of confluence. Exceptions to this rule are, however, occasionally met with. We have seen patients the skin of whose body was so profusely covered that it would have been impossible to place the tip of the finger upon a healthy area of the skin. Of course, in such cases the danger to the patient is correspondingly increased, inasmuch as the gravity of the disease is, as a rule, directly proportionate to the extent of the eruption.

In a well-pronounced case of semi-confluent smallpox under our care an approximate count of the number of lesions was made. This was accomplished by dividing the cutaneous surface into certain areas by means of a colored crayon and counting the pustules within these boundaries. Upon the face and scalp the confluence of the pustules precluded the possibility of their being counted. A conservative estimate of the number present was therefore made.

The number of lesions computed upon the different portions of the body is herewith appended:

Total on fingers of one hand	thumb	61	
	index-finger	97	
	middle finger	95	392
	ring finger	81	
	little finger	58	
Dorsal surface of one hand			382
Palmar surface of one hand			192
Total lesions on both hands			1,806
Forearms			4,400
Arms			2,840
Chest			1,000
Abdomen			175
Thighs			4,180
Legs			2,850
Feet			750
Back			5,700
Estimated number on face and scalp			3,000
Total			26,701

By evacuating some of the pustules with a pipette we estimated that the lesions at the height of their development each contained about three drops of pus. Such a computation developed the surprising fact that the patient referred to carried in his skin about five quarts of pus.

We have seen large men with more profuse eruptions who must have had in the neighborhood of forty thousand pustules. With this prodigious amount of purulent material in the skin the wonder is that any patient thus afflicted should recover.

The pustules on the trunk appear to have a more superficial seat in the skin than on cutaneous surfaces constantly exposed to the air; hence they are not accompanied by the same amount of inflammatory swelling or ulcerative destruction of the cutis. There is, moreover, very little tendency on the trunk and lower extremities to confluence of the lesions. We frequently note a coalescence of two or three pustules as a result of their contiguity, but the vast majority of the lesions remain discrete.

This statement, however, does not apply to the efflorescence on the hands and feet. In these regions the degree of confluence may be intense and cause the patient great suffering. As a result of the thickness of the overlying epidermis on the palms and soles, the pustules do not acquire as great a prominence as elsewhere. Being bound down by the tense and unyielding horny layer of the skin, pressure is made upon the delicate underlying cutaneous nerves, producing distressing pain. In a severe attack of smallpox the palms and soles, the fingers and toes, and the dorsal surfaces of the hands and feet are profusely covered. When the pustular stage is reached the patient becomes perfectly helpless; he is unable to feed himself or in any way use his hands. It is pitiful to behold him in bed, with his hands and fingers semiflexed, and his arms outstretched for fear of the dreaded contact with the bed clothing. At times the pustules on the back of the hands fuse and produce large bullæ or even an extensive undermining of the epidermis similar to that seen in a bad scald.

During the suppurative stage a most penetrating and offensive odor emanates from the body of the patient, and from the pus-stained bed and body linen. This stench results from the decomposition of the effete and purulent discharge, and is not peculiar to smallpox. In neglected cases the odor is most sickening, and may prevade the atmosphere of a room or, indeed of an entire house.

Eruption upon the Mucous Membranes.—Simultaneously with the appearance of the smallpox efflorescence upon the cutaneous surface, or a little earlier, the eruption develops upon the adjacent mucous membranes. The involvement is almost exclusively confined to those mucous surfaces which are near the

external orifices, or to which the air has access. The eruption early attacks the lining of the mouth, nose, and pharynx, and in severe cases the larynx, bronchi, and esophagus. The extent of the enanthem bears a direct relation to the severity of the eruption on the skin. The lesions, however, are seldom as profuse upon the mucous surfaces as upon the integument. If an examination of the mouth and fauces be made at the very beginning of the eruptive stage, small yet distinct red spots may be seen upon the roof of the mouth, buccal surfaces and anterior arches of the palate.

These macules are pinhead sized and larger, and of intense red color, which contrasts with the violaceous or bluish-red tint of the surrounding mucous membrane. In a short time the spots become slightly elevated or, papular, frequently exhibiting a whitish, glistening center. The parallelism with the evolution of the cutaneous pock ceases at this stage of the development. The mucous membrane lesion does not pass through the stage of papule, vesicle and pustule, but pursues a characteristic course which is determined by its peculiar structure and its different environment. There is, perhaps, an effort on the part of nature toward the formation of vesicles, but the thin and delicate epithelium which serves as a covering is destroyed by the macerating influence of the moist secretion in which they are constantly bathed. As the eruption upon the skin becomes vesicular and pustular, the lesions in the mouth assume a whitish or grayish appearance, with but little if any elevation above the surface. The denudation of the epithelial covering of the pocks leads to the production of circumscribed erosions or superficial ulcerations.

Soreness of the throat, particularly on swallowing is one of the most distressing symptoms of the early stage. But few patients with well-marked attacks escape this suffering. Even when the patient is feeling otherwise well, the condition of the throat constitutes a source of bitter complaint. In severe cases, at a later stage, the mucous membrane of the mouth is so abraded, swollen and painful that the use of solid food is rendered impossible, and the patient is forced to subsist entirely on a liquid diet.

The tongue is often the seat of lesions which seriously embarrass its movement in speaking and eating. Occasionally an intense form of glossitis is set up, causing the organ to swell so enormously as to prevent its retention wholly within the mouth. This condition which was designated by the older writers as glossitis variolosa, is apt to greatly interfere with swallowing, and is under all circumstances to be regarded as an unfavorable sign.

Much annoyance is occasioned by the presence of the eruption in the nasal cavities. The mucous membrane is at first swollen and inflamed, and later covered with crusts which obstruct the nares and render nasal breathing difficult and often impossible. This is particularly a source of distress to nursing infants, who are obliged to release the nipple from time to time to obtain the necessary amount of air.

The eruptive process may involve both the pharynx and larynx and cause so much inflammation and swelling as to make deglutition difficult or impossible, or it may lead to the production of hoarseness and complete aphonia. In severe cases an acute edema of the glottis may develop, which may seriously or even fatally impede respiration. Trousseau records several fatal cases of this character: "The smallpox patients, on the eighth day of the disease, which had run a perfectly normal course, were suddenly seized with a fit of suffocation which carried them off in a few seconds, before there was time for anyone to come to their assistance. In one patient autopsy showed laryngitis, with variolous lesions below the glottis."

In severe smallpox in children in the Municipal Hospital of Philadelphia, it was found necessary in four instances to employ intubation in order to prevent asphyxia. In all of these cases there was laryngitis with considerable swelling of the mucous membrane. Although relief was temporarily afforded, death ultimately occurred in all four cases. In one of the children the laryngeal stenosis came on late after complete decrustation had occurred on the skin.

The mucous membranes on the lower portion of the body may also be involved. The eruption may attack the vulva and the mucous surface of the vagina, but the lesions in these parts are not apt to be abundant. The lower part of the rectal mucosa may also be the seat of the variolous eruption. The meatus of the urethral channel is occasionally involved in both males and females, but the urethral channel nearly always escapes.

Delirium.—As previously stated, a variable degree of delirium may accompany the high fever of the initial stage. In our experience the most violent disturbance of cerebration occurs during the early eruptive period. This may be, in some cases, merely the continuation of the earlier delirium, but in others, it seems to begin after the exanthem has made its appearance. Some patients are apparently the subjects of delusions of persecution and of hallucinations, and imagine that someone is about to do them bodily harm. Acting on this supposition the demented patient attempts to escape from the hospital and what is quite strange, will always prefer to gain egress through the window. On a number of occasions patients, by the exercise of cunning and the awaiting of a favorable opportunity, have effected their flight with marvelous celerity, and have gained a temporary liberty in this manner. In some patients the temporary derangement takes the form of suicidal or homicidal mania. One of the patients in the Municipal Hospital of Philadelphia attempted self-destruction by striking himself on the head with a drinking mug, inflicting several large and painful wounds.

On another occasion a female, by cunningly embracing an opportune moment, quickly ran to an open fire-grate, on which she seated herself. While her clothing was burning around her and her flesh charring, she violently resisted the efforts of the nurse to extricate her. Another patient rose from his bed at night, struck the nurse to the floor, and effected his escape in his night clothes; he wandered a considerable distance from the hospital, and succeeded, by a shrewd and plausible story in prevailing upon the credulity of a wagon driver, who conveyed him to his desired destination.

These patients are often able to answer coherently, and one, unprepared, may be completely deceived as to their mental condition. They are apt to exhibit, however, some injection of the conjunctivæ and a wild expression of the countenance. This form of delirium was called by the older writers "delirium ferox."

Patients thus affected require to be closely watched, and if necessary, restrained in bed by straps or other means. When a patient complains of persecution or asks to be permitted to attend to some business at home for a day or two, close surveillance is necessary.

We have observed this active delirium most often during the papular and vesicular stage of the eruption. When it occurs it is usually associated with the confluent variety of smallpox, yet we have known it to occur in comparatively mild forms of the disease or when the patient has become quite apyretic. The persistence of the delirium for a number of days is a symptom of evil portent.

The delirium which is seen later, during the decline of the eruption, is of a different character. It is then of a low, muttering form and frequently associated with general tremor, dry tongue, quick and tremulous pulse, and a collapsed appearance of the features. These nervous symptoms are not peculiar to smallpox, but may be seen in the terminal stage of typhoid and other fevers.

The various forms of delirium, while more fre-

quently observed in alcoholics, appear to be the result of the poison of the disease acting upon the nerve centers.

It has already been stated that the initial fever in unmodified smallpox continues high until the third or fourth day of the eruption, when there occurs either a well-marked remission or a brief period of apyrexia. In very mild cases the fever subsides earlier. The fall of the temperature at this stage, even in severe cases, is not infrequently very rapid, so rapid, indeed, as to drop from a high degree to normal or even subnormal in the course of twelve or eighteen hours. The difference between the morning and evening temperature is not great, although the latter, as a rule, is slightly higher. When the temperature falls, there is usually amelioration of all symptoms. The pulse becomes almost normal; the respirations are easier; the pain in the back, headache, and irritability of the stomach all disappear, except in critical cases; the delirium ceases, enabling the patient to rest and enjoy refreshing slumber. Even the appetite may return, and the patient may be lead to believe that the critical period of the disease has passed and that recovery has begun. The subsidence of the symptoms is never so complete in variola vera as it is in varioloid. In the latter variety the fever and other symptoms frequently disappear and the beginning of convalescence is established; but in the former the chief danger is yet to be encountered.

At or shortly after the commencement of the stage of suppuration the temperature again begins to rise, and continues elevated until the completion of the eruptive process, or longer if complications arise. This rise constitutes the so-called secondary or suppurative fever of smallpox. This latter pyrexia is not apt to equal in intensity the initial elevation of temperature. When the disease is of moderate severity the temperature may not rise above 102° F., or 103° F., but in well-marked confluent cases it frequently reaches 104° F., rarely exceeding that point. When hyperpyrexia develops, the thermometer registering 105° F., 106° F., or 107° F., the danger of a fatal outcome is correspondingly increased. The maximum degree of fever is often reached during the hours which immediately precede dissolution. Wunderlich reports an antemortem temperature of 109.2° F., and Simon has seen temperatures of 110° and 112° F. immediately after death.

The secondary fever commences ordinarily on the fifth or sixth day of the eruption when the vesicles begin to fill with pus. It is of indefinite duration, depending directly upon the extent and severity of the cutaneous outbreak. In a well-marked, discrete, or semi-confluent smallpox the pyrexia is apt to last from three to six days. In severe confluent cases it may continue to last from eight to twelve days or longer. It is not uncommon for the secondary fever to merge without intermission into the pyrexia produced by the common septic complications such as boils, abscesses, etc. The elevation of temperature may, under such conditions, continue for four, five or six weeks or even longer. In the beginning of the suppurative fever the variation between the morning and evening temperature is apt to equal one or two degrees. The maximal elevation usually occurs, in severe cases, between the seventh and tenth days. Later, when boils and abscesses develop, the diurnal variations are most pronounced, the evening fever not infrequently reaching 104° or 105° F., while the matinal temperature registers only 99° F. The pulse and respiration correspond in a general way with the temperature curve. The pulse, however, is apt to be higher in proportion to the temperature than during the initial stage. With a temperature of 104° or 105° the cardiac pulsations not infrequently reach 140 or 150 to the minute. When the morning remission occurs, there is a considerable slowing in the pulse rate. As is quite to be expected, the patient experiences more comfort in the mornings than later in the day. During the pustular stage the chief complaint of the patient is general soreness of the skin.

The couch upon which he lies is metaphorically, if not actually, a "bed of thorns;" whichever way he turns he makes pressure upon the sensitive and inflamed pocks. Nervous apprehension, restlessness, and sleeplessness are prominent symptoms of this period. The patient is conscious of an increasing degree of prostration, and is frequently much concerned as to the outcome of the illness. It becomes necessary to allay the nervousness of the patient and induce sleep by the administration of an anodyne. At the end of the eighth or ninth day a sudden improvement in the general condition of the patient is often observed. The sufferer becomes brighter, volunteers information that he feels better and exhibits altogether a lesser degree of prostration. This is usually coincident with the onset of the period of involution and retrogression of the eruption.

Period of Involution and Retrogression of the Eruption.—The exanthem of smallpox reaches the acme of its development with the completion of the pustular stage. This constitutes the turning point not only of the eruption, but frequently of the disease. The first evidence of retrogression of the exanthem is noted in the subsidence of the inflammatory swelling of the skin, more particularly in the immediate neighborhood of the pustules. The abatement is first seen on the face, where the redness and edema have been most conspicuous. The eyelids become less swollen, permitting the patient to again perceive the grateful, light of day. The tumefied features gradually assume their normal contour, and the patient begins to acquire some semblance of his former self. Synchronous with the disappearance of the intumescence the pustules begin to dry; this period is called, therefore, the "stage of desiccation." The drying of the contents of the pustule is soon followed by a casting off of the crusts, when the "stage of decrustation" is entered upon. Nature in this manner attempts to rid the surface of the skin of the effete products which have there collected, and, finally, restore it to its normal condition.

The involution of the smallpox exanthem does not occur simultaneously upon all portions of the body surface, but follows the same sequence observed during the development of the eruption. It is but natural, therefore, that the first evidence of desiccation should be found in the facial lesions. The pustules in this region may dry without rupture, although more commonly the purulent contents of the lesions exude upon the surface and dry in the form of yellowish crusts. The color gradually becomes darker until it assumes a brownish tint. In neglected cases the crusts may become almost black, enveloping the face in an unsightly, immovable mask. The adherence of the crusts to the subjacent tissues varies in degree according to the depth and intensity of the involvement of the cutis. Where the pustule is superficially seated and there is no ulceration of the skin, the crust is readily detached, exposing to view merely a reddened area of the skin.

At the same time that desiccation is well established on the face, the trunk and extremities will exhibit lesions distended with fluid pus. These rupture, form crusts, and then pass through the process just described. At this period of the disease the offensive odor previously mentioned becomes most marked; in some cases it is quite unbearable, especially when the contents of the pustules discharge and decompose on the skin, or soak into the bed clothes and there undergo putrefaction.

After the rupture of large pustules the centers frequently dry and sink in, producing a cup-shaped depression or umbilication. This secondary umbilication differs from the primary variety in being distinctly larger, more conspicuous, and occurring at a much later stage of the eruption. This form of um-

bilication is most typically seen on the dorsal surfaces of the hands.

When the variolous pocks desiccate without rupture they undergo a gradual condensation of structure and a deepening of their color. When they are completely dried they are convexly flat, rounded, of horny hardness, and of a characteristic reddish-brown or mahogany color. Upon the back of the hands the dried, horny pock not infrequently preserves in its center a well-marked umbilication. Some of the crusts exhibit peculiar markings resembling an × or a maltese cross. In severe smallpox these horny pocks are usually limited to the hands and feet. In varioloid they may develop in other regions also, even upon the face. In this case the pustule, which is usually small, contracts into a hard, horny, shining crust of a reddish-brown color. These crusts are often of diagnostic value particularly when mild cases are seen at a late stage of the disease.

Upon the palmar and plantar surfaces the smallpox lesion dries into the mahogany-colored crust described. These pocks have the shape of lentil seeds and are embedded in the thick corneous layer of the epidermis. Here they remain for weeks if undisturbed, becoming denser in structure and darker in color. But few patients have the patience to wait for the spontaneous shedding of these crusts. It is a favorite occupation of convalescents to shell out the dried pocks from their epidermal beds. Inasmuch as the pocks in this region usually have their seat in the epidermis, nothing is left save small excavations in the horny layer. The uppermost layer of the epidermis is later removed through the process of desquamation. The mahogany-colored pocks upon the palms and soles present quite a characteristic appearance, which may render aid in the diagnosis in doubtful cases. In very mild cases minute pocks not larger than pin heads are found interspersed with the larger lesions.

The stage of desiccation usually begins about the eleventh or twelfth day of the eruption; in mild cases it commences earlier, while in grave forms of the disease it is postponed. If the case is to end in recovery there is at this time, not only improvement in the cutaneous symptoms but also an amelioration in the general condition of the patient. With the involution of the exanthem, the fever subsides and the pulse lessens in frequency. In favorable cases the temperature each day more nearly approaches the normal standard. If there be considerable involvement of the skin and mucous membranes the temperature falls less rapidly, or if complications arise it continues for a varying period according to the nature of the associated conditions. Although the fever is steadily decreasing, the patient is still in danger from exhaustion, for the heart, kidneys and other organs have been severely taxed by the septicemic poisoning.

The mucous membrane lesions of the upper air passages improve in favorable cases at a rather earlier period than the cutaneous manifestations. The distressing pain on swallowing has often disappeared by the sixth day. The nasal, buccal and pharyngeal eruption, being less deep and destructive, undergoes a comparatively rapid involution.

In regular cases of variola vera it usually requires, after desiccation has commenced, from three to four weeks for all of the crusts to become detached and fall off. This makes the entire duration of the disease about five or six weeks.

During the drying stage a new symptom is added to the sufferer's already extensive category of ills. The incrustation of the pustules is accompanied by the development of itching which varies in intensity from slight annoyance to unbearable distress. Adults are usually enabled to restrain themselves from scratching by the exercise of self-control. Children, on the other hand, yield to the impulse to purchase relief by scratching or rubbing, with the result that injury is often inflicted upon the skin. It is not uncommon to see in children, who have had unbridled license in the use of their hands, large abraded bleeding surfaces or crusted sores where the pustules have been gouged with the finger nails. It is popularly believed that the scarring in smallpox is due to secondary injury from scratching. While this agency may be a factor in the production of a few of the cicatrices, the vast majority of them result from the destruction of portions of the corium by the variolous inflammation. That finger traumatism plays but an inconsiderable rôle in the scarring is evidenced by the fact that children, despite the mechanical violence which they inflict upon the skin, escape as a rule with less disfigurement than adults. This is doubtless due to the fact that the pocks in children are more superficially situated in the integument. The most serious consequence of scratching is in the increased liability to pyogenic infections of the skin and the subcutaneous tissue.

It is only after the completion of the decrustation that one can determine the extent of permanent injury to the skin. If the crusts have been softened off by unguentous substances or mechanically removed, small irregular depressions filled with granulating tissue show where the integrity of the papillary layer of the skin has been affected. On the spontaneous shedding of the crusts these areas will be seen as reddish, cicatrized excavations. The extent of scarring depends entirely upon the depth to which the destructive inflammation has extended. Pocks which remain encapsuled within the epidermis will leave no permanent evidence of their presence. They will be followed by reddish stains, the result of a passive hyperemia of the papillary, blood-vessels. These discolorations are quite disfiguring in themselves, but disappear in the course of a few months. On exposure to cold the reddish stains acquire a bluish or purplish appearance. As time goes on the reddish color becomes darker and eventuates in a brownish pigmentation. This pigmentation is fortunately less conspicuous and less persistent on the face than on the covered surfaces. Even after several months the trunk and limbs frequently exhibit stains of a café-au-lait hue. In persons of swarthy complexion and in negroes the pigmentation is greater than in fairer-skinned individuals. The stains in the African race are often quite black and appear to persist longer on the face than in Caucasians. Where the true skin has been destroyed in negroes, the normal pigment of the skin is frequently lost. In such cases a whitish or pinkish discoloration is seen in the center of the scar, with a hyperpigmented zone surrounding it.

After the lapse of three or four months the scars of smallpox assume a whitish color, paler, indeed, than the surrounding integument. They may be round, oval, linear, stellate, radiate, or irregular, according to the configuration or grouping of the lesions which caused them. They may be large or small, deep or shallow; not infrequently they present sharp overhanging edges. Indeed there is nothing specially characteristic about the pits left after variola, save their extent and distribution. Affecting most profusely and conspicuously the face, they give rise to the well-known "pock-marked" countenance. It is well to remember, however, that similar pits sometimes follow a severe acne, particularly of the necrotic type. The writer has seen scarred acne patients who might have passed for variola subjects. The older writers gave to acne the significant title of "stone-pock."

By a curious irony of fate, nature obliterates the remains of the vast majority of variolous lesions upon the covered surfaces of the body, whereas indelible evidence is left upon the face and frequently the hands to bear witness to the cruel disease through which the patient has passed. Time, however, accomplishes much toward the effacement of the more superficial scars and the mitigation of the disfigurement produced by the deeper cicatrices.

The hair of the head, beard, eyebrows, etc., may be lost after the termination of a severe smallpox, especially in cases in which the eruption has been profuse in these areas. This alopecia is probably in part of febrile origin and partly the result of the local influence of the exanthem. Restoration of the hair usually occurs, and this is complete except in areas in which the hair papilla has been destroyed by the variolous lesions.

The nails of the fingers and the toes may be shed in severe cases. This is usually accomplished slowly through the pushing off of the old nail by the new one growing from behind.

After six or eight weeks a sharp, elevated ridge is seen near the nail fold; this represents the free border of the new nail, which in the course of time extends forward. Not infrequently variolous lesions are located beneath the nail. These subungual pocks are of a purplish or reddish-brown color, looking not unlike traumatic ecchymoses.

When convalescence sets in in uncomplicated cases, improvement in the general condition of the patient is rapid. The appetite returns and is apt to become keen, sometimes even voracious. The digestive functions are active, and the patient rapidly regains strength and weight.

The Varieties of Smallpox.—Variations in the extent of the eruption of smallpox may reach extreme limits, from a few small pustules, scarcely characteristic enough to enable one definitely to proclaim the variolous nature of the disease, to the most extensive eruption, covering the entire cutaneous surface. Between the two extremes there may occur numerous grades of intermediate severity.

Confluent Smallpox (Variola Confluens).—Most prominent among the early symptoms of confluent smallpox are severe headache, persistent retching and vomiting, delirium, or in children stupor, violent pain in the back, and high fever. The temperature always rises rapidly and attains frequently an extraordinary height. It is not at all uncommon for the fever to reach 105° or 106° F., and cases have been recorded in which a temperature of 110° was registered. On the third, fourth or fifth day of the eruption the temperature declines, but this remission is never so complete as in milder cases nor does it continue so long.

Ordinarily in forty-eight hours, the efflorescence covers the entire body surface. Owing to the extensive involvement of the skin, redness and swelling begin early. The face is intensely hyperemic, and the seat of distressing burning and itching. The marked suffusion of the countenance frequently enables one to prophesy that the disease will take the confluent form. As the eruption progresses it passes through the usual stages, though somewhat more slowly than in the milder cases. The papules are thickly set, and even at this stage a coalescence of the lesions may be noted. The skin is thickened and indurated, and feels like embossed leather. Soon the grayish outlines of the vesicles make their appearance, and the confluent aspect of the exanthem becomes accentuated. With conversion of the vesicular contents into pus, great swelling and edema develop particularly about the face and scalp. The eyelids are enormously puffed, and the margin of the upper lid so greatly thickened that it competely overlaps the lower. The nose, lips, and ears are swollen and distorted, imparting to the countenance a most hideous expression. The hands and feet are swollen to double their natural size and are most exquisitely tender and painful. When full pustulation is established the neighboring lesions coalesce and form large, flat blebs. In severe cases the walls of the pustules are completely swept away, producing flat, purulent, pasty-looking infiltrations of enormous proportions. When the pus exudes upon the surface and dries, a most disgusting stench arises from the body.

In favorable cases, with the beginning of desiccation, a subsidence in the edema takes place, and the crusts are cast off from the skin. The decrustation is, however, slower than in the discrete and semi-confluent forms of the disease. The suppurative process is deeper and more persistent, and may lead to the consecutive production, in the same areas, of large crusts which are successively thrown off as they form. Owing to the greater depth of the purulent inflammation of the integument, more extensive destruction of the true skin occurs, and consequently the scarring is deeper and more conspicuous. Instead of discrete pits, the face may be seamed with scars in a most frightful manner.

In severe cases which are going to terminate fatally, the course pursued is rather different from that above described. The evolution of the eruption is exceedingly slow, the lesions appearing to be suppressed and accompanied by but little swelling. The face has a peculiar blurred appearance. An ominous sign in these cases is the early development of flat, brownish, depressed scabs on a few of the vesicles on the forehead and cheeks. In these suppressed eruptions the vesicles are only partially filled with fluid, and the features are only slightly swollen; the skin is roughened and presents a somewhat parchmenty appearance. There is most profound prostration, and death results in almost every case.

The constitutional symptoms during the suppurative stage of confluent variola are most pronounced. There are marked pyrexia (104° to 105° F.), rapid pulse, frequent cough and expectoration, great restlessness, inability to sleep and profound prostration. Delirium is very common, but the patient does not become maniacal, as he often does earlier in the disease. At this stage, also, complications are liable to occur, such as corneal ulcer, keratitis, pleurisy, empyema, suppuration of the joints, cellulitis, phlegmonous inflammation and gangrene of the skin. Vomiting and diarrhea may supervene, and still further exhaust the patient's ebbing vitality. In fatal cases the patient sinks into a comatose condition, the pulse becomes excessively rapid, and the temperature not infrequently rises to 105°, 106° or 107° F.

The mortality in confluent smallpox varies in different epidemics, but it is always extremely high. In general terms it may be stated that at least one-half of such cases perish. When this form of the disease terminates in recovery, it is only after a long and tedious convalescence, interrupted by the development of boils, abscesses, and other complications.

Hemorrhagic Smallpox.—Of all the forms of variola the hemorrhagic is the most formidable and malignant. For those who contract a well-marked attack of this type of the disease there is absolutely no hope.

According as the hemorrhage precedes or follows the appearance of the variolous lesions two varieties are distinguished: first, the so-called purpura-variolosa, in which the hemorrhage is the primary exanthem and secondly, variola pustulosa hemorrhagica, in which it comes on secondarily.

In certain epidemics a petechial eruption is frequently seen at the close of the initial stage of the disease, at or about the time when the eruption should appear. This symptom often precedes the purpuric or hemorrhagic form of the disease, and is, therefore, as a rule, an early sign of malignancy. At other times petechiæ and ecchymoses appear between the papules and vesicles, or develop actually in the bases of these lesions. The vesicles and pustules may contain purulent material, or may fill up with sanguinopurulent fluid. Considerable diversity of appearance is sometimes manifest in the eruption of a single case.

There is no satisfactory explanation at hand to elucidate the causation of hemorrhagic smallpox. It would appear that the determining factor is largely resident in the individual, inasmuch as such cases may

be derived from ordinary smallpox and, on the other hand, may give rise to the usual forms in other people. The frequency of this form of the disease varies in different epidemics, being commonest when a more malignant type of the disease prevails.

Variola purpurica, or purpura variolosa, is the gravest and most malignant form of smallpox. The initial stage does not differ essentially from ordinary variola. The patient suffers from chill, fever, and headache, although the temperature is not likely to reach so extraordinary a height as in confluent smallpox. The pain in the back is usually violent, and prostration excessive. Furthermore, the patient often suffers from precordial distress and from severe retching and vomiting. The vomiting in this form of the disease is a most distressing symptom, and commonly proves more persistent than in ordinary smallpox. It not infrequently continues for several days after the appearance of the exanthem. Toward the end of the initial stage a diffuse efflorescence appears on various parts of the trunk and extremities, while the face remains for a time exempt. The rash is at first scarlatinoid in appearance and disappears partially under digital pressure; later it becomes more intense and of a deeper hue, and hemorrhagic extravasation into the skin occurs. Petechiæ, vibices, and ecchymoses develop upon the chest, axillæ, lower portion of the abdomen, groins, and legs; the dark red or purplish discoloration now present no longer fades under pressure of the finger. The discoloration rapidly extends to the face, which becomes dusky red or livid and swollen. The conjunctivæ are injected, the eyes blood-shot and the lips bluish, owing to hemorrhage into the cellular tissue. Frequently the extravasation of blood under the conjunctiva covering the sclerotica is so great as to cause this membrane to project beyond the lids like a sac filled with blood. Under such conditions the patient is unable completely to close the eyes. The cornea retains its normal transparent appearance, but, owing to the elevated conjunctiva about its periphery, appears to be sunken deeply into the eye-ball. This condition together with a dark discoloration of the face and the tumefied features, gives to the patient a peculiarly unnatural expression. A close scrutiny of the skin usually reveals the presence of small, abortive vesicles, which may be almost obscured by the purplish ecchymoses upon which they may be situated. These are most apt to be found upon the forehead, axillæ, groins, or wrists. The vesicles, which are of a plum-colored or leaden-gray tint, never develop to any extent, but remain perfectly flat. As the disease progresses the discoloration of the skin deepens on all parts of the body, giving to the integument a deep indigo hue which at times almost approaches black. In such cases it is difficult to say, judging from the skin alone, that the patient is not of African origin. Hence this form of the disease has been known as "black smallpox" or "variola nigra."

In this, as in other types of variola, the pharynx and upper part of the respiratory passages participate in the eruption. Purplish spots may be seen upon the gums, palate, tongue, and buccal surfaces, but the general mucous membrane is usually pale. Hemorrhages are quite certain to occur from the nose, bronchial mucous membrane, kidneys, rectum, and uterus. Vomiting of blood occurs in quite a large percentage of cases, and bloody stools are by no means infrequent. Indeed, blood may issue from any or all of the mucous surfaces of the body.

The course of this type of smallpox is extremely rapid. Death usually takes place from the third to the sixth day of the eruption, commonly as a result of sudden heart failure.

Variola Pustulosa Hemorrhagica.—Hemorrhagic extravasation into the skin may develop at any time during the course of the variolous exanthem. Various types of hemorrhagic smallpox may exist, intermediate between variolous purpura and the pustular hemorrhagic form. Hemic effusion may take place during the papular stage of the disease and may occur in the papules themselves or in the intervening areas of skin. Or the cutaneous hemorrhage may first appear during the period of vesiculation. In this case the vesicles instead of containing serum, fill with a sanguinolent fluid. In other cases the extravasation of blood may be delayed until the pustular stage is reached. The later the hemorrhage is postponed, the more conspicuous are the variolous lesions. The earlier it develops, the more will the true smallpox eruption be suppressed. The amount of swelling and edema is proportionate to the extent and development of the smallpox exanthem. When petechiæ and ecchymoses develop early, the skin has a peculiar livid appearance and there is not much swelling. Scattered here and there between the flat, poorly formed vesicles are seen non-elevated, pea-sized or larger, bluish, ecchymotic spots.

The hemorrhagic condition of the pustules may be limited to certain localities, or it may extend over the entire body. Inspection of the legs will often afford the first evidence of this malignant tendency. During the papular or vesicular stage it will be noted that some of the lesions upon the lower extremities are surrounded by a halo of the tint of dilute claret wine. At a later period scattered pustules in this region will be seen to have centers of the color of indigo blue. By degrees others will take the same appearance, and the color gradually deepens until at last, in severe cases, the pustules on all parts of the body become distinctly hemorrhagic.

Pustular hemorrhagic smallpox is more apt to develop in aged and debilitated subjects, in pregnant women, and in those addicted to the free use of alcohol.

The prognosis in less marked hemorrhagic cases depends somewhat upon the character of the prevailing type of the disease.

The Mild Type of Smallpox.—Within recent years a remarkably mild type of smallpox has been prevalent in various sections of the United States. It appears to have had its origin in Florida in 1896. There is no evidence that this mild type was imported from Cuba, as has been suggested. Owing to the mild character of the disease, the usual precautions taken against smallpox were not generally observed and the affection spread extensively throughout the South and later to various localities in the United States. Hundreds of thousands of cases have developed since its origin. A remarkable feature of this type of disease is that it has, during a period of eighteen years, maintained its mild character and has not reverted to the normal virulence of classical smallpox. This is a most interesting epidemiological fact, and represents a phenomenon quite unique in the history of smallpox. Records of extremely mild epidemics of smallpox are not unknown, but such epidemics have never persisted for long periods of time. Van Swieten, the great Dutch physician of the eighteenth century, described in 1759 an outbreak of this mild type: Sydenham likewise described this variety of smallpox in 1771. Jenner, writing in 1798, referred to a mild species of smallpox occurring in the villages of Gloucestershire in about 1791, which was so mild that it scarcely caused any mortality, the epidemic persisting for about a year.

A similar, if not identical affection occurring in Africa is known under the name "alastrim," and in South America under the designation of "amaas." Alastrim is accompanied by a mortality of one to two per cent. It is claimed that this affection may occur after successful vaccination, and furthermore, that one may be successfully vaccinated after an attack of this disease. An examination of photographs of this affection leads me to believe that it is true smallpox of the mild type.

When the mild type of smallpox first appeared in the United States, there was much doubt in the minds

of the physicians who observed it as to whether it was chicken-pox or smallpox, or some other affection. It was called Cuban itch, elephant itch, impetigo contagiosa, etc., and was regarded by some as a hitherto undescribed form of cutaneous disease.

The period of incubation is, as a rule, longer than that of normal smallpox. The majority of patients develop their symptoms about fourteen days after exposure instead of eleven days. There are some cases in which the period of incubation continues beyond eighteen days. This is of importance in determining the quarantine of contact subjects.

The onset of this type of smallpox does not differ greatly, except in degree, from that commonly seen in the severer forms of the disease. The initial illness is so mild that the patients are not obliged to remain confined in bed. Indeed some patients allege that they are not sick at all; yet on close interrogation it is found that they suffer in some degree from the usual symptoms. After the eruption appears, the vast majority of patients do not remain in bed. The eruption is, as a rule, sparse, in some of the mildest cases, the pustules not exceeding a dozen or thereabouts. From time to time, however, copious eruption may be observed, and in some instances may be so profuse as to lead to confluence, at least upon the face. Indeed, some cases may prove fatal. This type of smallpox runs its course much in the same manner as classic smallpox in the once vaccinated individual; in other words, the development of the lesions suggests that the course of the disease had been favorably modified. The evolution of the lesions occupies a shorter time than in normal smallpox, and in some cases the eruption pursues a short abortive course.

Two phenomena of importance stand out in connection with this type of smallpox: (1) The disease occurs almost exclusively among the unvaccinated; a single vaccination, no matter how remotely performed, is protective in the vast majority of instances. Negroes vaccinated during the Civil War, living in the same household with persons suffering with this disease, were completely protected over forty years later. This is a common circumstance. In Carbondale, Pa., in 1912, ninety-six out of ninety-seven patients who took this type of smallpox were unvaccinated, and there was some doubt about the vaccinal condition of the remaining patient. The patients who are immune against this type of smallpox are not necessarily immune against smallpox of normal virulence. (2) As has been stated, the symptomatology of this affection is mild and the disease is accompanied by a very low mortality, varying from one-half to two per cent. In the epidemic referred to in Carbondale, Pa., there were no deaths. At the same time, smallpox of European importation was prevalent in Pittsburgh, Pa.; there were 114 cases with thirty-one deaths, a mortality of twenty-seven per cent. We note, therefore, that the disease is characterized by mild symptoms and a mild infectivity.

As to the cause of this deviation from classic smallpox, no definite statement can be made. Doubtless, as a result of some unknown cause, the parasite which produces this disease was attenuated in virulence; the phenomenon is what biologists would call a "sport." Whether or not this type of smallpox will continue to retain its present mild form no one can predict. It is possible that at some future time it may revert to the usual virulence of the disease.

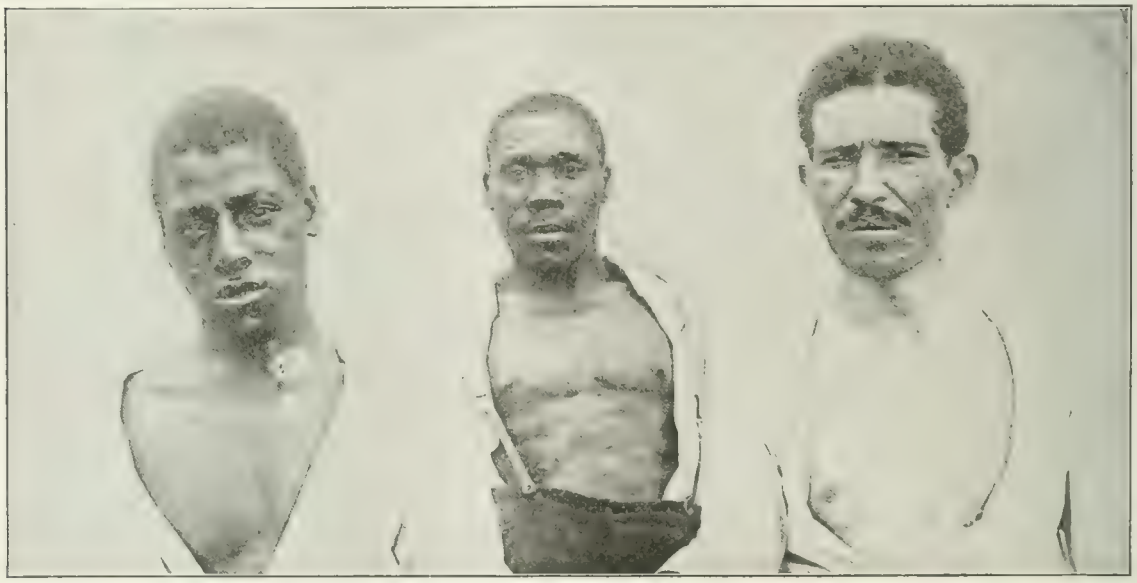


Fig. 4533.—The Mild Type of Smallpox Prevailing in the United States since 1896.

Varioloid (Variola Benigna; Variola Modificata; Modified or Mitigated Smallpox).—The term varioloid from an etymologic point of view, would indicate a disease merely bearing a resemblance to variola. The impression thus conveyed is, of course, a false one, for varioloid is true smallpox in a modified form. This is evident from the fact that the infection arising from this milder form of the disease gives rise to variola vera in unprotected persons. Since the introduction of vaccination, varioloid has become much more frequent than in former times.

The term varioloid may be reserved for vaccinated cases in which the eruption is markedly abridged in its course, and in which there is but little, if any, secondary rise of temperature. In many cases the invasive manifestations in varioloid are extremely mild, and will warrant a prediction of a sparse exanthem. The average case of varioloid is attended with fever only during the initial stage.

The extent of the eruption varies greatly in different cases of varioloid. I have seen several undoubted cases with but a single lesion upon the skin. The protection may be almost, but not quite, complete, and the patient may pass through the initial stage,

but remain free of eruption. To this benignant form of smallpox the term "variola sine exanthemate" of "variola sine variolis" has been given.

There is nothing peculiar about the eruption of varioloid except that it is milder in its course, of shorter duration than that of variola, and exhibits various irregularities. In the milder forms the lesions do not pass through all the stages, but become abortive and dry up at an early period. In the severer forms the eruption, although confluent or semi-confluent, pursues a distinctly modified course. In such cases the lesions do not penetrate into the deeper layers of the skin, but remain limited to the epidermis. Hence the course of the eruption is shorter, the process of suppuration is abridged, and the lesions desiccate early; in addition, the crusts are rapidly thrown off, and there is little or no scarring.

When the modification of the eruption is still greater, it is not unusual to find that the lesions develop into large, solid, conical papules, having at their apices small vesicles which rapidly desiccate and form thin crusts.

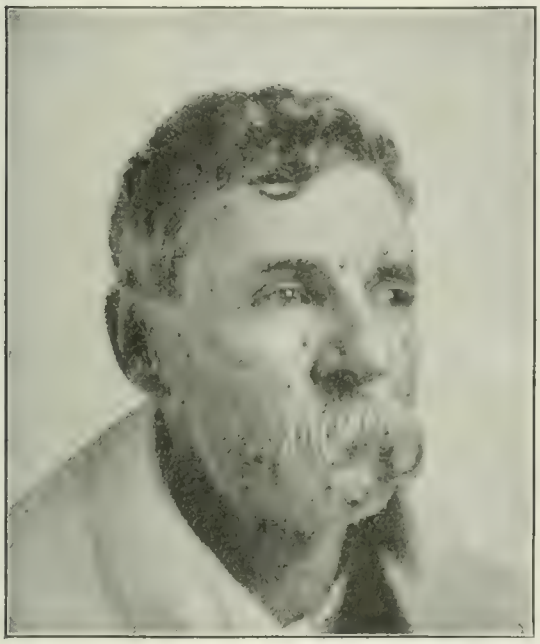


Fig. 4534.—Smallpox Mitigated by a Vaccination Performed in Infancy. (Welch and Schamberg.)

After the crusts have fallen off, the lesions remain tuberculated for some time. Sometimes these tubercles present the appearance of warty excrescences; to this form of the eruption the name "variola verrucosa" or "wart-pox" has been given. This modification of the smallpox eruption is seen usually upon the face. In the course of time the elevations flatten down and disappear, as a rule, without leaving scars. Another somewhat common form of the eruption is that known as variola miliaris; in this variety the majority of the vesicles are very small—not larger than a millet-seed; without progressing further they turn yellow, desiccate, and disappear. Not rarely a few tolerably well-developed pustules are found mixed with these smaller lesions.

Variola corymbosa is a designation applied to those eruptions which exhibit groupings of rather flat pustules in the form of corymbs or clusters. It is alleged by some writers that the mortality rate is particularly high in cases showing this character of eruption.

The contents of abortive vesicles and pustules frequently desiccate without rupturing, producing hard, horny, convex, shining reddish-brown crusts. This form is designated variola cornea, or horn-pox. The reddish-brown horny crusts are quite characteristic of smallpox. They are particularly common in varioloid, and often materially aid one in the diagnosis of doubtful cases.

The horny crusts are seen most frequently on the hands and forearms, but may also be noticed at times on the face.

In the form of the eruption termed variola siliquosa there is a retrogression of the pustules, with absorption of the contents and the production of epidermal cavities filled with air. In addition to the above irregular forms of smallpox eruption writers have described other varieties, such as variola conica, crystallina, emphysematica, fimbriata, lymphatica, pemphigosa, pustularis, rosea, morbillosa, carbunculosa, globulosa, etc. These various designations do not indicate separate varieties of the disease, but merely different appearances, produced by more or less trifling changes in the lesions.

Smallpox in the Pregnant Woman.—The functions of the uterus are disturbed with striking frequency during the course of smallpox. The menses quite uniformly appear out of their normal course, and in pregnant women abortion or premature birth is an accident of common occurrence, and one that adds greatly to the danger of the disease. Although the premature advent of menstruation and even the occurrence of abortion are not uncommon events in many other infectious diseases, their occurrence in smallpox is so extremely frequent as to suggest a direct relationship with the variolous process. It is probable that abortion is the result of the uterine hemorrhage, which is so commonly excited during an attack of smallpox. In some cases it may be due to the death of the fetus which is suffering from an intrauterine variola.

The symptomatology and course of smallpox are often markedly influenced by the pregnant state. The gravity of the disease is considerably augmented as a result of the coexistence of this condition. Of 113 cases of smallpox in pregnant women treated by Dr. Wm. M. Welch and the author, 35 died, constituting a mortality of about 31 per cent. In unvaccinated women the death rate has been truly frightful, 20 dying out of a total of 27 such cases, giving mortality of over 74 per cent. Of 85 women vaccinated at some previous remote period, 14 died, the mortality rate being about 16 per cent.

If abortion occurs during the initial stage the disease is apt to assume the form of purpura variolosa, in which case death is practically inevitable. Not every case in which abortion or premature birth occurs in the earlier stages of the disease takes on this malignant form. In attacks which are considerably modified by previous vaccination the smallpox process, is, of course, not so seriously affected by the occurrence of this accident. Even in cases of true variola, when the loss of blood is not very great—which is rarely the case—the variolous process may pursue its regular course and progress to a favorable termination. In about five cases out of thirty-one did recovery occur, when abortion took place before the tenth day of the eruption.

Of 113 cases of smallpox, including both variola and varioloid, occurring in pregnant women, 65, or 58.4 per cent. suffered from abortion or premature delivery. Of the remaining 48, 8 died without aborting, 9 recovered without abortion occurring and were delivered at term, and 31 were discharged still carrying the fetus, but were not heard from after leaving the hospital. Of the 65 cases (including variola and varioloid) in which abortion or premature birth occurred, 26 or 40 per cent., died.

Abortion occurs in variola more frequently than in varioloid, though the difference is not as pronounced as one might expect. Of 49 cases of variola, 35, or

71.42 per cent. miscarried, and out of 63 cases of varioloid, 31, or 49.2 per cent. miscarried. It is probable that some of the patients who left the hospital carrying the fetus aborted before the completion of the period of gestation, for we have observed this to occur not infrequently.

When miscarriage occurs in variola it proves, of course, a much more serious complication then when it occurs in varioloid. By reference to the table we find out of 35 cases of variola thus complicated, 26 or 74.28 per cent., died; while among 31 cases of varioloid in which the complication occurred but 1 died, and this death resulted from puerperal peritonitis.

The period at which miscarriage most frequently takes place is during the second, or eruptive stage of the disease. It not only occurs during the course of the disease, but frequently during convalescence, and in many instances even several weeks after complete restoration to health.

Miscarriages prove the more serious the earlier they occur in the course of smallpox. This is shown in the accompanying table which includes cases of variola and varioloid:

Day of Eruption on which Miscarriages Occurred, with Corresponding Mortality.

	Cases.	Deaths.
Initial stage	4	2
On or before the fifth day of eruption	30	17
From fifth to twentieth day	16	8
Subsequent to twentieth day	14	0

Miscarriage occurs doubtless much more often during the initial stage of the disease, particularly during epidemics, than the table would lead us to believe. In such cases death usually follows so speedily that the true nature of the disease is often overlooked, or if recognized, the critical condition of the patient forbids removal to the hospital; hence the table shows a relatively small number of miscarriages occurring at this stage of the disease.

The gravity of smallpox in pregnant women appears to vary considerably in different epidemics. Dr. Welch or the author has had the opportunity of observing these cases in three rather extensive periods of smallpox prevalence. The following table will indicate the comparative mortality rates of pregnancy and abortion complicating smallpox during the three epidemics:

		Number.	Deaths, per cent.
1871–72	Pregnancies	46	14 or 30.43
	Abortions and premature births	27	10 or 37.00
	Variola	10	10 or 100
	Varioloid	13	
1881–82	Pregnancies	31	16 or 51.61
	Abortions and premature births	19	13 or 68.42
	Variola	15	13 or 86.66
	Varioloid	4	1 or 25.00
1901–02	Pregnancies	36	5 or 13.88
	Abortions and premature births	20	3 or 15.00
	Variola	6	3 or 50.00
	Varioloid	14	

The above tables show that the mortality rate in pregnant smallpox women in 1871–72 was 30.43 per cent.; in 1881–82, 51.61 per cent., and in 1901–02, 13.8 per cent. Of those that aborted the mortality rate in 1871–72 was 37 per cent.; in 1881–82, 68.42 per cent. and in 1901–02 only 15 per cent.

Smallpox in the Fetus.—During an attack of smallpox the causative germ, in all probability, circulates in the blood stream of the patient. Therefore, when a pregnant woman suffers from variola, we would naturally expect the fetus to be likewise attacked and pass through all of the phases of the disease simultaneously with the mother. Strange to say, however, this is but seldom the case. In a minority of instances the fetus does become infected, but not synchronously with the infection of the mother. Indeed, in most cases in which the fetus develops smallpox it passes through a period of incubation in the same manner as if it were in the outer world, that is to say, about two weeks elapse from the time the mother shows symptoms until the disease appears in the child. From this observation, which is quite generally the experience of most writers, it would seem that the infant *in utero* ordinarily becomes infected, not through the maternal circulation, but through contact or proximity. If the blood of the mother were the infecting medium the disease in the fetus should be of constant occurrence. There are rare cases in which the fetus contracts smallpox after an exposure to the disease by a mother who happens to be an immune. In such cases it is difficult to understand how the causative agent could reach the infant *in utero* save through the maternal blood.

Smallpox may be communicated to the fetus *in utero* at any time between the fourth month of gestation or possibly earlier and the full term. When infection takes place in the earlier stages of intrauterine life, the fetus usually perishes and is expelled in three or four days, or it may be retained for three or four weeks after life has become extinct. There are well-authenticated instances in which the child suffers and recovers from an intrauterine attack of smallpox, and is born at term with variolous scars.

When the infection takes place during the later periods of pregnancy, the child at birth may be covered with the eruption, which may represent any stage of development. This occurrence is so well authenticated that it is unnecessary to quote any cases from literature. We have ourselves met with four or five instances of this character. In one case a six months' fetus presented a few red spots which evidently resulted from a mild vesicular eruption. In another instance an infant was born at the eighth month, on whose body at birth the eruption was just appearing. In a third case a four months' fetus was expelled on the thirty-seventh day of the maternal eruption. The eruption on the child was rather sparse, consisting of two whitish, variolous pocks on the sole of the right foot, one on the heel of the left foot, one on the chest, one on the back, and two firm lesions upon the palm of each hand.

The fourth case occurred in a colored child born at eight months, on the thirty-third day of the mother's eruption, the latter suffering only from a very mild varioloid. The infant had evidently been dead for some days, as the epidermis was detached from the underlying corium in large areas. Smallpox lesions in the pustular stage (about fifth or sixth day) were present upon the face, extremities, and body, but not profusely. It was calculated that the exanthem in the child began about twenty-seven days after the eruption appeared in the mother.

The child of a variolous mother may be infected with smallpox *in utero* and be born free of lesions, the eruption appearing some days after birth. If the infant is infected during parturition the outbreak of the eruption may be delayed for a fortnight after it has entered the world. If it is infected earlier the eruption may appear on the first, second, or third day of life, or at any period within two weeks. I have observed this phenomenon on numerous occasions. I recall a child born on the first day of the mother's eruption, which was hemorrhagic and rapidly fatal. The infant developed the eruption on the ninth day of its life and succumbed to the disease on the fourteenth day. It was vaccinated on the second day, on admission to the hospital, and although the vaccination took it was not sufficiently advanced to materially modify the smallpox exanthem.

The frequency of fetal infection does not seem to bear a relationship to the severity of the disease in the mother. Pregnant women suffering from the severest form of confluent variola do not communicate the disease to the fetus more often than those who

have the disease in the mildest possible form. Indeed, as already suggested, infection of the fetus may take place through the mother, although she personally remains free of the disease. A number of curious cases of this nature have been reported.

When a pregnant woman undergoes smallpox without miscarriage occurring, the susceptibility to the disease is not destroyed in the infant, except in rare cases. Susceptibility to the vaccine disease, in the vast majority of instances, is, I think, evidence of susceptibility to smallpox. Now and then an infant is born under the circumstances named that will not respond to vaccinia. I have met with three or four such cases. A woman suffering from a well-marked varioloid gave birth in the hospital to a child at term, on the twenty-first day after the appearance of the maternal eruption. The child was vaccinated with glycerinated lymph on three successive occasions, but without success. It remained in the hospital for three weeks and continued perfectly well. In another instance a woman suffering from mild varioloid gave birth to a child at term during the initial stage of the disease. The infant was vaccinated on successive occasions after admission to the hospital, but without securing a "take." A profuse smallpox eruption appeared upon the child on the seventeenth day of its life, which proved fatal.

Concerning the occasional failure of the offspring of variolous mothers to respond to vaccination, it may be said that it is sometimes very difficult, under ordinary occasions, to successfully vaccinate very young infants. In such cases a successful result may sometimes be obtained at a later period—say at the age of four or five months. This was exemplified in a case reported by Rigden, in which a mother with varioloid gave birth to an infant at term during the height of her eruption. She made a good recovery and was able to nurse her child almost from the day of its birth. The infant was vaccinated the day after its birth, but without success. Between the age of four and five months another attempt was made, with successful result.

It is of interest to note that in the case just quoted, and in the first case the child in each instance was insusceptible at birth to both vaccinia and smallpox. The failure to secure a successful vaccination in the second case may possibly be attributed to the use of inert virus.

But in the vast majority of instances smallpox in the pregnant woman does not destroy the susceptibility to vaccinia in the infant. My own experience and that of other writers constitute adequate proof of this statement. Rigden reports six cases of successful vaccination in infants born of mothers suffering from smallpox. In these cases vaccination was performed between the ages of three and six months, and was uniformly successful. Dr. Welch and the author have in a score or more of instances successfully vaccinated children who were born of variolous mothers; some of these infants were vaccinated as soon as they were born, while others were successfully vaccinated only several months later.

When the infection has occurred *in utero*, vaccination of the infant at birth frequently mitigates the character of the subsequent eruption. If a week or more elapses between the time of vaccination and the development of the variolous exanthem, the lesions are apt to be modified. When the eruption develops within the first week after birth, little or no modification is to be expected.

I must dissent from the view expressed by Roger that smallpox in the new-born infant differs clinically in any essential manner from variola in the adult. Roger contends that infants born of variolous mothers usually present a more or less latent smallpox characterized by hypothermia with or without a slight eruption which occasionally comes out in crops and aborts in the papular stage. There is also a tendency to icterus; a fatal termination occurs in most cases. Roger says: "At first sight the new-born appeared well constituted; their general condition was good and nothing could have caused a congenital infection to be suspected if one had not taken their temperature. All of the infants were hypothermic. . . . In six infants death occurred without their presenting any symptoms suggesting variola in any way." I have on a number of occasions seen new-born infants develop severe and even confluent smallpox. I am not familiar with a congenital variola which may exist without an eruption or be characterized by a sparse exanthem which is arrested in the papular stage. That most infants born of variolous mothers are not really suffering from smallpox at birth is proved by the fact that they will, in the vast majority of cases, respond to vaccination.

Cutaneous Complications and Sequelæ.—Boils constitute the most frequent complicating disorder met with in smallpox. But few patients pass through an attack of variola vera without suffering from numerous furuncles. The subjects of confluent smallpox suffer more severely than those who have a lighter form of the disease. Even patients with varioloid are not always exempt from this troublesome complication. The furuncles develop most commonly after the stage of decrustation, about the twentieth or twenty-fifth day of the disease.

Subcutaneous Abscesses.—Subcutaneous abscesses are commonly associated with the more superficial furuncular inflammations. These may occur upon any part of the body surface, but involve with predilection the scalp, face, arms, and legs. They are often preceded by a cellulitis or a phlegmonous inflammation of the skin and subcutaneous tissue.

Carbuncles occasionally occur during convalescence from smallpox.

Erysipelas.—This complication, when it develops, usually appears at the end of the second or third week of the disease. The face is the region most often affected, although the process may attack the extremities or trunk. At times a diffuse erysipelatoid inflammation of the skin occurs, without the actual development of a true erysipelas.

Bed-sores.—Bed-sores occasionally occur in the course of smallpox, as they do in other protracted diseases. They are far less frequent at the present time than in earlier days. They result from pressure, malnutrition and uncleanliness, and may usually be avoided by careful nursing.

Gangrene.—At times, during the pustular stage of smallpox, the swelling and inflammation of the skin may be so great as to produce multiple areas of necrosis. Sloughing of the skin may also result from undermining of the integument by subcutaneous abscesses.

Apart from these losses of cutaneous tissue, spontaneous gangrene of the skin occasionally occurs during the course of variola. The genitalia are the parts most commonly involved. Gangrene of the scrotum is a complication of great gravity, for most patients thus attacked succumb to the disease.

Gangrene of the skin is not limited to the regions above mentioned. It may attack almost any portion of the cutaneous surface. During a recent epidemic I observed three cases of gangrene of the scrotum and five cases in which gangrene occurred upon various portions of the thigh. In some of the latter cases extensive destruction of the cutaneous, subcutaneous, and muscular tissues occurred, the sphacelated areas attaining at times the size of the palm of the hand. In four of the five cases recovery took place after a tedious convalescence. It may be of interest to note that most, if not all, of these patients suffered from more or less impetigo variolosa.

Etiology.—Smallpox is one of the most contagious of all disorders, and there is an almost universal susceptibility to the infection. Age, sex, and condition

of life do not materially influence liability to attack. The prevalence of the disease is considerably influenced by the season, smallpox being in the temperate zones much more common in the cold months of the year.

Smallpox is infectious in all stages characterized by symptoms; the infectivity is least during the initial stage, and greatest during the suppurative and early desiccative periods. The disease is usually contracted by more or less close contact with a person suffering from the disease, but it may be transmitted through infected garments or other articles. The contagion may be carried a considerable distance through the air from large smallpox hospitals.

Bacteriology.—There can be no doubt that smallpox is the result of the introduction into the body of a specific microparasite. The causative organism must be present in the cutaneous lesions, for the disease may be readily inoculated. The fluid of early variolous lesions is sterile on ordinary media. After the seventh or eighth day it abounds in microorganisms, chiefly streptococci. Numerous organisms have been described in connection with smallpox, but most of these can be excluded as bearing any etiologic relationship. Great interest attaches to the researches of Guarnieri, and more recently to those of Councilman and his associates, upon the presence of an alleged protozoon, the *Cytoryctes variolæ*, in the lesions of smallpox and vaccinia. This is regarded by these and other workers as the parasite causing the disease. Certain other investigators believe the bodies to be degeneration products.

In view of our imperfect knowledge of protozoology the parasitic nature of these bodies can, at the present time, neither be positively proved or refuted.

Pathology.—The Histopathology of the Pock.—The microscopic structure of variolous lesions has been studied by Barensprung, Auspitz and Basch, Ebstein, Rindfleisch, Unna, Weigert, Touton, Renaut, Leloir, Buir, and others.

Unna has carefully studied the structural changes in the skin, employing the most modern histologic technic.

According to Unna, the development of the variolous vesicle is the result of certain peculiar degenerations of the protoplasm of the epithelial cells. The main features which differentiate the vesicle formation in smallpox from that in chicken-pox are the slowness in growth and the prompt addition of suppuration to the epithelial degeneration.

The changes in the protoplasm of the cells of the mucous layers of the epidermis are of two chief varieties. These have been designated by Unna "reticulating" and "ballooning" colliquation (softening). Both are special forms of fibrinoid degeneration.

Reticulating colliquation occurs as follows: As a result of the poison of the disease the protoplasm of the cells becomes edematous and undergoes partial or complete liquefaction, thus converting the cell body into a large cavity. When the liquefaction of the cells is partial, protoplasmic trabeculæ form, which coagulate into a network often radially arranged, and hold the nucleus and cell-mantle together. The name "reticulating" colliquation is given to this degeneration because of the net-like character of the structure.

In the second form of fibrinoid metamorphosis—that designated "ballooning" colliquation—the whole protoplasm of the cell swells up and becomes cloudy and opaque. Most of the cells have the form of hollow spheres or balloons, the predominance of which gives rise to the name "ballooning colliquation."

The reticulating degeneration mainly attacks the older cells, or those in the upper strata of the Malpighian layer, and the ballooning degeneration the younger cells, or those in the lower strata.

Exceptionally a sort of umbilication may result from the accidental piercing of the center of the pock by a hair-follicle, the cornified neck of which limits the swelling of the prickle-cells. The characteristic depression in the center of the vesicle is due, however, to another cause. It is the result of the reticulating degeneration and edematous swelling of the cells. These occur chiefly at the periphery, whereas the ballooning degeneration, which occurs slowly and gives rise to less swelling, takes place in the center. The umbilication is, therefore, due rather to a bulging of the periphery of the vesicle than to a retraction of the center.

The primary pustulation is due to the variolous poison, but prolonged suppuration must be ascribed to secondary pyogenic infection.

Healing.—Even before the contents of the pustule are completely dry, a thin layer of epithelial cells lying close on the connective tissue extends from all sides under the pustule. When the scab is thrown off, there is displayed a persistent, trough-like depression. Where the scab does not to any great extent depress the base of the pock, the papillary layer is not completely flattened out, and the scar is not so deeply excavated.

The pocks upon the palms of the hands and the soles of the feet develop in a somewhat different manner from those elsewhere. The reticulating and ballooning degenerations are only imperfectly seen here.

Stokes believes that "the primary exudation of plasma-cells has not been sufficiently emphasized by Unna. These plasma-cells are probably derived in part from proliferation of the endothelial lining of the lymph-spaces and blood-vessels. Very early there is increased number of plasma cells in the lymph-spaces and around the small blood vessels. The condition resembles the response to some injury, and seems to be the first change in the skin since the various changes in the epithelial cells are not yet present."

Councilman and his associates have carefully studied the pathology of variolous lesions. In the main, Unna's findings are confirmed, but some new facts concerning the histology of the pock are presented.

The earliest form of degeneration is said to take place in the nuclei of the cells of the rete mucosum. They become swollen, more vesicular, and exhibit increased central clumping of the chromatin. In the lesions leading to vesicular formation there is a reticular degeneration of the cytoplasm with a more advanced degeneration of the nucleus. The nuclei may lose their form and become irregular and shriveled, assuming peculiar shapes. Advanced forms of cytoplasmic inclusions are common in the nuclear spaces and in vacuoles in the protoplasm. A later form of degeneration, the ballooning degeneration of Unna, is regarded as a hyaline fibrinoid degeneration.

The early exudate is clear, and contains no admixture of cells. Indeed, a conspicuous feature of the smallpox process everywhere is the paucity of cells in the exudate. The cells appear only at a late stage of the process, and are much less than in other degenerations and exudations due to bacterial infection.

Councilman, Magrath, and Brinckerhoff believe that Weigert's explanation of the cause of the umbilication is correct in many instances. Weigert regarded the umbilication to be due to the diphtheroid degeneration of the epithelium of the center of the vesicle, thus preventing the distention of the center by the exudate; he believed, however, that the hair follicles and sweat-ducts also played a part in its formation.

Diagnosis.—The detection of smallpox in the pustular stage, particularly in well-marked eruptions, is a facile matter, even for the merest tyro in medicine. The picture of a profuse pustular variola can scarcely be mistaken for anything else.

It is especially the mild and modified forms of smallpox that present difficulties in diagnosis. The

degree of protection in varioloid, *i.e.* in smallpox modified by vaccination, may be so great that the eruption may consist of but a few papules or, indeed, the eruption may be absent altogether, constituting a variola sine exanthemate. The diagnosis in such cases would, of course, present perplexities. It is a matter of considerable importance to ascertain whether variola is prevailing in a community, and whether the patient has been exposed to the infection.

The degree to which the patient is protected by vaccination or a previous attack of smallpox should always be investigated.

The presence of a comparatively recent vaccine scar or pits of a former attack would constitute strong presumptive evidence against the existence of smallpox in the individual.

The occurrence of a characteristic initial illness preceding, by several days, the outbreak of an eruption, is of important diagnostic value. The diagnosis cannot be positively made before the appearance of the eruption, unless there has been undoubted exposure to the disease.

The initial illness may be confounded with influenza, typhus or typhoid fever, meningitis, acute gastritis, etc. After the appearance of the eruption, the diseases which may be brought into diagnostic conflict are measles, scarlet fever, chickenpox, roseola vaccinosa, syphilis, acne, iodide and bromide eruptions, glanders, eczema, etc.

Measles.—Measles may be confounded both with the morbilliform prodromal rash and with the beginning true eruption of variola.

That measles may bear strong resemblance to smallpox is evidenced by the fact that in epidemics of variola cases of measles are not infrequently sent to the smallpox hospitals under erroneous diagnosis. It is the confluent forms of variola, which, in the early eruptive stage, resemble measles most for in this type of the disease the face is often considerably suffused.

The diagnosis can, in the vast majority of cases, be determined by attention to the following points:

The constitutional symptoms preceding the eruption in smallpox are usually more severe (temperature 104° to 105° F.) and are commonly, though not always, accompanied by pronounced backache. The temperature, moreover, falls a few days after the appearance of the eruption, while the fever in measles at this time continues high. The catarrhal symptoms affecting the eyes and the respiratory passages and the buccal eruption, which are so constant in measles, are absent in smallpox, at least during the prodromal stage. The eruption in measles consists of large maculopapules which are soft and velvety to the touch, while the papules in smallpox are smaller and have a firm and shotty feel. The sweep of an experienced hand over the skin will often suffice to differentiate the two diseases. Where there is doubt, twenty-four hours' delay will dispel all uncertainty, for by this time the eruption of measles will have become flatter and more diffuse and the papules of smallpox firmer and more distinctly elevated.

Scarlet Fever.—The peculiar distribution and fleeting character of the scarlatiniform prodromal rash will enable one to distinguish it from scarlet fever. Scarlet fever may, however, be closely simulated by that form of hemorrhagic smallpox in which the entire cutaneous surface becomes the seat of a diffuse, dusky-red rash, especially well marked in the crural triangle. This form of purpura variolosa is, however, usually preceded by excruciating backache. If the patient be watched for a short time, a few ill-defined vesicles will usually make their appearance. The development of hemorrhages will not in itself be conclusive, as these might occur in hemorrhagic scarlet fever, except that hemorrhage beneath the conjunctiva would indicate the existence of smallpox. The early occurrence of sore throat would point toward the scarlatinal nature of the disease.

Chickenpox.—The differential diagnosis between smallpox and chickenpox has been considered under the latter disease.

Syphilis.—It may at first seem strange that syphilis and smallpox should ever be confounded. Upon reflection, however, it will be seen that the two diseases have many phenomena in common. They are both infectious diseases, due, we may assume, to the invasion of the blood by a microorganism. Each has a period of incubation, at the end of which there develop certain general manifestations accompanied by an exanthem and an enanthem. The resemblance may be still further accentuated by the fact that the varioliform syphilid is not rarely associated with, and even preceded by, fever and general aches and pains. It is particularly the pustular syphiloderm which is apt to be confounded with smallpox. The eruption may at times appear rather suddenly and pass through the stages of papule, vesicle and pustule in a surprisingly brief period of time. The lesions may be quite firm to the touch, and in other respects closely simulate those seen in smallpox.

In syphilis one can frequently obtain (1) a history of infection and a description of the initial lesion. Indeed, the chancre or the remains may still be detected. Not uncommonly there are present associated evidences of syphilis, such as mucous patches, flat condylomata, ulceration of the tonsils, alopecia, etc. The varioliform syphilid may develop after the disappearance of one of the earlier syphilitic eruptions.

(2) The onset of the two diseases is, as a rule, quite different. The syphilitic subject will usually give a history of having felt weak and debilitated for some weeks. If fever precedes the eruption, it is ordinarily not very high, and is not accompanied by severe prostration. When the eruption appears, the patient usually calls upon the physician at his office or at the hospital. We do not note that sudden illness and prostration which precede unmodified smallpox. In the latter disease, the patient instead of calling upon the physician, sends for him.

It must be remembered, however, that in varioloid the initial symptoms may be mild, or, in rare instances, absent. On the other hand, in rare cases syphilis may be present an initial illness which strongly counterfeits that of smallpox.

(3) The development of the eruption in smallpox is rather sudden. Ordinarily, in twenty-four to forty-eight hours, the full complement of lesions has appeared. In syphilis the eruption may continue to come out for quite a number of days in successive crops. It must be admitted, however, that in modified smallpox three or four days may sometimes elapse before the complete appearance of the exanthem.

(4) The distribution of the varioliform syphilid may be similar to that observed in smallpox. Frequently, however, variations are noted. The pustular syphilid may involve the trunk more copiously than the face; this would be exceedingly rare in well-marked smallpox. The dorsal surfaces of the wrists and hands are nearly always involved in smallpox, but are relatively free of eruption in syphilis. The palms of the hands and soles of the feet are always involved in severe smallpox; in moderate eruptions they nearly always present some lesions, and in modified smallpox they may or may not escape completely. The pustular syphilid, on the contrary, rarely, if ever, attacks the palmar and plantar surfaces.

(5) The character of the eruption in syphilis and smallpox may, in the beginning, be so nearly identical as to make the diagnosis from the eruption alone quite impossible. It will be noted, however, that the efflorescence of smallpox presents a much greater uniformity in character and development of the lesions over the body than does syphilis. Syphilis is characterized by an essentially multiform eruption; it is not uncommon to find small pustules, large pustules

and papules interspersed, and these in varying stages of evolution and involution.

The vesicles and pustules of syphilis are usually conical, and involve merely the summits of the elevation, they never become full and globular, and fill the entire lesion, as do those of smallpox. Beneath the syphilitic crusts considerable ulceration not uncommonly occurs. According as this is slight or severe, there will be seen, upon the detachment of the crusts, a small reddish-brown pigmented stain or an excavated ulcer. The latter heals with the production of a depressed scar.

(6) The course of syphilitic eruption is relatively chronic, compared with that of smallpox. The lesions of variola undergo a striking change in a few days. The syphilitic efflorescence is indolent and presents, as a rule, no decided alteration of appearance within this period of time. By the sixth or seventh day in smallpox the lesions develop into those large, full, round, hemispheric pustules which are so characteristic in the disease.

Finally to the physician who has never seen much smallpox, there is a something in the picture—an impression given by the ensemble—which, while not definable in language, is, nevertheless, of subtle aid in the diagnosis.

Roseola Vaccinosa.—Vaccination with animal virus sometimes causes an erythematous or rubeoloid rash, known as roseola vaccinosa, to appear from the eighth day to the twelfth day of the vaccine disease. I have on several occasions seen this rash confounded with the eruption of variola, especially during epidemic visitations of the disease. The distinguishing features are that it accompanies vaccinia, that it is not preceded by a very high temperature, and that it consists of macules rather than papules.

Acne.—Mild cases of modified smallpox, exhibiting but a few papulopustules about the face, may bear a close resemblance to acne. The history of exposure, the existence of an initial stage, and the progressive evolution of the lesions will speak for the variolous nature of the eruption, while the presence of blackheads, a history of previous outbreaks in the individual, and the absence of preceding illness will decide in favor of acne.

Drug Eruptions.—Drug eruptions, particularly those resulting from the ingestion of the iodides and bromides, may simulate the exanthem of smallpox. The history and absence of an invasive stage will usually suffice to make the diagnosis clear. I have seen some bromide eruptions which closely resembled the eruption of smallpox.

Glanders.—Glanders in an early stage may be mistaken for smallpox. The febrile symptoms are not unlike those of variola, and the subepidemic abscesses, when small, feel like hard infiltrations in the skin. In this disease, however, there are, in addition, deep-seated abscesses, infiltration of the areolar tissue, rapid ulceration, and at times, gangrene. The disease is rare, and the patients are usually stablemen.

Eczema.—Severe crusted eczemas of the face may bear a rough resemblance to confluent smallpox during the desiccative stage. I have known physicians experienced in smallpox to make this error through a hasty superficial examination of the patient. Inspection of the trunk and extremities will make the diagnosis clear.

During epidemics, the anticipatory attitude of the physician's mind will often lead him to suspect and diagnose as variola diseases which bear only a superficial or remote resemblance to it. Thus patients with febrile herpes zoster, erythema multiforme, and other skin diseases have at such times been sent to a smallpox hospital as cases of variola. Contrariwise in the absence of an epidemic, mild cases of smallpox are very likely to be overlooked.

Whenever the diagnosis between smallpox and a disease simulating it is in doubt, observation of the progress of the eruption for a period of twenty-four to thirty-six hours will usually make clear the nature of the disease.

Prognosis.—The prognosis of smallpox is influenced by the vaccinal condition of the patient, the severity of the prevailing form of smallpox, the age of the patient and the extent and depth of the cutaneous lesions. Of all the factors bearing upon the outcome of the disease, the vaccinal condition is the most important.

Treatment.—The treatment of smallpox may be considered in its relationship first, to the patient himself, and, second, to the community at large. The latter aspect of the subject concerns the prophylaxis or preventive treatment of the disease. This may be conveniently classified under the following captions—notification, isolation, surveillance, or quarantine, disinfection, and vaccination.

Prophylaxis—Notification.—It is important in the interests of public health that the existence of a case of smallpox should be promptly made known to the proper health authorities. It is usually the duty of the physician in attendance to transmit this intelligence. Every practitioner of medicine should feel himself called upon to aid and sustain the sanitary authorities in their efforts to prevent or stamp out a pestilential disease and should willingly comply with any arrangements whose object is the attainment of so desirable an end.

Most large communities have enacted laws making compulsory the notification of smallpox and other pestilential diseases, under pain of fine or imprisonment. It is only through a knowledge of the distribution and extent of smallpox in an infected district that the health authorities are enabled to intelligently and efficiently inaugurate measures toward its suppression.

Isolation.—It is of paramount importance, when smallpox appears in a community to prevent the dissemination of infection; to this end the isolation of the patient—the source of infection—becomes essential. This can only be accomplished with any degree of certainty by having the sick removed to a well-organized hospital. General hospitals and other public institutions cannot, with justice to the other patients or inmates, harbor and threat those suffering from smallpox. Even the caring for such patients in isolated pavilions in general hospitals is open to the objection of multiplying the foci of contagion in the city or town. It follows, therefore, that every city and large town should be provided, either temporarily or permanently with a special institution for the treatment of this disease in the event of its outbreak. It should be located in a healthful district sufficiently removed from the thickly settled portions of the city to preclude the possibility of transmitting the contagion to inhabited domiciles, but not so remote as to interfere with its accessibility. It is also of importance that such institutions should be constructed in a modern manner with a view to making the unfortunate patients as comfortable as possible.

Of course, a special hospital of this character should be managed under strict quarantine regulations. No person, however well protected, should be allowed to visit a patient in the institution except under extreme circumstances, and then only after every possible precaution shall have taken place to prevent his carrying away the infection. The nurses and attendants should not be allowed to leave the hospital, nor come in contact with other persons, until they have had an antiseptic bath and have changed their infected clothing. In providing nurses and other employees for the hospital it need not be required that they shall have had smallpox, but they should invariably be vaccinated or revaccinated before entering upon duty. When delay is possible it is wise to wait the result of such vaccination before the individual is brought into the infected atmosphere. The hospital should be sup-

plied with closed ambulances for the transportation of patients. Private or public vehicles should never be used for this purpose. Indeed, this is regarded as so important a matter that in some large cities in this country the use of any kind of public conveyance for carrying persons afflicted with smallpox is prohibited by law, and its infringement is made punishable by fine.

Lest infection be spread by the ambulance itself, it should be disinfected and provided with clean bedding, blankets, etc., every time it is used. In order that the public may know the character of the disease that it conveys, it should bear the name of the hospital to which it belongs.

If the smallpox patient is to be treated at home, every possible effort should be made to seclude him from all persons, excepting only such as are required to act as nurses and they should be protected by recent vaccination. In selecting the apartment for the patient, a room most completely separated from all other parts of the house is to be preferred. If this is not practicable—which is usually the case in the ordinary city residence—the uppermost room of the house should be preferred. It should be well ventilated and, if possible, have an open fireplace in which fire should be kept constantly burning. All unnecessary articles of furniture, such as drapery, upholstery, carpets, etc., should be removed. Every precaution in regard to cleanliness and disinfection of bedding, clothing, and everything in use in the room exercised, so that the danger of spreading the infection shall be reduced to the minimum. A sheet wrung out in a strong solution of carbolic acid, Labarraque's liquid, or some other disinfectant, and suspended across the doorway may aid in preventing the infection from being disseminated to other parts of the house. The spaces around doors that are not in use, which communicate with other parts of the house to be protected, should be sealed by pasting strips of wrapping paper over them.

Surveillance or Quarantine.—When smallpox appears in a house, the question arises, what shall be done with the exposed but well members of the household? If the patient is treated at home, the other inmates as well as the sufferer should be quarantined. For, if removed to another locality, save to a quarantine station or hospital, the disease might subsequently appear there, and a new center of infection be thus established. To depend upon people voluntarily to curtail their personal liberty for the public good would be confiding too much, at the present time, in human benevolence and public spirit. Therefore, the best results will be obtained, when the patient is retained at home, by stationing reliable guards about the house to enforce detention of the exposed inmates and also all other necessary precautionary measures.

On the other hand, when the patient is removed to the hospital, it is (in my judgment) not necessary to enforce the above-mentioned restrictions. Indeed, I am of the belief that the object desired is often defeated in large cities by a routine quarantine of the inmates of houses from which smallpox patients have been removed. To make such a quarantine effective, the individuals should be detained for a period of eighteen days, the outside limits of the stage of incubation. Segregation of the inmates of the household for so long a period works a great personal hardship and prompts them, in many instances, to escape before the quarantine is placed upon the house. Persons frequently flee from houses where there exists an individual suspected of having smallpox, but in whom the diagnosis has not been definitely made. The settling of these exposed persons in different parts of the same city and in other cities results in the outbreak of the disease in these various localities. Thus, instead of limiting the infection too rigid quarantine laws may favor its dissemination. Furthermore, unpopular restrictive measures tend to provoke evasion of the law and concealment of the existence of the disease.

When the patient is removed to the hospital, immediate vaccination of the exposed individuals should be performed. To avoid, as far as possible, failures through imperfect virus or technique, three or four insertions with different virus had better be made. At the same time there should be thorough disinfection of the infected articles and apartments. After this has been accomplished, the exposed individuals might resume their freedom. They should, however, be kept under medical surveillance, and should be daily visited by a physician who should watch for any symptoms of variola. Such inspection should be continued for sixteen days (or a few days longer in the case of the mild type of smallpox) from the onset of the disease in the original patient, at the end of which time the suspected individuals, if well, may be exempted from further surveillance. During his visits the physician can determine whether the vaccinations are "taking" and, if not, the procedure can be repeated, thus giving the patient a still further chance of protection if vaccinal susceptibility exists.

The above plan is based upon the assumption that smallpox is not contagious during the period of incubation, and this view is in accord with the belief held by practically all authorities on the subject. Until active symptoms manifest themselves, the exposed individual is not a menace to the health of the community, and it is unnecessary and injudicious to restrict his liberty during this period. Furthermore, a large experience has demonstrated that under a system such as outlined, a much larger percentage of exposed individuals will submit to vaccination and a correspondingly increased number of patients will consent to be removed to the hospital, for only those who comply with this advice will be exempted from quarantine.

Apart from these considerations, the system of routine quarantine, during epidemic prevalence of smallpox, will be found to involve the expenditure of large sums of money.

The quarantining of exposed persons may be practicable and wise in dealing with sporadic cases of smallpox or with the first or last cases in a community, for under such circumstances extraordinary precautions are justified in an endeavor to limit the outbreak of the disease to the original patients.

Another means of restricting the spread of smallpox is to apprise the public of the particular locality in which the disease exists, so that no one may unknowingly approach within infecting distance of the place. But how to do this without exciting unnecessary alarm is a problem not easy of solution. The plan adopted in some cities of "placarding" the infected house with a large and conspicuous poster is believed by many to serve a useful purpose, notwithstanding the fact that it frequently meets with opposition. But whether this plan be adopted or not, the sanitary authorities should keep the premises under constant supervision, instituting daily visits by officers qualified and empowered to advise and direct the observance of proper sanitary precautions.

Disinfection.—Disinfection is a highly important prophylactic measure. The infection of smallpox is not only imparted to the atmosphere surrounding the patient, but to all articles which have been used by him or have been near him. It clings to these articles for a variable length of time, and they are, therefore, not infrequently the media by which the infection is conveyed to others. Disinfection consists in the complete destruction of the infecting agent of the disease. Fresh air and sunlight are nature's disinfectants; when infected articles are freely exposed to the atmosphere and rays of the sun for some time, the infecting principle becomes less and less active, and finally disappears. Therefore, the house, especially the room, occupied by the patient should be freely though cautiously ventilated. If the weather is cool, an open fire upon the hearth would consume much of the infected atmosphere.

Chemical substances, however, furnish the more speedy and reliable disinfectants, and it is upon such that we mainly depend for the destruction of the disease germs. Some agent of this nature should be brought directly in contact with all the excrementitious matter from the patient, and with everything that has been used by him or has been near him during the progress of the disease. All discharges not excepting those from the mouth and nose, should be received into a vessel containing such disinfectant as chloride of lime, carbolic acid, or bichloride of mercury. Under no circumstances should the excreta be allowed to flow into the sewer or be cast away without first having undergone disinfection. In country districts where disinfectants may not be readily obtained, the discharges should be deeply buried in the ground, in a locality where there is no danger of contaminating the water supply. Every handkerchief, towel, and article of bedding and clothing used by the patient should be steeped for some time before leaving the room in a solution of two fluidounces of chloride of lime or four fluidounces of carbolic acid to the gallon of water, and afterward boiled by themselves for half an hour or longer in plain water; all small articles, such as bits of linen, sponge, absorbent cotton, and the like should be burned immediately; all utensils used for eating and drinking should be sterilized in boiling water; and, in short, nothing should be allowed to leave the room without having first been subjected to some form of disinfection.

The attendants should not be more numerous than the necessities of the case require. They should be carefully instructed in regard to the importance of cleanliness, disinfection, and isolation. Not only should they be instructed to exclude from the sick-room all persons not having authority to enter, but also all domestic animals, such as the dog and cat, as they are exceedingly liable to serve as conveyers of the infection.

The clothing of the attendants should be of such material as can be readily boiled and washed, and it should be frequently changed and subjected to this process. No attendant while engaged with the case should come into contact with other persons. On leaving, either temporarily or permanently, a bath should first be taken, using freely carbolic acid soap, and the hair should be washed with a solution of mercuric chloride. No clothing that has at any time been in the infected atmosphere should be worn or carried away from the premises, unless it has first been disinfected.

Physicians should also exercise care lest they may be the means of communicating the infection. When called upon to attend a case of smallpox the physician should not remain in the infected atmosphere longer than is necessary to make a proper examination; the prescription may be written and advice given in another apartment. After each visit he should carefully wash his hands, face and hair, his hands especially should be washed in some disinfecting solution. He should then expose himself for a considerable time in the open air before visiting another patient.

The physician should wear in the sick chamber a long mackintosh or a linen duster buttoned up to the chin, and a cap to cover the hair, and these garments should be kept hanging in the open air in the intervals of his visits. In hospitals where there are many patients to be examined, and where he is required to spend considerable time in the wards, nothing short of a change of his entire outer clothing before leaving the institution should be considered. It is also of importance for the physician to cover his shoes with rubbers, so that no variolous crusts which may be upon the floor will be carried out of the infected house.

The isolation of a smallpox patient should be continued until all the scabs are removed. The time necessary to effect their separation varies greatly in different cases. In severe confluent forms of the disease, a month or more will be required, while in extremely mild and abortive cases of varioloid the skin may be entirely smooth in a week or ten days. Upon the palms and soles the inspissated pocks remain embedded for a long time and require mechanical removal in order to avoid long and tedious waiting for spontaneous exfoliation. Even after removal of the variolous crusts the patient should not be allowed to associate with the public until he has had one or more antiseptic baths. Perhaps the most reliable antiseptic bath that can be given is one containing corrosive sublimate. The safest way one may proceed in the use of such a bath is by simply sponging the body and carefully wetting the hair with the solution (1 : 2,000) and then have the patient freely bathed in plain water with the use of carbolic acid soap, or the patient may take a full bath in a tub containing 1 : 10,000 or 1 : 20,000 solution of mercuric chloride. A five per cent. solution of Labarraque's liquid also makes a very reliable disinfecting bath. After this he should put on clothing which has not been exposed to the infection, or, if exposed, has been disinfected, and he may then safely mingle with the public.

Inasmuch as the body of a person who has died of smallpox, is capable of imparting the infection, some precautions should be observed in regard to it. For instance, the body should be thoroughly wet with a solution of corrosive sublimate 1 : 1,000 or with a solution of chloride of lime in proportion of six ounces of the drug to a gallon of water, or with some other equally powerful disinfectant; besides, it should be wrapped in a sheet saturated with one of these solutions and buried at once. The preferable method of disposing of the dead from this disease is by cremation; but this method is yet too strongly opposed by the public sentiment to be practicable. It is not advisable to transport the corpse a long distance or from one city to another for burial, but if this be really necessary, it should first be placed in a metallic coffin hermetically sealed. In its burial it should be put at least sx feet under ground, and should not be disinterred unless absolutely necessary, and then only under sanitary supervision. The vehicle used for conveying the body to the grave should afterward be disinfected. It is, perhaps, unnecessary to say that the funeral should by no means be public.

After the sick chamber has been vacated, either by recovery or death of the patient, every article it contains of no great value should be immediately burned. Everything else which will not be injured by the ordinary operation of the laundry may be safely and cheaply disinfected by immersion in boiling water for half an hour. It should be remembered, however, that the water must be maintained to the boiling point for that length of time. But if it is impracticable to subject such articles at once to the boiling point, they should be immersed for about four hours in some reliable disinfecting solution—such as mercuric chloride in the proportion of 1 : 2,000, or carbolic acid 1 : 50—and subsequently boiled.

The sick room should be disinfected according to the principles laid down for disinfection of apartments. The room should then remain closed for twelve to twenty-four hours, afterward opened, thoroughly ventilated, and all surfaces, including the furniture, washed with a disinfecting solution (chloride of lime, carbolic acid 1 : 50, or mercuric chloride 1 : 1,000) : afterward the floor and woodwork should be thoroughly scrubbed with soap and water. The wall paper, if there be any, should be well moistened with the carbolic acid solution and scraped off and burned. Paper may be reapplied or the walls whitewashed or painted according to fancy. In addition to all these precautions it is advisable to have the room remain unoccupied for three or four weeks, during which time it should be well aired.

For disinfection of outer clothing, carpets, bedding, and all articles which cannot be boiled, there is nothing superior to steam under pressure. The germs of smallpox will certainly perish if exposed for half an hour at a temperature of 230° F. There are, however, certain articles which would be injured by moist heat, and for the disinfection of these, dry heat may be substituted. In this case a temperature of at least 230° F. continued for two hours, will be required. Formaldehyde, however, could be used instead of dry heat.

Vaccination.—Of all the measures employed to prevent the spread of smallpox, none is so important and efficacious as Jenner's great discovery. There is perhaps no single scientific fact better established than that vaccination periodically repeated, is capable of effectually preventing the occurrence of that disease in man. In view of this fact it does at first sight seem strange that variola should continue to prevail in civilized communities; and while nothing appears easier than to control the spread of the disease, or even to eradicate it altogether, yet there are difficulties in the way of accomplishing this end which seem almost insurmountable. These arise from various causes but chiefly from individual carelessness or indifference about employing vaccination, and from the absence of a general law making it compulsory. We know that many conscientious citizens are opposed to enforcing vaccination by law, but as every unvaccinated person is liable to contract smallpox and disseminate the infection among others, he should be regarded in the light of a public enemy, and dealt with accordingly. Surely it is not an unreasonable position to assume that no person through ignorance or prejudice should be allowed to contravene the public welfare.

But, in the absence of a statutory law requiring the vaccination of all persons, very much can be done in the way of enforcing the measure by restricting the privileges of the unvaccinated. For instance, satisfactory evidence of successful vaccination should be required of every child before admission into public and private schools and institutions for the care of children; no unvaccinated person should be allowed to serve as a soldier in the army or navy, or in the State militia; and no unvaccinated immigrant should be allowed to land until vaccination has been performed.

In view, therefore, of the great importance of this prophylactic measure, it becomes the duty of all municipal and State authorities to provide gratuitous vaccination for the poor, and, indeed, for all helpless children of careless or improvident parents no matter to what class of society they belong. No expenditure of money should be spared by these authorities in order to protect their citizens against a disease so loathsome and fatal as smallpox. From a purely monetary point of view such expenditure is wise, for a single epidemic of this much dreaded disease in a community may necessitate a greater outlay to care for the indigent sick alone than would be required to purchase the means of protection for that community for a decade of years.

If vaccination were universally practised, and repeated from time to time as circumstances required, there would be little need for other means of prevention. Whenever a case of smallpox occurs in a family, the physician's first duty is to vaccinate promptly all members of the family who have never been vaccinated, and revaccinate all others without regard to the character of their previous vaccination. It is a good plan to vaccinate on several successive days those who have never been previously subjected to this procedure, in order to increase the probability of obtaining a successful result. If this be done, and the patient sent to the hospital, the disease may be prevented from spreading.

The preventive treatment of smallpox outweighs all other considerations in the therapeutics of this disease. Proper vaccination and revaccination are all-sufficient safeguards against this dread malady. After the symptoms have once developed, the purpose of treatment is to keep the patient alive until the disease has run its course. The general treatment is not unlike that applicable to any other acute infectious process—consisting of a nutritious and easily assimilable diet, stimulants, and symptomatic remedies.

Local Treatment.—The topical use of antiseptics in smallpox has been advised and employed for many years. Mercury, in the form of corrosive sublimate solution or an ointment of some salt of mercury, boric acid solution, permanganate of potash solution, iodoform, carbolic acid, eucalyptus, thymol, salicylates, and a host of other remedies have been used without striking results.

The object of local treatment is to assuage the pain, burning and itching, to correct the offensive odor, to guard against septicemia, and to lessen or to prevent scarring.

Lint masks soaked in ice-water and glycerin greatly relieve the itching and burning. Dusting powders containing five per cent. of iodoform or fifteen per cent. of aristol are useful in abating the offensive stench.

To guard against septicemia prolonged warm baths may be given during the stage of suppuration and desiccation; the pustules become macerated and may be evacuated by rubbing the skin with gauze. These baths serve also to lower the temperature and improve the nervous symptoms. Sometimes it is advantageous to give antiseptic baths, the water containing bichloride of mercury (1:10,000 to 1:20,000) or creolin in the strength of 1:500. When it is inconvenient or impossible to employ the baths, much good will often be derived from opening and evacuating the pustules on the trunk and extremities and sponging the bases with absorbent cotton wet in a 1:5,000 bichloride of mercury solution.

For extensive impetigo variolosa a bichloride bath is given followed by dusting of the body with

Calomel	℥j	4 gm.
Talcum	℥iv	120 gm.
Or		
Aristol	℥iij	12 gm.
Talcum	℥iv	120 gm.

Prevention of Scarring.—Various methods have been employed to prevent pitting in smallpox, but none has stood the test of experience. It must be remembered that many patients will escape scarring no matter what treatment is employed. In children the lesions are more superficially located, as a rule, than adults. In a patient once vaccinated the chances of recovery without pitting are also good.

In order that so-called ectrotic remedies should be regarded as meriting the claims made for them, they should prevent pitting in severe smallpox in unvaccinated individuals. In unmodified smallpox, pitting is as great and as much to be dreaded as in former times. Gregory, the great English smallpox expert, wrote: "There is no peculiar method which can be devised for the prevention of pits and scars. . . . The application of cold cream to the hardened scabs is all that can be recommended."

I have seen pretty much all the vaunted remedies tried, but without encouraging results. The application that seemed to accomplish most was the tincture of iodine — the pure or diluted tincture upon the face once or twice a day according to the sensitiveness of the skin. About the eighth or tenth day a hard parchmenty mask is formed, which begins to crack and peel off, at which times a weak carbolized vaselin is to be applied. The iodine treatment tends to shrink the pustules, to hasten decrustation, to destroy the offensive odor, and to some extent to lessen pitting, although in severe cases it will not prevent it. The liability to secondary pyogenic infection of the skin is obviated.

The red-light treatment of smallpox based upon the exclusion of the chemical rays of light, was strongly championed by the late Niels Finsen, of Copenhagen. I concur in the verdict of Ricketts and Byles of London, who say: "We cannot agree that the treatment has any merits which have been claimed for it."

JAY FRANK SCHAMBERG.

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10. Catlin: Letters and Notes on the Manners and Customs and Conditions of the North American Indians, London, 1841.
11. Extracts from a paper prepared by Sir John Simon in 1857, and presented by him before the Royal Commission on Vaccination in 1889, Appendix No. 1, p. 63.
12. Gentleman's Magazine, 1753.

Smegma Præputii.—The secretion of the prepuce, smegma præputii, consists mainly of fat, together with cholesterol and ammonium soaps.

F. P. U.

Smell, Sense of —See *Olfactory Nerve.*

Smellie, William.—Born in England during the last decade of the seventeenth century. He practised medicine at first in a provincial town, but, in the course of a few years, he attained such success that he felt justified in transferring his field of activity to the capital. He appears to have devoted himself chiefly to obstetrical cases, and it was not long before he came to be considered the leading authority in this branch of medicine in London. Although his practice was extensive, he found time to give instruction in midwifery to large numbers of pupils. In addition, he kept a careful record of the observations which he made in actual practice, and thus was enabled (according to Dezeimeris) to hand down to posterity one of the best collections of cases of unusual interest that has ever been published. He was also the inventor of a most useful type of obstetric forceps. The exact date of his death is not known.

Of his published writings the following deserve to receive special mention: "A Collection of Preternatural Cases and Observations in Midwifery," London, 1767; and "A Treatise on the Theory and Practice of Midwifery; to which are now added his set of anatomical tables, and additional plates of instruments, etc.," 3 vols., Dublin, 1764 (and a later edition, Edinburgh, 1784). A. H. B.

Smith, J. Lewis.—Born in Onondaga county, New York, on October 15, 1827. He received his A.B. from Yale University in 1849. His medical studies were begun with Dr. Green, and he attended a course of lectures at the Buffalo Medical College, and also served for one year in the principal hospital of Buffalo. In 1853 he received his medical degree from the College of Physicians and Surgeons, New York City, where he immediately established himself in practice. While he engaged in general practice Dr. Smith became one of the best known specialists in the diseases of children and held the following positions: Physician to the New York Foundling Asylum, and the New York Infant Asylum, Consulting Physician to the City Hospital, to the French Hospital, to the Pediatric Department of Bellevue Outpatient Department, to the Nursery and Child's Hospital, and to the Infants' Hospital on Randall's Island. He was also Clinical Professor of the Diseases of Children in the Bellevue Hospital Medical College. He died in New York City on June 9, 1897. He was one of the founders and second President of the American Pediatric Society, President of the Pediatric Section of the Ninth International Congress, a Fellow of the New York Academy of Medicine, and a member of the New York Pathological Society, of the County Medical Association, and of the American Medical Association. Dr. Smith was the author of a "Treatise on Diseases of Children," which was for a long time the authoritative text-book on this subject, and was also a contributor of pediatric articles to Pepper's "System of Medicine," to the first edition of this REFERENCE HANDBOOK, and to the leading special and general medical journals of this country. E. L. J.

Smith, Nathan.—Born at Rehoboth, Massachusetts, September 30, 1762. Determined to study medicine, he supplemented his early education, which was only such as pioneer life offered, by a course of study with a clergyman at Rockingham, Vermont. When twenty-two years of age he began his medical education at Putney, Vermont, under Dr. Goodhue, in whose home he remained for three years, leaving in 1787 to establish a practice in Cornish, N. H. According to the customs of the times Smith began to practise before he had obtained a medical degree from any one of the three medical schools then in existence in the United States. Two years later realizing the need of further medical study he gave up his practice and entered Harvard, where in 1790 he received the degree of Bachelor of Medicine. He returned to Cornish and resumed his practice with the realization that the time was ripe for the establishment of another medical school. In 1796 he made a determined effort to establish a professorship of medicine at Dartmouth College, but was requested by the trustees of the College to wait a year, which time he spent abroad at the University of Edinburgh and in London. After his return in 1797 he received a diploma from the Medical Society of London and was made a corresponding member of the same Society. In the autumn of the same year, 1797, he delivered the first full course of lectures in medicine at Dartmouth, but did not receive his professorship until August, 1798, when he also obtained his degree of Master of Arts. This date, August, 1798, marks the founding of the Dartmouth Medical School. He received his degree of Doctor of Medicine from Dartmouth in 1801. Smith continued as professor of anatomy, surgery, chemistry, and theory and practice of medicine until 1810, when he discontinued teaching the first two subjects, but held his professorship in chemistry and theory and practice of medicine until 1813. In 1811 Harvard conferred upon him the degree of Doctor of Medicine. In 1812 the Medical Department of Yale College was established and in 1813 Dr. Smith, on account of his wonderful ability as an organizer and teacher, was offered the professorship of theory and practice of physic, surgery, and obstetrics, which he accepted and held until his death. In June, 1821, with President Allen, Smith inaugurated the Medical School in connection with Bowdoin College, Maine, holding the professorship of anatomy, surgery, and theory and practice of medicine until 1823, and the theory and practice of medicine until 1826. The summer course at Bowdoin did not interfere with his work at Dartmouth. Later, in 1821, the Medical Department of the University of Vermont was established, largely through the efforts of Dr. Smith and his son Dr. Nathan Ryno Smith. Dr. Ryno Smith became professor of sur-

gery and anatomy, while Dr. Nathan Smith delivered courses of lectures and continued his interest in the school. The last medical school to enlist the interest of Dr. Nathan Smith was Jefferson Medical School of Philadelphia which was founded by his son, Dr. Ryno Smith, and Dr. George McClellan. Thus in the course of a busy life of private practice Dr. Smith succeeded in founding five new medical schools in the United States, as well as delivering forty-two general courses in medicine in thirty-two years, and giving instruction in about 138 special courses. He died in New Haven, Connecticut, on January 26, 1829.

In addition to his remarkable ability as a teacher and organizer, Dr. Smith displayed talent as a surgeon. He invented an apparatus for the treatment of fractures, a mode of reducing hip dislocations, and a method of amputation of the thigh. He also seems to have been remarkably successful in performing operations for the removal of cataracts, and in the treatment of bone necrosis. The publications of Dr. Smith were not many. His earliest, "Dissertation on the Causes and Effects of Spasms in Fevers," was published in 1791; but his most important contribution is a "Practical Essay on Typhus (Typhoid) Fever," published in 1824. Dr. Smith was twice married, and had ten children by his second wife. His four sons, David, Nathan Ryno, James, and John, all entered the medical profession in which they won marked distinction. E. L. J.

Smith, Nathan Ryno.—Son of the preceding; was born in Concord, New Hampshire, May 21, 1797. He studied medicine, under his father, in the medical department of Yale College, and received the degree of Doctor of Medicine from that institution in 1823. He established himself as a practising physician first in Burlington, Vermont, and then in Philadelphia; but in 1827 he removed to Baltimore, and remained there until the time of his death. During his brief residence in Burlington he was Professor of Anatomy and Surgery in the University of Vermont, and for two years (1825 and 1826) he held the position of Professor of Anatomy in the recently organized medical department of Jefferson College, Philadelphia. In 1827 he accepted the Chair of Surgery in the School of Medicine of the University of Maryland, and also that of Clinical Surgery in the Baltimore Infirmary. During 1838 and 1839 he was Professor of the Practice of Medicine in the medical department of Transylvania University, Lexington, Kentucky; but he retained his home in Baltimore during the greater part of each of these years. In 1840 he resumed his Chair of Surgery in the University of Maryland, and continued to perform its duties until 1870. He died in Baltimore July 3, 1877.

Dr. Nathan R. Smith was the inventor of "an instrument for the easy and safe performance of the operation of lithotomy—an operation in which he had been eminently successful, having performed it some 250 times, in almost all cases with success. In 1860 he invented and introduced an apparatus for the treatment of fractures of the lower extremity, termed the anterior suspension apparatus, and a few years afterward he published a volume descriptive of its application." (Stone.) He also published an important paper on the subject of dislocations of the hip-joint. A. H. B.

Snakeroot, Canada, or *Wild Ginger,* is the rhizome of *Asarum canadense* L., and that of *A. reflexum* Bicknell has probably been more or less used for and with it. These plants are natives of rich woodlands in the northeastern United States. The rhizomes lie very near the surface of the soil, may become a foot or more in length, branch rather freely, and bear few coarse roots. The leaves are long-petioled, kidney-shaped, and sometimes reach a breadth of six inches. The solitary flower is terminal, cup-shaped, three-lobed, about an inch broad, and of a deep purple color. The dried rhizomes are quadrangular or two-edged, longish-jointed, deep purple, lightly curved, and about as thick as matchsticks. The odor and taste remind one strongly of ginger. With some resin, starch, gum, and sugar, Canada snakeroot contains an unknown bitter principle and 1.5 to 3.5 per cent. of a volatile oil. An alkaloid is also thought to be present. It is an excellent aromatic bitter, the aromatic element predominating, and a carminative and diaphoretic. The dose is gr. xv.–xxx. (1.0–2.0), the tincture being the preferable form of administration. The volatile oil is also known to commerce. Its active constituent is *asarl* ($C_{10}H_{18}O$). Under the name "*asarabacca,*" the rhizome of *A. europeum* L. has long been employed similarly. It is now very little used. Its oil contains *asarone* instead of asarol, and it is distinctly emetic, or even purgative in the dose above specified for the other species. Its ordinary dose is only one-tenth as large. Henry H. Rusby.

Snakeroot, Virginia.—See *Serpentaria.*

Snellen, Herman.—Born at Zeist, near Utrecht, Holland, in 1834. He studied medicine at the University of the latter city, and received his doctor's degree from that institution in 1857. In 1862 he was made an Instructor (*Dozent*) in Ophthalmology at the Hospital for Eye Patients in Utrecht. In 1877 he was chosen Professor of Ophthalmology at the University. Snellen is known to the Profession at large as the author of a book ("Ophthalmo-Metrologie") which he published conjointly with E. Landolt, and in which is printed a collection of black letters that may be utilized in testing the acuteness of a person's vision. This collection, printed on a stiff card, and commonly known as "Snellen's test types," is in general use. He died in 1908.

Of Snellen's published writings the following deserve to receive special mention: "Die Behandlung des Glaucoms," 1888; "Notes on Vision and Retinal Perception; being the Bowman Lecture for 1896," Ophthalmological Society's Reports, London, vol. xvi.; "The Methods of Determining the Acuteness of Vision," Philadelphia, 1897; and "Die Behandlung des Keratoconus," in *von Graefe's Archiv,* 1897. A. H. B.

Soamin.—This is a preparation of sodium arsanilate, similar to atoxyl, containing about twenty-two per cent. of arsenic. It occurs in the form of a white crystalline powder. It has been used in the treatment of syphilis in daily doses of gr. ¾–3 (0.05–0.2) continued for a week and resumed after an interval of another week; or in a course of ten intramuscular injections of ten grains (0.6) each. Great caution should be observed in the use of the drug because of the danger of blindness. T. L. S.

Soap.—See *Sapo.*

Sodium.—I. General Medicinal Properties of the Compounds of Sodium.—From the close chemical alliance between sodium and potassium, theory would assign to compounds of sodium physiological properties similar in kind to the corresponding potassium compounds, but less strongly pronounced. The prediction is true in that the sodic effects, such as they are, are potassic effects weakened; but an inference that all the potassic effects, in kind, will be reproduced to some degree in the action of sodium, will not hold. The notable potassic effects are irritation, catharsis, cardiac paresis, general motor paresis, oxidation quickening, and, toxicologically,

general toxemia. Sodium, in comparison, is irritant, salt for salt, in decidedly less degree; is purgative in only slightly less degree; paralyzes heart and motor function so very little that the action appears only at all in excessive dosage in animal experimentation; scarcely seems to quicken oxidation at all, nor, even in high dosage, to impoverish the blood after the manner of potassium. So far, however, as concerns those compounds of sodium that are alkaline in reaction, or which, as in the case of citrates, acetates, and tartrates, are converted into an alkaline compound in the blood, the degree of alkalinity is but little less than that of the analogous potassium compounds, and hence the effects that follow simply from the fact of such alkalinity are, with sodium compounds, well pronounced. But yet, therapeutically, so far as constitutional alkalizing is concerned, the diseases calling for alkaline medication are also specifically benefited by the specific potassium effects, so that in their case sodic salts, though strongly alkaline, still cannot compete in curative power with their potassic rivals.

II. The Compounds of Sodium Used in Medicine.—As in the case of potassium, those compounds only will be discussed here whose effects are either *sui generis* to the compound, or are determined mainly by the basic radical. Such salts, official in the United States Pharmacopœia, are the following: *Hydroxide, carbonates, borate, acetate, citrate, potassiosodic tartrate, sulphate, phosphate, pyrophosphate,* and *nitrate.* Of these the borate will be found under the title *Borax,* and the potassiosodic tartrate (Rochelle salt) will be found discussed under the title *Potassium.* Other sodic salts, whose properties are derived mainly from the acid radical of the composition, are treated of under the title of such radical. Such pharmacopœial salts are the following: *Arsenate,* see *Arsenic; benzoate,* see *Benzoic Acid; bromide,* see *Bromides; chlorate,* see *Chlorates; chloride,* see *Chlorides; hypophosphite,* see *Hypophosphites; thiosulphate,* see *Sulphites; iodide,* see *Iodides; nitrite,* see *Nitrites; salicylate,* see *Salicylic Acid; sulphite,* see *Sulphites; phenolsulphonate,* see *Phenolsulphonates.*

Sodium Hydroxide: NaOH.—This substance, commonly called *Caustic Soda,* is official in the United States Pharmacopœia, in solid condition under the title *Sodii Hydroxidum,* Sodium Hydroxide, and in about five-per-cent. aqueous solution, as *Liquor Sodii Hydroxidi,* Solution of Sodium Hydroxide. Sodium hydroxide is a white, hard, opaque substance, occurring either in lumps or in moulded cylindrical pencils. It is odorless, but has an intensely acrid, caustic taste. It deliquesces in moist air, but becomes dry and efflorescent in dry air. It dissolves freely in water and alcohol. It should be kept in well-stoppered bottles made of hard glass. Soda is commonly made by evaporating an aqueous solution of the substance, until the water is driven off and the hydroxide remains in a state of fusion, and then either pouring the viscid fluid into cylindrical moulds or allowing it to harden *en masse.* Solution of sodium hydroxide may be made by dissolving sodium hydroxide in water. Solution of sodium hydroxide is "a clear, colorless liquid, odorless, having a very acrid and caustic taste, and a strongly alkaline reaction. Specific gravity about 1.056 at 25° C. (77° F.)" (U. S. P.). The solution should be kept in green glass bottles, glass stoppered, and the stoppers should be coated with vaselin or paraffin.

Sodium hydroxide and its solution are powerfully alkaline and caustic, like potassium hydroxide, but to a somewhat inferior degree. Sodium hydroxide is available as a caustic, to be used after the manner of potassium hydroxide, but the latter being the stronger agent, is generally preferred. Solution of sodium hydroxide is possible as a local alkali for the skin or the stomach, but the carbonate is almost always used in preference. If given internally, the dose of solution of sodium hydroxide is fifteen minims, diluted. In considerable quantity, undiluted, solution of sodium hydroxide would prove a caustic poison, with symptoms generally similar to those of poisoning by potassium hydroxide.

Sodium Carbonate: $Na_2CO_3 + H_2O$.—Sodium carbonate in crystals or effloresced powder is official in the United States Pharmacopœia as *Sodii Carbonas Monohydratus,* Monohydrated Sodium Carbonate. Sodium carbonate is the salt commonly called *sal soda* or *washing soda,* and is obtained in part from natural deposits—"native soda," so called—in part from the ashes of certain plants growing in or near the sea, the impure yield of which constitutes *barilla* or *kelp,* and in part by artificial making from sodium chloride, sodium sulphate, or the mineral *cryolite.* Sodium carbonate occurs as large, colorless, monoclinic crystals, which effloresce in dry air and fall into white powder. The salt has no odor, but has a harsh, alkaline taste. It dissolves freely in water, but is insoluble in alcohol. It should be kept in well-stoppered bottles.

Sodium carbonate combines, very purely, strong alkalinity with absence of specific qualities of any kind except the irritation or even causticity in concentrated application which is inherent in a powerful soluble alkali. Its uses are solely those of a local alkali, and are practically confined to external employment in lotion or ointment in skin affections. Lotions average two per cent. in strength, and ointments between two and ten, the basis being lard. For internal use, the acid carbonate, next to be described, is preferred, because of its more agreeable flavor and milder action. In considerable quantity and strong solution the normal carbonate is a corrosive poison.

Sodium Bicarbonate: $NaHCO_3$.—This salt, the well-known *cooking soda,* so called, occurs in two grades of purity. One, corresponding to ninety-five per cent. of the pure salt, is the commercial *bicarbonate of soda;* the other, purified to represent ninety-nine per cent. of the pure salt, is what is used in medicine, and is official in the United States Pharmacopœia under the title *Sodii Bicarbonas,* Sodium Bicarbonate. This salt is a white powder, permanent in the air, without odor, and of a not unpleasant taste, cooling, mildly saline and alkaline. It dissolves in twelve parts of water (15° C. = 59° F.), but is decomposed by hot water, losing carbon dioxide, and becoming the normal carbonate. It is insoluble in alcohol.

Sodium bicarbonate is purely alkaline, like the normal salt, but to a less degree, and by reason of that fact is far less irritant. In all ordinary dosage it is indeed practically free from danger. Its taste also is mildly mawkish only, instead of harshly alkaline. For these various reasons this salt is a favorite one for stomachic alkalizing, as in acid dyspepsia or diarrhea. In rheumatic conditions it has also been used. It is also much used to make alkaline lotions for the skin. Internally from fifteen to sixty grains (1.0–4.0) may be given at a dose in water, and externally washes or ointments may be made in the same manner and of the same strengths, as in the case of the normal carbonate. Both of the carbonates are incompatible with acids and acidulous salts, lime water, ammonium chloride, and salts of the metals and metals of the earths.

Troches of the bicarbonate—*Trochisci Sodii Bicarbonatis*—are official in the United States Pharmacopœia, each troche containing three grains (0.18 gram) of the salt. The salt is also an ingredient of the pharmacopœial preparations, *Mistura Rhei et Sodæ,* for which see *Rhubarb,* and *Pulvis Effervescens Compositus* (Seidlitz powder), for which see *Potassiosodic Tartrate,* under *Potassium.*

Sodium Acetate: $NaC_2H_3O_2 + 3H_2O$.—The salt is official in the United States Pharmacopœia as *Sodii*

Acetas, Sodium Acetate. It occurs in large, colorless, transparent monoclinic prisms, efflorescent in dry air. It is odorless, with a bitter, saline taste; dissolves in one part of water and in twenty-three parts of alcohol at 25° C. (77° F.), and freely in boiling water and boiling alcohol. It is rarely used in medicine. Its purpose would be as a constitutional sodic alkali, its acid, as in the case of other alkaline acetates, undergoing conversion, in the blood, to carbonic. The pharmacopœial dose is fifteen grains (1.0).

Sodium Citrate: $2Na_3C_6H_5O_7 + 11H_2O$.—This salt is official in the United States Pharmacopœia as *Sodii Citras*, Sodium Citrate, and contains ninety-seven per cent. of pure sodium citrate. It is "a white granular powder, odorless, and having a cooling saline taste. It slowly effloresces on exposure to dry air. It is soluble in 1.1 parts of water at 25° C. (77° F.) and in 0.4 part of boiling water; slightly soluble in alcohol" (U. S. P.). Like the other citrates, sodium citrate has been used to retard or prevent the coagulation of blood; this is due to its affinity for calcium. In infant feeding, it has also been employed in doses of one grain to each ounce of milk, to prevent the formation of large and tough curds.

Potassiosodic Tartrate. (See under *Potassium.*)

Sodium Sulphate: $Na_2SO_4.10H_2O$.—This salt, commonly called *Glauber's Salt*, is official in the United States Pharmacopœia as *Sodii Sulphas*, Sodium Sulphate. It occurs in large, colorless, transparent, monoclinic prisms, rapidly efflorescing on exposure to air, and ultimately falling into a white powder. It is odorless, with a cooling but bitter saline taste. It dissolves in 2.8 parts of cold water (15° C. = 59° F.); in about 0.25 part at 34° C. (93.2° F.), and in 0.47 part of boiling water. It dissolves also in glycerin, but is insoluble in alcohol. The salt should be kept in well-stoppered bottles. Sodium sulphate is formed as a by-product in the manufacture of many chemicals. It is a salt of low diffusion power, and hence in full dose, in comparatively strong solution, is a purgative. As such it is powerful in action, like the other alkaline sulphates, producing watery stools, with nausea and griping. From its sickening taste it has been almost wholly superseded by the less disagreeable magnesium sulphate (Epsom salt). From ʒss.–i. (fifteen to thirty grams) is a full purgative dose, to be taken in aqueous solution, aromatized or slightly acidified to disguise the nauseous bitter taste of the salt. Sodium sulphate is a purgative ingredient of many mineral waters.

Sodium Phosphate: $Na_2HPO_4 + 12H_2O$.—This salt is official in the United States Pharmacopœia as *Sodii Phosphas*, Sodium Phosphate. It occurs in large, colorless, transparent, monoclinic prisms, which, on exposure to air, effloresce rapidly and become opaque, losing five per cent. of their water of crystallization. The salt is odorless, with a cooling, saline, and slightly alkaline taste. It dissolves in about 5.5 parts of water at 25° C. (77° F.); and in about 1.5 parts of boiling water. It is insoluble in alcohol. Sodium phosphate is made from the calcium phosphate of calcined bone, by decomposition by sulphuric acid. It should be kept in well-stoppered bottles in a cool place. The U. S. P. also recognizes *Sodii Phosphas Effervescens*, Effervescent Sodium Phosphate; and *Sodii Phosphas Exsiccatus*, Exsiccated Sodium Phosphate.

Sodium phosphate is a bland salt, of low diffusion power, whose prominent physiological properties are to purge mildly, and to excite the secretion of bile. At the same time it is feebly alkaline, and possessed of a clean, non-nauseous, salty taste, quite like that of common salt. Therapeutically this phosphate may be used for the general purposes of the milder saline purges, and, more specially, has also proved of avail, even in non-purgative doses, to correct bowel derangements associated with acidity and assumed sluggishness of the liver. From its mildness and not unpleasant taste it is particularly convenient for giving to young children. Mixed with foods, such as soup, in lieu of common salt, it may be administered in moderate quantity without suspicion. As a purge the dose for an adult is about one ounce (30.0) but for corrective purposes, much less—even so little as ten or fifteen grains (0.6–1.0)—given a number of times through the day, may suffice.

Normal Sodium Pyrophosphate: $Na_4P_2O_7 + 10H_2O$.—The salt is official in the United States Pharmacopœia as *Sodii Pyrophosphas*, Sodium Pyrophosphate. It is not used in medicine, and is official for pharmaceutical purposes only to prepare ferric pyrophosphate.

Sodium Nitrate: $NaNO_3$.—The salt is official in the United States Pharmacopœia as *Sodii Nitras*, Sodium Nitrate. It occurs in colorless, transparent, rhombohedral crystals, which deliquesce in moist air. It is odorless, with a cooling, saline, slightly bitter taste. It dissolves in about 1.1 parts of water, and in about 100 parts of alcohol at 25° C. (77° F.); and in 0.6 part of boiling water, and in 40 parts of boiling alcohol. It should be kept in well-stoppered bottles. Sodium nitrate is the salt called *cubic niter*, and is obtained from South America, where it occurs native. It is a salt of high diffusion power, and in its physiological relations closely resembles ordinary niter (potassium nitrate), except that it is, of course, devoid of the characteristic properties of a potassium salt as such. It is hardly used in medicine.

EDWARD CURTIS.
R. J. E. SCOTT.

von Soemmering, Samuel Thomas.—Born at Thorn, Germany, Jan. 25, 1755. He received the degree of Doctor of Medicine, from the University of Goettingen, on April 7, 1778. One year later, he published at Cassel a volume on the functions of the lymphatic system in health and in disease. Between 1794 and 1801 he published his great work on the structure of the human body (6 vols.), a work which was very highly esteemed, and which passed through a large number of editions during the succeeding years. von Soemmering's great reputation, however, rests more particularly on the fact that he was the author of the celebrated "Icones embryonum humanorum" (issued in 1798), a series of well-drawn plates representing the different stages of development of the human embryo. von Soemmering died at Frankfort-on-the-Main March 2, 1830.

In addition to the works which we have already mentioned the following also deserve to receive special mention: "Abbildungen des menschlichen Hoerorganes," 1806; "Abbildungen der menschlichen Organe des Geschmacks und der Stimme," 1806; "Abbildungen der menschlichen Organe des Geruchs," 1809; and "Abhandlung über die Schnell und langsam toedtlichen Krankheiten der Harnblase und Harnroehre bei Maennern im hohen Alter," Frankfort-on-the-Main, 1809 (a later edition in 1822).

A. H. B.

Somnal.—Introduced as an hypnotic by Radlauer, of Berlin, in 1889. He described it as a true chemical compound formed by the direct combination of chloral alcoholate with urethane.

It is properly a clear, colorless crystalline powder, with a hot burning taste, and very deliquescent, but is supplied in the form of a liquid on account of its instability. It is an alcoholic solution, one part in three. It has also been described as a solution of chloral hydrate and urethane in alcohol.

Dose twenty to thirty minims.

BEAUMONT SMALL.

Somnambulism.—See *Sleep, Disorders of.*

Sozoiodol.—(Di-iodo-para-phenol-sulphonic acid.) An acid base which contains forty-two per cent. of iodine, twenty per cent. of carbolic acid, and seven per cent. of sulphur. The acid itself is not employed, but it forms salts which possess all the properties of the acid and are recommended in all conditions in which iodoform is indicated. The potassium and sodium salts are most employed. The mercurial salt is supposed to be a very suitable salt for the administration of mercury as an intramuscular injection.

BEAUMONT SMALL.

Spalding, Lyman.—The originator of the United States Pharmacopœia. He was born at Cornish, New Hampshire, June 5, 1775, was educated at Charlestown Academy nearby, and was graduated there in 1794. He then entered the office of Dr. Nathan Smith, who was practising at that time in Cornish, and during the years 1794–97 he attended medical lectures at Harvard, from the medical department of which institution he graduated in 1797. During the absence of Dr. Smith in Europe Dr. Spalding attended to his patients, and, upon his return in November, 1797, he assisted the doctor in the founding of the Dartmouth Medical School, lecturing on Chemistry and preparing the subjects for Dr. Smith's lectures on anatomy and regional surgery. In 1799 he settled in Walpole, New Hampshire for a few months, but in June of that year he removed to Portsmouth, New Hampshire, where he practised until 1813. During these years he established a local medical society, was a Fellow, Secretary, and Vice-President of the State Medical Society, built for himself a complete anatomical museum, and took great interest in raising medicinal plants like poppy and lactucarium in his own garden. From this early interest in materia medica, arose the idea, original with him, of a National Pharmacopœia. He also introduced vaccination into New Hampshire, corresponding zealously upon this topic with Dr. Waterhouse, of Cambridge, his instructor at the Harvard Medical School.

In 1809 he took what would now be called a post-graduate course in the shape of a winter series of lectures in Philadelphia. The frequent mention of his name in the lectures of Dr. Rush, and the display of his beautiful preparations of the lymphatics in the dissecting rooms of Dr. Caspar Wistar, made him so well known throughout the United States that he was invited in 1810 to lecture on anatomy and surgery before the medical department of Fairfield Academy (in Herkimer County, New York). These lectures so increased his fame that, in 1813, he was elected President of the College of Physicians and Surgeons of the Western District of New York, at Fairfield, a position which he filled until his resignation in 1817.

The wearisome character of the long journey from Portsmouth to Fairfield and return became so pronounced that Dr. Spalding decided to remove his practice to New York, from which city he could make the journey to Fairfield and return more easily. He made the change in 1813. From that time onward his fame as a physician increased steadily. He held, at one time or another, the following positions: Fellow and Secretary of the New York County Medical Society; Member of the New York State Medical Society; Trustee of the College of Physicians and Surgeons; etc.

At a meeting of the County Medical Society in 1817 he proposed the foundation of a National Pharmacopœia, and in 1819 was elected secretary of the Convention of the Middle States for bringing about the formation of a Pharmacopœia; he was also elected secretary of the National Convention at Washington which was organized for the same purpose in 1820; and, finally, was chairman of the publication committee, together with Drs. Hewson, Ives, De Butts, and Bigelow.

Just as the great task was completed, toward the end of 1820, Dr. Spalding met with an accident. He then retired into the country, in the hope that the change would afford him relief, but he failed to secure it. Then, seeing that he could not recover, he returned to Portsmouth, which he called his home. He survived the journey but a few days and died October 21, 1821, having completed a little more than forty-six years of life. In that time he had proved himself a skillful surgeon, a great anatomist, an eloquent lecturer, and a capable writer on medical topics. His completion of the Pharmacopœia met with great enthusiasm in Europe, and the nations followed the example, which he had set, of a National Pharmacopœia. At home, however, he met with many rebuffs and indifferent opposition, which he conquered in the end by determined perseverance. (The preceding sketch was very kindly prepared, at my request, by Dr. James A. Spalding, of Portland, Maine, grandson of Dr. Lyman Spalding.) A. H. B.

Sparganum.—A generic name given to certain tapeworm larvæ belonging to the family *Dibothriocephalæ* which are too immature to be determined generically. Three different "species" have been described from China, Japan, Egypt, United States, and East Africa. See *Cestoda.* A. S. P.

Sparkling Catawba Springs.—Catawba County, North Carolina.

POST-OFFICE.—Sparkling Catawba Springs. Hotel and cottages.

ACCESS.—Via Southern Railroad to Hickory, sixty miles west of Saulsbury; thence six miles by automobile to springs.

The location of the Sparkling Catawba Springs is within the shadow of the Blue Ridge Mountains, 1,200 feet above the sea level. This part of the State, known as the "Piedmont Section," has long been famous for its bracing climate, pure air, and uniform temperature. The springs are three in number, and gush from the ground in a shaded valley surrounded by a circular range of timbered hills and within one mile of the banks of the Catawba River. No analysis has been made, but the springs are said to be blue and white sulphur and chalybeate in character. The water is highly gaseous. The hotel and cottages afford comfortable accommodations. We are informed that the waters possess well-marked alterative and tonic properties, and generally increase the appetite, assist the digestion, and promote the assimilation of food. They have proved valuable in insomnia. A very complete and comfortable bathing establishment is at hand.

EMMA E. WALKER.

Spasmus Nutans.—See *Eclampsia Nutans.*

Spasms.—See *Convulsions.*

Spearmint.—See *Mentha Viridis.*

Spectroscopy, Medical.—The spectroscope is an instrument for examining the *spectrum.* A *spectrum* is, primarily, the series of colors produced when a ray of white light is transmitted through any transparent body, the surfaces of which are not parallel. The general form which this transparent body takes is that of an equilateral *prism* of glass, the sides forming an angle of sixty degrees. Hollow prisms of similar form are also used, being filled with transparent liquids, but these are not suited for accurate work.

Sir Isaac Newton first made the observation that when a ray of white light is transmitted through a prism the ray is not only bent out of its course, but is spread into an array of colors, the order of which is nearly invariable, no matter what the source of light or the material of which the prism is composed. Since the facility of differentiating colors differs in different persons, the exact tints of the spectrum so formed are not easy to express, but they are generally assumed to be seven in number, and arranged as follows: violet, indigo, blue, green, yellow, orange, red. If the ray of light be, as in Newton's original experiment, admitted through an opening of appreciable dimensions, the colors will be somewhat confused and will appear unbroken, but when the opening is very narrow a more distinct effect is produced, and, as will be seen below, the spectrum of sunlight is crossed by numerous dark lines. It is a law of the propagation of light that when a ray passes from one transparent substance to another of different density it undergoes a deflection, known technically as *refraction*. The direction and extent of this refraction depend on the nature of the materials and on the difference of the densities. When the ray passes from a rarer to a denser substance—for instance, from air to water, or from water to glass—the ray is bent (refracted) so as to be more nearly parallel to a line perpendicular to the surface of contact, while if the ray passes in the reverse direction—that is, from a denser to a rarer body, as from glass to water—the refraction is away from the perpendicular. It is upon this principle that the image-forming and magnifying properties of all lenses depend.

The accepted theories in regard to light refer it to very rapid vibration, and the difference between the various colors is supposed to be due to differences in the rate of vibration. White light is supposed to contain all the rates of vibration, and when such a ray undergoes refraction the different vibrations are refracted to different degrees, and hence are separated. If we view a ray through a plate of glass or other transparent body with parallel sides, the refraction produced in one direction on entering the glass is corrected by the refraction in the opposite direction on emerging, so that, with the exception of a slight displacement of the line of light, no striking optical change is manifest. If, however, the equilateral prism is used, the refraction on emergence is in the same direction as on entering, and the optical action is exaggerated. The separation of the different vibrations that compose a ray of white light is called *dispersion*, and is not coextensive with refraction; that is, bodies of equal refractive power do not necessarily separate the colors to the same extent. This law is a very important one in practical optics, for all lenses are forms with more or less prismatic outlines, and hence produce a dispersive effect. If it were only possible to prevent production of color by neutralizing the refraction, it would be impossible to construct any convenient optical apparatus free from colored images, but by combining different varieties of glass in such forms as to have equal and opposite dispersive powers with difference of refraction, large lenses entirely free from color defects (achromatic) may be constructed.

In the spectroscope the object is to secure as complete and extended a dispersion as possible; that is, to separate the colors thoroughly. For these purposes prisms of dense glass are much used, but spectroscopes may be constructed on a wholly different principle, as noted below.

The simplest method of examining the spectrum is to allow a ray of light to enter a dark room or dark box through a small opening and fall upon a prism. Upon the side of the room opposite the opening will be seen a more or less confused spectrum, in which all the colors will be found diverted from the path which the original ray would pursue if it did not enter the prism, the violet being most diverted and the red the least. Such a method of observation, however, is unsuitable for scientific purposes. The most serious defect in it is that if the ray has an appreciable thickness the vibrations on one part interfere and overlap those of the other, so that the series of colors obtained is really a combination of a number of spectra not coincident with each other. To obtain a pure spectrum the ray must be reduced to an exceedingly fine line of light, in which there will be but few sets of vibrations. This is accomplished by using a very narrow slit, and shutting off all light from the prism except that which passes through this slit. The observation is also much facilitated by viewing the spectrum through a telescope of low magnifying power.

Over a century ago Dr. Wollaston, an English chemist, discovered, by using such a slit, that the spectrum of sunlight is not continuous, but is interrupted by numerous fine, dark lines. He did not develop this observation, and it was not until 1814 that Fraunhofer, a German optician, rediscovered these lines and mapped the positions of some of them. A few of the most prominent he distinguished by letters of the alphabet. They have in consequence generally been known as the Fraunhofer lines. They are all at right angles to the direction of the spectrum, and their distance from each other depends on the dispersive power of the prism. Since each particular line is always seen in the same color, and is more easy to define than the limits of the color itself, the lines are preferred for purposes of comparison.

Refraction Spectroscope.—Various improvements and advances in the construction of apparatus for observing spectra have been made from time to time. The most common spectroscope in its usual form consists essentially as follows: A straight tube terminates at one end by a narrow, upright, adjustable slit, and at the other a convex lens, the focal length of which is the distance between it and the slit, so that the rays of light as they pass through the latter are rendered parallel by the lens. In the course of these rays is placed a dense glass prism, or series of prisms, greater dispersion being attained by a combination of prisms. A movable telescope of low magnifying power, arranged so that it can be brought in the course of the rays emerging from the prism, enables one to view conveniently the spectrum formed. In the cut (Fig. 4535) there is shown a third tube, illuminated by a candle. This contains a graduated scale, an image of which is projected in the field of view above the spectrum, for the purpose of measurement, as given below.

Many forms of spectroscope are now available, but most of them being intended only for advanced research in physics, need not be described. A convenient modification is the "direct vision" instrument, in which the optical train is so arranged that it may be pointed directly toward the object to be examined. Of this type the most important in the present connection is the "microspectroscope" intended for use with the ordinary table microscope. This is a complicated and expensive instrument, but is of great use in physiological and medicolegal investigations.

Another type of the instrument depends on a different principle, and, as it is now in frequent use and possesses advantages over the older form, it will be necessary to describe it.

Diffraction Spectroscope.—When the surface of a polished plate ruled with fine lines in close proximity is viewed obliquely, series of spectra are seen which are due to interferences in the different light waves as they are reflected from the angular surfaces produced by the ruling. This effect is called *diffraction*, and a plate so arranged is called a *diffraction grating*. The superiority of such an instrument rests principally on the fact that in all parts of the spectra the colors are proportionately distributed. In the ordinary spectrum, as seen by the prism, the dispersion is proportionately greater toward the violet end, and conse-

quently this portion is abnormally spread out and the distances between the dark lines are exaggerated.

Spectra, by whatever method observed, may be divided into three groups:

1. Continuous spectra: those in which a more or less continuous sheet of color is seen, usually beginning with violet and ending with red. Such spectra are produced by the light which is emitted from solid objects in a highly heated state.

2. Interrupted or bright-line spectra: those in which the colors are seen in the form of narrow lines or bands, separated by proportionately wide, dark spaces. Such spectra are derived from light emitted by gaseous bodies in a highly heated condition.

3. Absorption spectra: those in which a nearly continuous series of colors is present, but interrupted by dark lines or bands. Such spectra are produced by many conditions, principally, however, by the transmission of white light, or light which would give a

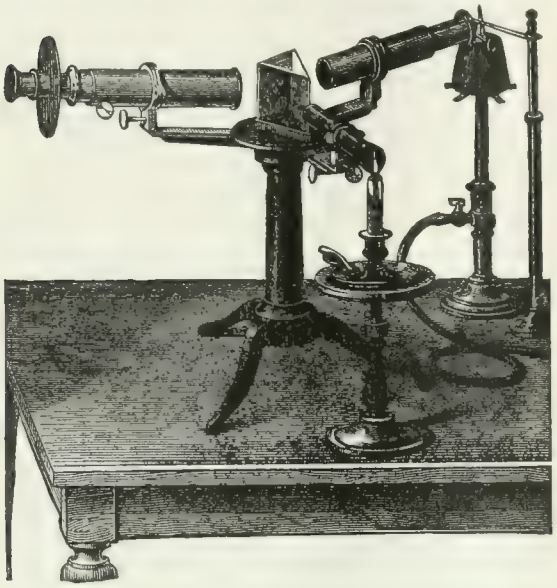

Fig. 4535.—Ordinary Table Spectroscope. In use the prism and abutting ends of the tube must be well covered to exclude light. This is usually attained by enclosing them in a brass box.

continuous spectrum, through substances which have the power of absorbing or annihilating special vibrations. In the applications of the spectroscope to medicine and organic chemistry these absorption spectra are the most important.

It is obvious from the above considerations that we have in the spectroscope, whether of the refraction or of the diffraction form, a very valuable means of studying structure. In the first place, we can determine with great exactness the character of the source of light, *i.e.* whether it is composed of gaseous matter intensely heated or of solid particles. Further, taking a source of known character, we can, by interposing various substances in the path of the light, determine the effect which these substances produce upon the different forms of light vibrations present in the ray, and, as particular effects are often peculiar to particular bodies, we have here a means of identification. Thirdly, using a source of heat practically non-luminous, such as the flame of the Bunsen burner, we can detect different substances by the color which they impart to this flame, and when several such substances are present the eye alone is unable to separate and distinguish the colors, but by the spectroscope each tint is distinctly indicated.

As stated above, it is the absorption spectra that are most important in reference to the medical applications of the spectroscope. Except in the comparatively rare cases of the study of the character of light emitted by luminous organic bodies, living or dead, and in the detection of certain metals present in minute amount in the tissues and secretions, *e.g.* lithium, the direct study of normal spectra is not much resorted to in biological work.

The arrangement of the spectroscope for observation of absorption spectra is simple. An oil or gas flame is adjusted so as to throw a beam of light through the slit of the instrument, by which a continuous spectrum, that is, one not broken at any point by dark lines, is obtained. Sunlight does not answer so well for the purpose, because, owing to certain interfering conditions occurring at the surface of the sun, and also during the passage of the sunlight through our atmosphere, there are numerous absorption bands (Fraunhofer's lines) always present in its spectrum.

The material to be examined is placed in a cell with flat sides in the path of the light before it enters the slit. It is scarcely necessary to observe that to secure a satisfactory result the body must be sufficiently transparent to permit some light to pass, otherwise no comparison as to the effect on different parts of the spectrum can be made. Such a condition is easily obtained by using solutions of the substance in the usual colorless solvents—water, alcohol, ether, glycerol, etc., and diluting until a satisfactory result is obtained. The character of the absorption spectra sometimes differs, according to the solvent used and the presence of free acid or alkali. Working spectroscopes are generally arranged so that two spectra can be compared, one being a standard obtained under known conditions, the other being that of the body to be tested.

To understand the functions of the spectroscope it is necessary to bear in mind that the colors seen are practically images of the slit through which the light passes, and that when the ray contains all the colors—that is, every vibration from violet to red—the prism, in setting out the vibrations according to dispersive power, gives, of course, a continuous series of images, that is to say, a continuous spectrum. When, however, in the ray of light that enters the slit any vibrations are missing, as in sunlight, or when by some interposed condition certain colors are struck out of the ray, the images which would otherwise be formed by those rays are missing, and hence the spectrum appears interrupted. When the interposed substance strikes out many rays, *e.g.* deep-colored glasses, the great bulk of the spectrum is missing. The red glasses, for instance, used in photographic dark rooms strike out almost all rays but the red. The spectroscope as ordinarily constructed is, unfortunately, subject to serious defects, which can be avoided only by instruments of very expensive form. It has been found that all the forms of glass possess marked absorption powers for certain rays of light. If, instead of employing glass lenses and prisms, we use those made of quartz, and employ as a source of light the electric arc, or burning magnesium wire, a spectrum is obtained which is very much extended at the violet end. This portion of the spectrum exists to a greater or less extent in white light from any source, but is absorbed to such an extent by glass that it is not seen in the ordinary spectroscope. There are also color waves beyond the red, which are only demonstrable by special apparatus. In the usual applications of the spectroscope we cannot, therefore, utilize the so-called infrared and ultraviolet rays.

A very important advance has been made recently in practical spectroscopy in the application of photography. A sensitive plate is capable of responding to and recording conditions which the eye is unable to recognize, and we have, therefore, not only a method of extending our knowledge of spectra, but we may obtain permanent records of absolute accuracy, and

independent of any general or special defects in vision. The photographic plate is especially capable of receiving impressions from the violet and ultraviolet portions of the spectrum, which are especially those which the eye appreciates with the greatest difficulty, while the yellow and red rays are practically inactive.

Many substances are known which have the power to retard the rate of vibration of light rays, so that they change the color of the light falling on them. Now the ultraviolet rays, which are inappreciable to the human eye, are caused by extremely rapid vibrations; any substance which will reduce this rate will bring the rays within the range of vision. This property is known as fluorescence. It does not come within the scope of this article to more than refer to it, but it may be mentioned that one of the best methods for the preparation of photographic plates is to incorporate into the sensitive material some fluorescent body by which the rays of light are modified and effects produced with colors that would otherwise be inactive.

The only way of acquiring familiarity with spectroscopic appearances is by actual use of the instrument. No drawing, colored or otherwise, can convey perfectly the appearances. Nevertheless, a method of indicating the character and position of the lines is useful, and several plans have been adopted. The use of colored plates is, of course, the most vivid, but too costly for most purposes. The usual methods are either by recording the position of any line, or the center of a band, by its position on an arbitrary and fixed scale, or by angular position. In the latter form, the view telescope moves in a graduated arc, and cross-lines in the field enable it to be brought to exact position with any line. By such method or by the scale the lines may be mapped in their relative positions as seen in that particular instrument.

Another method is to indicate the positions of lines by their calculated wave lengths; that is, the length of one complete movement constituting the ray which produces a line at the given point. Such a method has the advantage of being an absolute indication, and not dependent on any particular instrument. Wave lengths are determined by mathematical calculation by means of the phenomena observed in diffraction, and the calculation may be easily applied to ordinary cases by plotting off on a chart certain lines of which the wave lengths are known, and interpolating those of which it is desired to determine the wave length. These lengths are very minute, and are usually expressed in millionths of a millimeter.

Description of Special Spectra.—*Bright-line Spectra.*—Each of the known elements gives a special and distinct spectrum when heated sufficiently to become a luminous gas. It has been pointed out at the beginning of the article that solid substances give continuous spectra, and hence there is no appreciable difference between the spectroscopic appearances of the different elements as long as they remain solid bodies. When the temperature rises sufficiently to convert them into gases, and render them at the same time luminous, the characteristic bright-line spectra are obtained. This temperature can be attained with most elements only by the use of the electric spark. A few bodies, among which are potassium, sodium, lithium, barium, calcium, strontium, and boron compounds, yield, at the temperature of the non-luminous gas flame—Bunsen-burner flame—a limited number of rays which are easily observed by the spectroscope as bright lines. Sodium imparts to flame a deep yellow which consists of two tints, and is seen in the spectroscope as a narrow double line. Potassium gives red and violet lines. By increasing the temperature some of these spectra are modified. When the electric spark is employed the spectra obtained are usually more complex, the bright lines being numerous. The detection of the different elements by this means is not so widely applicable as might at first be supposed, for the method is extremely delicate, and it is difficult to distinguish between the minute traces which often have no significance and the presence of an appreciable amount. Nevertheless, the method has been of great usefulness in special cases in showing the occurrence of some elements in unexpected relations, and the wide distribution of others in minute quantities. Several elements, occurring in such minute quantities that ordinary chemical analysis would have failed to indicate them, have been discovered by the spectroscope.

There are a few substances which give a limited bright-line spectrum before reaching the temperature at which they became gaseous.

Absorption Spectra.—These are of several kinds. The absorption may affect a considerable part of one or both ends of the spectrum, by which a whole block of color may be cut out, or it may take place in broad bands or in fine lines. The spectrum of the sun and of many of the fixed stars is an example of the latter class. The lines of absorption are numerous, but they are narrow and represent but a small portion of the entire field, which appears to the unassisted eye to be a uniform sheet of color. Band absorption—that is, the cutting out of a considerable number of rays at some point on an otherwise continuous spectrum—is brought about very easily by means of many organic bodies.

Extended absorption, by which a considerable portion of the spectrum is absorbed, is seen in many substances possessing deep color, and the absorption may include all but a single color. Various colored glasses may be used. To test the effect of a graduated increase of color wedge-shaped glasses may be employed. Hollow wedge-shaped cells are often used for the examination of colored liquids.

The method of observing absorption spectra has been given above. It has been also already pointed out that no description, nor even drawing, can give an adequate idea of the actual appearances of spectra, but for the purpose of completing the article and indicating some of the practical applications of the methods a few absorption spectra will be described.

Line-absorption Spectra.—Some of the rarer elements possess the peculiar property, when in solution, of absorbing special rays of light. Among the best known of these are the metals formerly included under the term didymium. It consists of two elements, forming compounds that have distinct colors, but, even when so far diluted as to make the tint not perceptible, they give absorption bands. The vapors of bromine and of nitrogen dioxide, NO_2, which to the eye have much the same color, give each a peculiar series of numerous fine absorption lines in the central part of the spectrum. The absorption lines that normally occur in the spectra of the sun and stars are an important clue to the chemical composition and physical condition of those bodies, but a consideration of this topic does not belong here.

Band Absorption.—One of the most familiar and striking instances of this form of absorption is seen in *chlorophyl*, which is the general term under which the green coloring matter of plants is designated. A solution of this substance is easily obtained by macerating leaves with ether or alcohol. The filtered liquid being diluted so as to be fairly transparent, is bright green by transmitted light, and when viewed through the spectroscope transmits all the colors except a part of the extreme red, at which point there appears a well-marked broad dark band. The position of this band is highly characteristic of this substance, and can be detected by careful observation, even when the solution is too dilute to exhibit the color to the eye. In this way the adulteration of animal oils by vegetable oils—for instance, of lard oil by cotton-seed oil—may often be detected, for cotton-seed oil exhibits the absorption band of chlorophyl derived from the vegetable tissue.

Valuable use is made of absorption spectra in detecting the nature of various natural and artificial coloring matters. Fuchsin, for instance, not infrequently employed as an artificial coloring matter in wine, gives a broad but not very sharply marked band about the junction of the green and yellow of the spectrum.

It is, however, with reference to the absorption bands produced by the fluids of the animal body that the clinical applications of the spectroscope are seen. The most important of these are the appearances seen in blood under various conditions. These appearances are due to the hemoglobin. As ordinarily seen by examining blood much diluted with water, the spectrum is that of oxidized hemoglobin, *oxyhemoglobin*. The dilution must be sufficient to allow considerable light to pass, and a modification of the absorption spectrum is obtained by continually adding water until no absorption at all occurs. The same effect may be produced by examining the solution through a wedge-shaped cell, gradually diminishing the thickness of the solution through which the light passes. The effects are briefly as follows: In rather strong solution, all the light is cut off except a portion of the orange and red; when the solution is diluted somewhat, green rays are transmitted, and the dark interval between these and the orange constitutes a broad absorption band; still further dilution produces a yellowish-green mass of light dividing the dark space into two nearly equal portions, developing, therefore, two well-marked absorption bands. On still further diluting, the absorption becomes reduced to a single band in the yellow. When to a solution of blood of sufficient density to give the two bands we add some reducing agent, *i.e.* some body having an affinity for oxygen, the hemoglobin is *reduced*, and a new spectrum is obtained. For this reduction ammonium sulphide is preferred. The spectrum of reduced hemoglobin is a single band, broader than, and not exactly coincident with, either of the bands obtained from oxyhemoglobin, the darkest portion corresponding to the mass of light dividing the two bands in that spectrum. The chemical condition of the blood in the vessels may in this way be tested. Another important result is in determining the effect of various gases and chemical substances in blood, either by direct action or by poisoning animals and quickly subjecting the blood to examination. If we examine blood charged with nitrous oxide (N_2O), we find the spectrum of reduced hemoglobin, but agitating the blood with air will reproduce the oxyhemoglobin. When, however, carbon monoxide (CO), carbonic oxide, is introduced into blood, we get a new condition which gives a spectrum resembling, but not identical with, that of oxyhemoglobin, there being two bands, but their position being slightly nearer the violet.

Furthermore, we cannot so easily restore the original condition by agitating the blood with air, nor will the ordinary reducing agents produce the spectrum of reduced hemoglobin. Carbon monoxide is known to be one of the most active of the gaseous narcotic poisons, and the above observations show, in part at least, the peculiar action it has on the essential breathing constituent of the blood. The carbon-monoxide-hemoglobin spectrum is seen in the blood of persons poisoned by water-gas or fumes of burning charcoal, and an examination of the blood by the spectroscope in cases of this character may be an important medico-legal point. Another important modification of the hemoglobin is produced by the action of sulphides, especially by hydrogen sulphide (H_2S), sulphureted hydrogen. This gas is often present in sewer air, cesspool exhalations, and in other foul places, but not invariably, nor in so great quantity as is generally supposed. When its action upon blood is examined we find a spectrum which presents the broad single absorption band of reduced hemoglobin (see above) but in addition a band in the red just at the junction with the orange. This band does not disappear on shaking the blood with air, although the two bands of oxyhemoglobin appear. The body produced by the action of hydrogen sulphide on blood, and to which the properties above described are due, has been called *sulphemoglobin*. It has been noticed that this substance cannot be formed by the action of hydrogen sulphide on reduced hemoglobin, which is the form that exists in the veins; hence hydrogen sulphide may be introduced into the venous circulation without marked effect, but taken into the arterial system it is very dangerous. The difference between inhalations of this gas, by which it would get directly into arterialized blood, and its introduction into the system through the veins, has been shown strikingly in a method formerly in vogue of treating phthisis by injections of hydrogen sulphide and carbon dioxide. In this case the gas is taken up by the veins of the portal system and excreted before it comes in contact with the arterial blood.

If a solution of blood be exposed to the air for some time it undergoes various changes, accompanied by an alteration in the absorption spectrum. This alteration can be brought about by the action of weak acids, and also of potassium permanganate, on blood. A substance called *methemoglobin* is formed. Its absorption bands are three, nearly coincident with those seen when sulphemoglobin is shaken with air, but one band is more completely within the limits of the red. Methemoglobin is believed to be a highly oxidized hemoglobin, but its constitution is in some doubt.

Many other changes in the absorption spectra of blood are known, but while the investigation of them has much to do with physiological chemistry, the matter is too technical for discussion here. It is obvious, from what has been said, that very important medicolegal toxicological, and even clinical questions can be determined by means of the spectroscopic appearances. The different effects produced on blood by different poisonous gases and vapors, the general symptomatology of which may be the same, offer a means of determining even postmortem the character of the gas.

Clinically, the spectroscopic appearances may be utilized for examining the fluids of the body either in their normal or in their abnormal condition. The spectrum of bile, for instance, may be utilized for the detection of it in the urine, for when the color reaction is too faint to be perceived by the unassisted eye, the spectroscope will show it. Normal urine contains a coloring matter believed to be derived from a constituent of bile, which gives a broad absorption band on the green. In certain febrile affections another band appears, also in the green, toward the border of the yellow. Blood in urine may also be detected by the spectroscopic tests. If it be in solution in the urine, the absorption spectrum is seen without difficulty. If the blood be present in the form of methemoglobin, as is sometimes the case, it will give the three bands peculiar to that body, but it is necessary to distinguish these bands from those produced by a decomposition product of hemoglobin known as *acid hematin*. This distinction can be made by the use of ammonium sulphide, when, if methemoglobin is present, the band of reduced hemoglobin, as described above, will appear. If the blood is in the insoluble form no absorption bands may be shown. In this case the blood is filtered and the filter paper treated with alcohol and ammonia, and then with ammonium sulphide; bands then appear which are due to *reduced hematin* formed by decomposition.

In the accompanying map (Fig. 4536) are shown some of the important absorption spectra as seen in a refraction spectroscope of moderate power. Over the plate has been placed indications of the limits of the various colors, but these must be regarded as a mere approximation, as it is not possible to determine

precisely at what point one color ceases and another begins. The dotted lines at each end of the plates represent the limits of the visible spectrum in each case, and it will be noticed that there is considerable extinction of color, especially toward the violet end. *A* represents the spectrum of sunlight, with some of the principal absorption bands, and the letters which distinguish them. All these bands, as has been remarked above, are absent in the light of ordinary flames and electric lights. The observation of absorption spectra being made with artificial light does not therefore show any such bands. *B* shows the absorption bands of oxyhemoglobin. The visible spectrum, it will be seen, extends only from

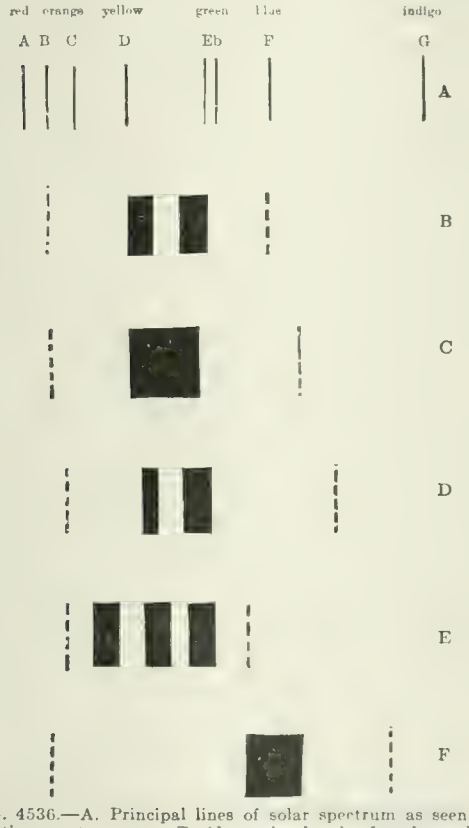

Fig. 4536.—A. Principal lines of solar spectrum as seen in a refraction spectroscope. B. Absorption bands of oxyhemoglobin. C. Bands of reduced hemoglobin. D. Bands of carbon monoxide hemoglobin. E. Bands of methemoglobin. F. Spectrum of normal urine.

green to a short distance on the red. *C* shows the spectrum of reduced hemoglobin. The limits of the visible spectrum are extended slightly toward the violet. *D* is the spectrum of carbon monoxide hemoglobin, that is, of blood impregnated with carbon monoxide. *E* is the spectrum of methemoglobin. *F* is the spectrum seen commonly in normal urine. The broad band is at about the junction of the blue and green and is somewhat faint.

Limited practical clinical application is made of these spectroscopic appearances. The instruments required are expensive and involve delicate adjustment, and hence they are unsuited to the general uses of the practitioner. A combination of spectroscope and polariscope has been constructed for use in rapid approximate estimation of sugar in urine. The use of the spectroscope in the detection of various natural and artificial colors, and in the recognition of blood stains, belongs to special treatises.

Henry Leffmann.

Speech.—See *Larynx, Physiology of.*

Speech Defects.—Aphasia.—The life of organized bodies, plants as well as animals, is characterized by two very distinct trends. The cell or cells that constitute a living organism continue their existence by nutritional processes and reproduce their kind. In plants and in lowly organized animal forms, both types of activity are carried on without that specialized type of cell called nervous. But with steadily advancing evolutive types there grows up within the body of the organism a system of cells called the nervous system, which in its essential structure consists of receiving organs or receptors, adapted to come in touch with the environment, conducting addenda to such organs, central stations for the switching of the incoming information regarding the surrounding world of things, outgoing conducting elements which go to moving mechanisms, which by processes of adaptation make purposeful movements for the two chief trends, *i.e.* for preservation of the self and perpetuation of the species.

This is not the place to enumerate all of the complexities of the receptors which have been developed to bring different organisms into wider and wider contacts with the world surrounding them; nor is it here possible to analyze in detail all of the purposeful movements which have come to be of value for the purposes mentioned. In man they have found their widest and fullest development and it is only our purpose to single out from the mass of receiving organs and movements, those connected with a special type of development which is one of the greatest achievements of human evolution, namely, speech.

The chief end and aim of speech is to bring man as a social animal in understanding relation with his fellowman. Other social animals have developed other means of communal interchange. Touch, taste, smell, have all been called into use in many lower animals but they have lacked the evolutive capacities of the purposeful movements of the speech mechanism and it is a truism to note that through speech the evolution of man has chiefly expressed itself. It is the medium par excellence of human contacts. Societies have developed without it, as is seen in those of ants and bees, but with it human society has developed to be what it is.

One can conceive of a time when speech was much more elemental than at present; when it was largely pantomime, when as in insects, birds, and many animals, it consisted of but a few simple sounds, pantomimic actions and gestures. With the happy invention of word symbols, probably a mixture of instinct and intelligence at first or the first glimmering of that great leap when creative evolution definitely said goodbye to instinct as its main guide and forged a new one, through speech, *i.e.* intelligence, having more or less definite connotations, the limits for human evolution made enormous extensions which through the later happy trick of writing still further widened the possibilities of human mental development.

It is with a certain type of disturbance of this highly elaborate mechanism of speech that this article will deal. In view of the fact of the millions of years of continuous growth in complexity and of effectiveness of this particular series of purposeful movements, it is no wonder that the many problems connected with speech and the mechanism of its production are still far from being clearly resolved, nor will this be undertaken.

What is here attempted is simply a general sketch of certain disturbances of speech which have for many years been called aphasia. No attempt will be made here to review in detail all of the many interpretations that have been given to the term. Such may be found in large and valuable works upon the subject, notably in the monographs of Elder, Bastian, Collins in English; of Kussmaul, Wernicke, von Monakow, Niesl von

Mayendorf in German; and those of Dejerine and Miraille, Marie and Moutier in French; not to mention scores of others of both ancient and modern productions. Nor would the writing of these word symbols be purposeful movements, save from the historical viewpoint, for the analysis of the problem has been found to be more and more complex, successively more time consuming, money costing, and scientifically difficult. Each advance has cast into the scrap heap most of the classics of a generation past and it can be said that the problems now can be solved only by the most exacting and rigorous technical methods coupled with most penetrating and comprehensive clinical observations. To analyze a single case of aphasia according to present-day requirements requires years of painstaking observation, two or three years of more or less continuous microscopical technical manipulations, and at the cost of thousands of dollars.

As Adolph Meyer once expressed it, Now that the North Pole and the South Pole have been discovered, perhaps some one will take interest in that most important undiscovered country, the human brain. Certainly no better expedition could be fitted out than one to explore the uncharted seas of the human speech areas.

History.—The work that the early explorers did is work that cannot be thrown away. It outlined the chief landmarks of the country which now must be left to the skilled pilots of our state institutions, endowed laboratories and university organizations with their corps of skilled technicians, neophytes to whom a year is but a day, and to trained interpreters learned in the difficult charts of brain anatomy. The old-time dabbling in these problems, though dabbling is but a relative term, has gone out of fashion.

To Bouillaud in 1825 history turns for its first noteworthy find in this field. Tinctured with the notions of Gall, Bouillaud's work was worth while, in that he controverted the long prevailing and orthodox doctrine of Flourens that the brain had no influence either direct or indirect upon the muscles. Bouillaud maintained that the brain was indispensable for movement and he very roughly localized the organs of articulate speech in the anterior lobes. As Soury well says, arguing from Bouillaud's own writings of 1847 and 1865, he was not really a seeing pioneer in this limited field, although his work was full of remarkably clear, valuable material. His work was too much colored by the conceptions of Gall, but he was a precursor of Broca who in 1865 really charted the first outlines of the aphasia sea. Bouillaud, however, noted that articulate speech could be abolished without paralysis of any of the muscles of phonation and separated completely motor aphasia from dysarthria—which separation Marie and Moutier in 1906 have attempted to do away with, concerning which we shall discuss later. Bouillaud also apparently had an idea of what is spoken of as internal speech for he wrote as early as 1825, that "the loss of speech depends at times upon the memory of words, at times upon that of the muscular movements of which speech is composed, or what is the same thing, at times upon a lesion of the gray matter and at times of the white substance of the anterior lobes." For Bouillaud the lesions were bilateral.

Marc Dax writing in 1836, however, made the following interesting observations which belong to the steps we are attempting to retrace. "In the month of September, 1800, I made the acquaintance of a captain of cavalry who, wounded in the head by a blow of the sword during battle, later suffered from a great alteration in the memory of his words although his memory for things remained intact. Such a marked distinction between the two memories made me very anxious to know the cause. After two or three years of useless research I hoped at last to find the answer to the enquiries in the system of Gall which commenced to be known in France. I then learned from the parents that it was the center of the left parietal bone that was wounded. In the year 1806 the celebrated naturalist Brousonnet lost the memory for words following an attack of apoplexy, from which he died after a year. In 1809 I gathered another observation of forgetfulness of words in a man with cancer of the left side of the face." He then goes on to say that "from all that precedes I conclude that not all diseases of the left hemisphere can alter verbal memory but when this memory is altered by disease of the brain it is necessary to seek the cause of the disorder in the left hemisphere." Bouillaud, who was professor of clinical medicine at this time, contested the notion which Dax could not support by autopsy findings. Furthermore, Bouillaud, following a custom of the times, offered a prize of 500 francs to him who would show him a single case of the loss of speech described. This was in 1848 and the whole story of the times and Broca's presentation in 1861 is well told in an admirable critical essay by Marie.

The clinical pictures noted by Bouillaud, Gall, by Dax, father and son, Marce, Jackson, Lelut, Leidat, and others, and which we have indicated, received their anatomical explanation by Broca in 1861, in his first autopsical case of Leborgne, a man fifty-one years of age who since the age of twenty-one has lost his use of language. He could pronounce only a single syllable which he repeated two or three times in succession, tau, tau, tau. He understood practically everything said to him. A second case, Lelong, soon followed, and Broca, then thirty-seven years of age, made the deduction that the seat of the lesions of motor aphasia (aphemia he called it at that time) was in the third left frontal convolution. These two brains were conserved in the Dupuytren museum at Paris and have been seen by many. In 1863 Broca reported eleven cases in which the left third frontal convolution was involved and in 1865 he presented a general thesis upon the subject. He noted the presence of right-sided lesions in left-handed persons.

It may not be without value to note just what Broca's aphasia was, at least to Broca. Broca defined his aphemia in the following words: "There are individuals in whom the general faculty of language persists unaltered, in whom the auditory apparatus is intact, and where all the muscles, not excepting those of the voice and of articulation, obey the will, and in whom as a result of a cerebral lesion the articulate speech is abolished. This abolition of speech, in individuals who are not paralytics, nor idiots, constitutes a symptom sufficiently distinctive which it seems to me useful to designate under a special name. I shall call it aphemia (ἀ, without, and φημί, I speak, I pronounce) for that which these patients lack is solely the faculty of articulating words. They hear and understand all that is said to them; they have their reason, they emit sounds with facility; they can move the tongue, and the lips much more energetically than is necessary to articulate sound and yet, notwithstanding, the response, while they understand perfectly what they would wish to say, is reduced to a few articulatory sounds, always the same and always uttered in the same manner. Their vocabulary, if one can call it such, is composed of a short series of syllables, often of a monosyllable which expresses everything, or rather which expresses nothing, for this unique word is most often a stranger to all vocabularies. Certain patients have not even a vestige of articulate speech; they make vain efforts without pronouncing a syllable."

Going into the anatomical correlation Broca says, "Aphemia, that is to say the loss of speech without other intellectual disorder, and without any paralysis, has been the consequence of a lesion of one of the frontal lobes. In our patient the site of the lesion was in the second or third left frontal convolution, most probably in the latter. It is then possible that the faculty of articulate speech is located in one or the

other of these convolutions." It is not necessary to proceed further with his very temperate statement and his careful wording, in which we can see his desire to support a superior in the Faculty, Bouillaud, and yet not offend him nor the most active believers in the localization of Gall. In 1862 he saw a patient with aphemia from a right-sided lesion which caused him to be cautious. In 1863 Parrol demonstrated a case of extensive destruction of the right third frontal convolution without any speech or intelligence defect, which also contributed much to a very active discussion going on in Paris. Finally in 1865 Broca came out flat-footed and said that the third left frontal convolution was the seat of his aphemia. Thus to use Moutier's phrase the "dogma" was created, although it was not by any means accepted by all. All of the acrimony of a great discussion raged but Trousseau gave it the weight of his great authority and it prevailed for many years and, gradually subjected to certain modifications, prevails at the present time.

Then began the great period of electrical stimulation of the cortex. Localization, a fantastic dream for Gall, became a scientific reality for the English physiologists and when in 1870 Fritsch and Hitzig published their studies with electrical excitability of the cortex an entirely new method of localizing muscular movements, and of the speech mechanism, became possible. Meanwhile the aphasia question was actively studied. Fleury 1865 distinguished Broca's aphemias from what he called aphrasics; they could pronounce but did not use the right meaning. Gardner 1866 separated internal speech trouble from intact ideation. Ogle 1867 fell upon the idea of agraphia and Bastian 1869 really discovered word deafness. Paraphasia, jargonaphasia, were also described by Jackson and other English writers.

The honor has been given to Wernicke, however, as the discoverer that the incoming receptive side of the speech mechanism, *i.e.* the auditory understanding of speech, separated from the hearing of sounds, was of immense importance in solving the problems of speech disturbances and he founded that form of aphasia which is termed sensory aphasia. These patients heard sounds but they might as well have been Chinese or Choctaw. They had lost their meanings. This was in 1874 and the defect he then stated was due to a defect of the first left temporal convolution.

The aphasia problem at first comparatively simple, and not yet a general problem, began to become complicated. Wernicke described his zone of language. There existed a motor aphasia, the aphasia of Broca and due to disturbance of the F_3 left and a sensory aphasia due to disease if the first temporal of the left side and posterior, in which comprehension of spoken words was lost. This served as a control of the motor center and lesions here produced the various clinical pictures described particularly by the English as amnesic aphasia, paraphasia, agraphia, etc.

A most searching reanalysis of the entire question followed Marie's iconoclastic utterances in 1906. (Semaine Médicale, Nos. 21, 42, 48, 1906; also see Moutier's Thesis for complete discussion of the whole problem.) Insufficient comprehension of speech, *i.e.* as an intellectual defect—a dementia Marie called it, was the principal concept that ruled this presentation of aphasia. The whole problem is extremely technical and involved, and the discussion cannot be entered into here. At all events the work of Marie caused several realignments of former attitudes but did not essentially modify the accepted types, a brief résumé of which is here given:

Clinical Forms.—Aphasia as here understood consists in a disturbance or loss of speech resulting from a failure to evoke or control the memory of these auditory or visual symbols used in social interchange of concepts or ideas. This loss of control or failure to evoke the proper symbols is due to a definite structural change involving the complex brain pathways, or it may result from purely psychological blocking. It has been seen that for speech as for any other volitional act, receptor and effector pathways must be open. The receptor pathways, *i.e.* the sensory part of the process, includes the hearing and the seeing of word symbols. The memories are stored in certain areas or zones and have been termed auditory and visual word areas. Centers is an older term but is somewhat objectionable. The auditory word zone or area is located about the upper surface of the temporal lobe in the anterior transverse gyrus of Heschl and extending also into the adjacent portions of the posterior and of the first temporal convolution. The gyrus angularis serves as a visual area for those who have learned to read. Lesions, which occupy these locations or in such a position as to cut the pathways immediately related thereto give rise to word deafness—auditory aphasia, or word blindness, visual aphasia. These are the types of so-called sensory aphasia.

The emission or effector side of the speech reflex arc, *i.e.* the motor side wherein motor images are more or less stored up, is, as has been pointed out, in and about Broca's convolution and the adjacent areas of the precentral and insula convolutions. Lesions here result in motor aphasia, or, as Broca called it aphemia.

The chief lesions causing these aphasias are hemorrhages, abscess, encephalitis, tumors, thromboses, emboli and acute edemas. More functional losses are seen resulting from the epileptic discharge from certain hysterical dissociations, in uremia or in severe angiospasms, as in migraine for example.

Symptoms of Types.—Motor Aphasia.—Here the patient has lost the capacity to express himself in speech. He cannot read or talk spontaneously. He may say a few words, is usually able to say, yes, yes, no, no, is irritated over his loss, frequently saying "damn" or other expletive in the fruitless and exasperating search for the words. Typical expletives are frequent and are often repeated over and over again. It is convenient to distinguish two types of motor aphasia:

Subcortical or So-called Pure Motor Aphasia.—Here the motor speech pathways on the way out to the medullary nuclei are cut off. The patient is usually quite able to understand spoken and written symbols, but cannot speak spontaneously, read aloud, or even repeat what is spoken to him. He usually is able to write. Hysterical dissociation may bring about this type, as well as the concrete lesions already mentioned.

Cortical Motor Aphasia.—This type, less common and theoretically more difficult of comprehension, suffers a greater loss of internal speech. The patient is usually unable to write and usually fails to bring together long sentences or complicated word relations. He fails to grasp them in their entirety. The more severe the speech defect, the more pronounced, as a rule, is the agraphia. It may be added that Marie's searching attempt to break down the classical motor aphasia, by calling it anarthria plus a lenticular lesion causing dementia, has not stood the test of careful investigation.

Auditory Aphasia (Word Deafness).—The patient hears without difficulty but heretofore known symbols are now as though foreign. He is usually able to repeat the phrases, imitate the sounds, but they might as well be Chinese for all his comprehension of them or his ability to use them properly is concerned. Here also two trends in the symptoms are capable of fairly sharp separations.

Subcortical or Pure Auditory Aphasia.—The pathways between the receptors and its central station are blocked just distal to the auditory area. Spontaneous speech does not suffer but cannot be counted upon unless through visual correction. By the guidance of the written word the patient may express himself perfectly. Repetition of sound symbols may be

impaired, hence these patients cannot repeat spoken phrases.

Cortical Word Deafness.—Spontaneous speech is much more involved and the patient's talk is usually quite disturbed whether he attempts spontaneous speech or when reading aloud. Internal speech is seriously disturbed. The patient cannot repeat, nor copy to dictation. Mistakes in orthography are frequent. While he may be fluent in his speech it may be fairly clear or a mixed-up jumble. Furthermore, the patient is not aware of his mistakes or only partially aware of them.

A great variety of partial forms are met with. One patient will lose the value of names, of nouns, of objects, others are merely confused (paraphasia).

Auditory aphasics usually clear up but in those patients who are rich in auditory forms of memory, in contrast to those whose memory type is more apt to be visual, the disability is usually greater.

Visual Aphasia (Word Blindness).—This type is also spoken of as *alexia* at times. The patient sees but does not take it in. Previously recognized signs are now as though Egyptian or cuneiform. Shapes are recognized and may even be copied but are not comprehended. They have lost their acquired context. Two types are here to be recognized also.

Subcortical or Pure Word Blindness.—The area or center being intact the lesion involves the incoming pathways adjacent to the cortex. The patient fails to understand written words, cannot read aloud but may write or may copy from dictation. Partial blindness (hemianopsia) usually accompanies this disturbance. These patients are unable to read their own writing even though that writing may convey sensible meanings and be a correct medium of intercommunication.

Cortical Word Blindness.—Spontaneous writing, writing from dictation, or writing from copy are lost. The patient is agraphic. He has lost all memories of written or for printed symbols, words, designs, or what not. Minor grades of the defect cause "paragraphia" in which the patient writes with mistakes in misplacing letters, or syllables or words. Such paragraphias are very frequent in paresis, for instance.

In actual practice the more or less sharply cut forms here summarily described are less often met with than the numerous mixed forms. A frequent type is a complete or global aphasia in which the entire brain speech mechanisms are wiped out. These are the forms seen following severe hemorrhage with the middle cerebral syndrome, hemiplegia, etc., accompanying. SMITH ELY JELLIFFE.

Speech Defects.—STUTTERING.—*Definition and Classification.*—Stuttering is a disorder of speech characterized by spasmodic hesitations resulting from perverted reflexes, due to functional derangement associated with organic derangement of the normal status of an individual.

Stuttering according to the latest scientific classification is divided into *phanerogenetic stuttering*, characterized by objective physical evidences, as spasms and hypertonicity of muscles especially those involved in speech; and *cryptogenetic stuttering*, characterized by no objective physical evidences, being rather of a hidden or occult nature.

History.—Although stuttering can be traced back to early Biblical days, it was not until comparatively recently that physicians fully realized that it was a psychological, physiological problem, requiring the utmost refined psychotherapeutical and physicotherapeutical measures for its alleviation. Such men as Arnott, Columbat, Schultess, Kussmaul, Bastian, Wyllie, and Gutzmann, were instrumental in giving us the basis of our knowledge on this subject.

Cause.—While a vast number of theories have been and are expounded for the cause of stuttering, to date they are still theories and fail to satisfy as the definite cause of this condition. The following are some of the expounded theories: Stuttering is a surgical condition; stuttering is a weakness of the speech mechanism; an incoordination between respiration and articulation, an incoordination between respiration, articulation, and mentation; an incoordination neurosis; an infective neurosis; an anxiety neurosis or fright inhibition; a condition of amnesia; a deranged state of mind; a disturbance of the cerebral or cortical centers; a transitory auditory amnesia; an aphasic condition; a mental tic; a psychosis; an imitative condition; a condition sometimes due to infectious diseases; a condition which may be due or associated with an enlarged thymus.

Stuttering occurs, with especial frequency in infancy and childhood. Male stutterers are the more numerous, the ratio of the male and female being about two to one. Gutzmann brings out definitely that heredity in stuttering is an established fact aside from nervous predisposition. Stuttering in most cases appears before lingual development is completed. There is a disproportion between lingual understanding and the ability to speak, and the efforts to overcome this incoordination arrests speech. The state of mind resulting from unsuccessful attempts at speech may lead to serious spastic manifestations.

Pathology.—Autopsy findings of structural changes in the brain have still to be demonstrated. Associative local conditions of the upper air tracts are found in almost every case, such as nasal intumescence, adenoids, hypertrophied tonsils, etc. Kobrak considers spasms the result of spastic paresis of the levators in contradistinction to flaccid paresis of the constrictors. The result of the paralysis is seen in the exaggerated uncertainty of a patient's speech.

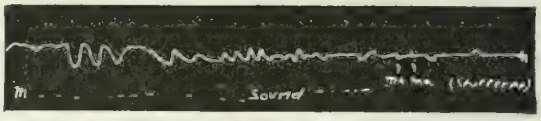

FIG. 4537.—Kymographic Tracing Showing a Stutterer's Spasm while Attempting to Articulate "Mama."

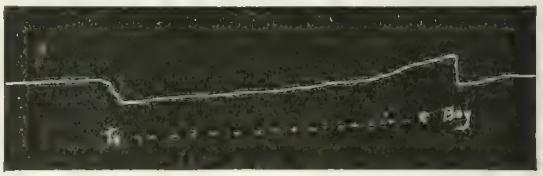

FIG. 4538.—Kymographic Tracing of a Stutterer's Respiratory Spasm while Saying "The Boy."

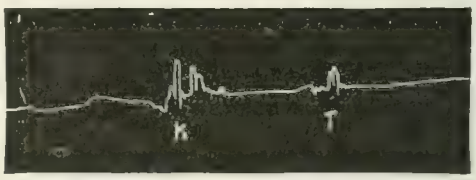

FIG. 4539.—Kymographic Tracing Showing Loss of Air through the Nose and Spasm of the Velum Palati while the Stutterer is Pronouncing K and T.

Symptoms.—The symptoms of stuttering are just as varied as they are numerous. Foremost are the various disturbances of respiration which may or may not be combined with muscular spasms. These conditions may be definitely demonstrated through graphic tracings (Figs. 4537, 4538, and 4539). There

are also disturbances of phonation and articulation, the coordinate action of which is necessary for normal speech. Cramps of the muscles of the larynx cause a reaction on the voice of the stutterer making it monotonous, harsh, and husky. A condition of mental flurry, in conjunction with a lack of self-confidence and a fear of being ridiculous, when speaking, is always present.

Stutterers make use of different expedients which they devise to help them over an attack, some of them very odd and inappropriate, such as the altering of words in a sentence, pointing at objects, the insertion of redundant words, and phrases—"but," "yes," "no," "er," etc. Whatever form stuttering may exhibit, and from whatever cause it may have arisen, it always exercises upon the individual a pernicious influence which permeates his physical and psychical life.

Diagnosis.—A careful examination of a stutterer will readily establish various anomalies. Pneumographic examinations will illustrate any irregularities of thoracic, abdominal, or nasal respiration. Inability of patients to hold the breath for a few seconds shows weakness of the respiratory musculature. Spasms of the muscles of the larynx can be felt or seen. By means of the fluoroscopic screen we can observe irregular movements or the sudden fixation of the diaphragm. The nature of a stutterer's speech can be ascertained through reading, questions, answers, reciting, repeating sentences, singing, and whispering. The tonal quality of the voice must be noted, also involuntary movements of the upper or lower extremities, head, etc. A general physical examination is of prime importance in all cases.

Prognosis.—The prognosis depends on the etiological factors and on the physical and mental condition found in a given case. In most cases occurring in early childhood it is favorable. Cases that occur about the time of puberty have a favorable prognosis, if treated early. Optimistic, intelligent persons yield a favorable prognosis while distracted or physically depressed persons yield a bad one. Patients classed as phanerogenetic stutterers are amenable to treatment while those classed as cryptogenetic stutterers are not. In all cases extreme caution should be used in giving a prognosis.

Treatment.—A rational treatment for stuttering should aim to remove all physical disabilities and all psychic inhibitions which may directly or indirectly interfere with the innervation of speech. It would be an easy task to overcome stuttering if nothing but gymnastics of the physical organs were required; it would only be necessary to drill the refractory organs and muscles, and pay some medical attention to the nervous system. But any one who has observed stutterers from the medicopedagogical viewpoint, soon discovers that he has to do with a physical ailment as well as a mental short-coming. The stutterer does not think clearly; ideas do not become associated in his mind in a normal way; he is either seemingly dense, frivolous, or dreamy. This is not only the case with children, but with grown-up persons as well. Most stutterers are, consequently, inclined to be lazy, and to resist more or less passively, any attempt to impose a methodic treatment on them. On the other hand, they rush at any "cure" that seems to be less troublesome, and to promise speedier results.

The treatment, therefore, is a very difficult task and in order to obtain successful results medicopedagogical methods must be used to combat the psychophysical condition present. *There is no general definite curative therapy for stuttering.* Each case demands special treatment depending on etiology and pathogenesia. According to Kobrak, "Psychic arrests should receive psychic treatment (sanatoria for children), deficient intelligence which often consists merely in want of attention and concentration, should be improved by suitable pedagogic treatment. Defects of the centers of speech require practising of exercises; arrests localized in the peripheral organs of speech may require operative interference."

Anomalies of respiration, phonation, and articulation must be carefully analyzed and measures for normal action instituted. All actions of the parts involved necessary for speech production must be consciously and physiologically practised until through constant repetition speech becomes a normal subconscious automatic act. The old idea, still occasionally heard, that psychotherapy is all sufficient for a cure is obsolete; advanced psychologists of to-day fully realize that psychotherapy in the form of education and reëducation yields successful curative results only when used in addition to necessary medical and surgical measures for the relief of respiratory, phonatory, and articulatory disturbances. Hypnotism, at one time popular as a cure for stuttering, has now been practically discarded. The general health of every patient must be carefully considered and prescribed for.

Recently, in those cases where an enlarged thymus was considered the causative factor of stuttering, *x*-rays have been used as a therapeutic measure in order to effect a fibrosis of the gland without completely destroying it.

Stammering (Lisping*).—*Definition and Classification.*—Lisping is a disorder of speech characterized by defective enunciation, that is, the inability to form correctly or utter any or all of the sounds of speech.

Lisping is subdivided into two classes:

1. Central Lisping (cerebral); (*a*) primary or so-called functional lisping; (*b*) secondary (acquired).

2. Peripheral Lisping due to malformations of the organs of speech; (*a*) Congenital (harelip, cleft palate, malformation of the tongue, "wolfs' jaw"); (*b*) Acquired (condition of lips, teeth, gums, palate, tongue, pharynx, larynx, ears).

In all conditions of lisping there is present an anatomical defect. This defect is found either in the brain proper or in the organs of articulation, *i.e.* the organs of speech, or in the nervous connections between these two parts. This defect may be congenital or acquired, either through injury or disease.

Central or cerebral lisping is that form of lisping due to an anatomical defect within the brain proper, in contradistinction to peripheral lisping, where there is present some defect of the organs of speech (lips, palate, etc).

For purposes of clearness it may be more advantageous to consider first the subject of *Peripheral Lisping*, the so-called organic lisping. It must be understood however, that all lisping is essentially organic, inasmuch as there is always present in all forms of lisping an anatomical defect; consequently, it is a misnomer to limit the term organic lisping only to defects of the organs of speech.

Causes of Peripheral Lisping.—Peripheral lisping is the term that is applied to such speech defects as arise from anatomical defects of the vocal organs. These defects are either congenital or acquired (injuries, diseases, spasms, paralysis). In most of the cases of peripheral lisping congenital defects are the cause; it is in but a very small percentage of the cases that the defect is an acquired one. In other words, in the great majority of cases of peripheral lisping, there is found a congenital defect due to arrested development.

These congenital defects according to the law of embryological development are always to be found at certain definite points on the surface of the body. The points related to lisping are to be found at the lips, jaw, tongue, palate, or nose.

In order to obtain a clear conception of peripheral lisping it is absolutely essential to have some definite knowledge concerning the embryological development

* Lisping, denoting certain forms of defective enunciation has been used in recent writings to denote *all* forms of defective enunciation, thus supplanting the word stammering, which had been used inconsistently and was constantly being confused with stuttering.

of the parts involved, also the medical and surgical principles at issue.

Causes of Central Lisping.—The lisper's difficulty is fundamentally dependent on some organic condition of the structure of the human body. We have pointed out that in peripheral lisping there exists an organic or pathological structural change in the speech organs themselves, likewise in central lisping there is found a similar organic change. The structure of the brain itself is involved.

In peripheral lisping the defect is always found upon the surface of the body. It is easily seen and recognized because of its superficial situation. In central lisping the defect is centrally located within the brain, therefore cannot be so easily detected.

It is a well-known clinical fact that injuries to the brain, when the motor areas are involved, may result in spasms, paralysis, convulsions, etc. Likewise when a sensory area alone is effected, there result the various disturbances common to sensory nerves, numbness, parasthesia, etc., or when other particular centers are involved, the various forms of aphasia may result.

Concomitant with these resultant conditions or existing independently, lisping has been known to result from cranial injuries received in childhood, for instance, a fracture of the bones of the skull or a concealed hemorrhage beneath them, causing destruction and disintegration of brain tissue (either centers or tract fibers between them) with resultant degeneration of the nervous elements.

In primary central lisping there is always found an organic condition in the cerebral tissue in various stages of development; in some instances this condition partakes of the nature of a manifest anatomical structural disintegration of the cells or fibers which go to make up the various speech centers or their proper association tracts. In other instances this condition partakes of the nature of a functional disintegration of the speech centers or their tracts; this functional disturbance being sometimes immediately apparent at the first efforts directed in speech, and sometimes of a more latent and potential character. In other words, the fundamental cause of some cases of primary lisping is not a destruction of one or more of the speech centers, but a general enfeeblement or weakness of the cerebral cells found within the centers, thus betraying itself in a special way through the delicate function of speech. Therefore, we can often expect to meet with solitary disablement of one of the speech centers and functional integrity of the others; for example, the motor speech and auditory speech centers although very closely related to each other in function may be enfeebled or disabled together or separately, consequently presenting to us the symptoms referable to failure in reception and interpretation of speech, more frequently than the symptoms referable to the failure in production. In this enfeeblement of function the images resulting from external stimuli, such as hearing or seeing, are unable to continue in response to such stimuli and as a result there ensues a substitution, a distortion, or even an entire loss of the efforts following the reception of the images. In order to make these facts more vivid it is important to understand the formation of image, perceptions, etc., and also the development of association between them. This refers especially to the so-called speech centers of the brain.

Symptoms (Forms).—The symptoms of lisping are usually very pronounced and are readily appreciated when classified according to definite forms, the terminology of the forms depending on the parts involved. The forms are as follows:

Labial Lisping. The lip letters, *b, p, m, w, wh,* may be substituted or omitted.

Labiodental Lisping. The sounds *f* and *v* may be substituted or omitted.

Anteglossodental Lisping The sounds *s* and *z*, *th'* and *th"* are substituted or omitted. Defects of *s* and its combinations, *ss, sh, z, zh,* etc., are generally designated as *sigmatism.* Various forms of sigmatism may occur.

Anteglossopalatal Lisping. The sounds *t, d, n, r, l,* may be substituted or omitted.

Medioglossopalatal Lisping. The sounds *j, ch, y, hy, sh, zh,* may be substituted or omitted.

Postglossopalatal Lisping. The sounds *k, g, ng,* may be substituted or omitted.

Vowel Lisping. Vowels may be substituted, omitted or added. Vowel lisping is especially prominent in the dialects of language.

Syllable and Word Lisping. Parts of words or whole words may be slurred, changed, disjointed or otherwise mutilated, so much so that a person's speech becomes so altered that he seems to be speaking in a language of his own. This condition is sometimes known as *idioglossia* and is particularly observed in young children.

Nasality. Sounds are substituted, non-nasal sounds being changed to nasal sounds.

Diagnosis.—A careful medical and pedagogical examination with special consideration of the etiology will always yield a correct diagnosis. By the use of charts and different apparatuses the abnormal sounds can easily be differentiated from the normal.

Prognosis.—The prognosis is favorable. In all cases of peripheral lisping it is of prime importance to refer the patient to a competent surgeon for the necessary surgical measures that may prove auxiliary to the cure of the speech disorder. Following operative procedures the patient must be given instruction similar to that given for primary central lisping, because there is always a resultant faulty psychical element as well as faulty physical element present to account for the defective speech. This is definitely exemplified in cases of cleft palate, for although operative measures have been successful the speech continues to remain the same. Patients consider their cleft palate speech a normal speech and this psychical state must be counteracted before normal speech can be instituted.

Prophylaxis.—An essential for the prevention of defective speech is having the speech of all children during their entire scholastic period properly trained and supervised. Clear distinct enunciation on the part of the instructor firmly fixes perfect mental images of speech in the child's mind. A knowledge of glossokinesthesia is a great aid for the correct formation of the sounds of our language.

Treatment.—In all forms of lisping the treatment must be based on a fundamental knowledge and correct understanding of the vocal organs and the positions assumed during phonation. Recently, by means of specially prepared plates, I have obtained excellent results in the elimination of faulty position of the vocal organs during phonation through knowledge and development of glossokinesthesia. Charts, pictures, mirrors, etc., are used in order to attain correct vowel and consonant formation. Speech exercises are given till finally independent normal speech is acquired. In the correction of lisping, the old adage "Patience is a virtue" is highly exemplified.

Nasality.—Nasality is a speech disorder due to disturbances in the vocal vibrations which pass from the oral to the nasal cavity, producing nasal out of non-nasal sounds. According to Kussmaul "The nose is either open when it should be closed, or closed when it should be open."

During normal breathing the soft palate hangs loosely so that there is a communication between the nasal cavity and the mouth cavity. When the mouth is closed the soft palate, which is held somewhat tense, is swayed by the respiratory currents in a passive manner. For all sounds, except *m, n, ng,* the velum or soft palate, moves upward, almost entirely closing off the mouth cavity from the nasal cavity.

Nasality may be due to congenital conditions (cleft palate); to injuries, following the removal of tonsils and adenoids; to inflammations (nose, pharynx, etc.), tonsillitis, diphtheria, syphilis, tuberculosis, etc.; to tumors; to nervous conditions, bulbar paralysis, tics, etc.

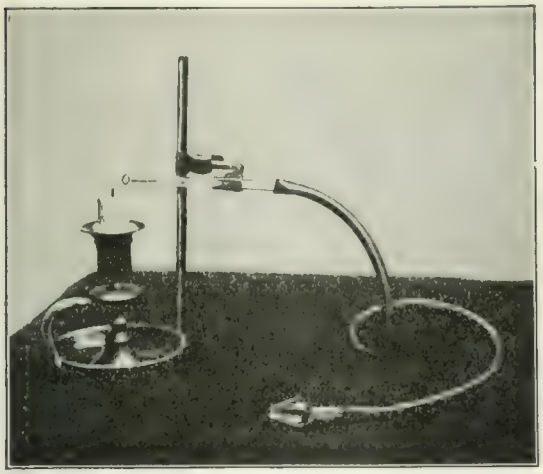

Fig. 4540.—Candle-flame Test. Have patient insert glass tip into one nostril and hold the other nostril closed while repeating the alphabet. Any strong deflection of the flame denoted the escape of air from the oral into the nasal cavity and thence through the tube. This deflection should occur only on M and N sounds; if it occurs on any other sounds it shows defective action of the velum palati with the resultant nasality.

Nasality causes the voice to become weak, flat, or dull, non-melodious in quality approaching twang characteristics; in fact in very severe cases nasal twang presents one of the most conspicuous symptoms. Nasality causes a change in speech, making articulation difficult, the resultant disturbance coming under

Fig. 4541.—Multiple Velum Test. To a multiple-armed center piece short pieces of rubber tubing are attached in pairs, each pair consisting of a nasal and aural tube. The nasal tube has a nasal (glass) tip at the end, the aural tube has an aural (rubber) tip at the end. The patients insert the nasal tip into nostril and the aural tip into ear and in turn recite the alphabet, all noting simultaneously changes in tone vibration. A characteristic loud sound is heard when the nasals M and N are enunciated; any deviation from this signifies defective action of the velum or intra-nasal obstruction.

the head of acquired peripheral lisping. It impairs the function of swallowing, causing in marked cases a tendency for fluids to enter the nasal cavity. It causes an abnormal collection of saliva in the mouth.

The local appearance of the palate depends upon the nature of the process causing the nasality. It should be borne in mind that in addition to the symptoms enumerated there usually are present the symptoms of the original primary causative factor.

Diagnosis.—Various tests are employed for the diagnosis of nasality. A simple test for the diagnosis is as follows: While producing different speech sounds, alternately open and close the nose. If any changes in quality and volume of tone occur, excepting the nasals (*m*, *n*, *ng*), a condition of nasality exists. By means of a small mirror the escape of air from the nostrils can be detected. The *flame test* (Fig. 4540) shows irregularities in movement of a candle flame, which depends upon the quantity of air emitted through the nose when repeating speech sounds. The multiple velum test (Fig. 4541) is an accurate test allowing both patient and examiner to note and recognize changes in tone vibrations. Normal graphic tracings are used to show comparison with abnormal tracing obtained in nasality.

Fig. 4542.—Standard Bubble Test. Have patient insert glass tip into nostril and repeat alphabet. If action of velum is normal two large sized bubbles will appear in the bottle when the nasals M and N are enunciated. Any deviation from this standard number and size of the bubbles signifies defective action of the velum or intra-nasal obstruction.

The standard bubble test (Fig. 4542) is a therapeutic as well as a diagnostic measure. It not only determines nasality, but is a strong factor for its elimination. Children consider the test a plaything and through constant interest and practice promote normal action of the velum.

Prognosis.—Nasality is readily corrected if intelligent consideration is given to the causes and conditions present. On the whole the prognosis is favorable.

Treatment.—The treatment, besides being reeducational is operative or non-operative, depending upon each individual case. Special hand obturators and electricity have been found beneficial.

Foreign Accent.—The existence of foreign accent in our English speech of to-day has begun to be universally recognized. It is a potent factor in the imperfect amalgamation of the numerous elements which constitute our American citizenship. Foreign accent, being of the nature of imperfect or defective speech, must necessarily be considered and classified. Since it is the result of incorrect articulation and enunciation it may be classified as a form of lisping. The establishment of a correct knowledge of the

phonetics of our language developed through the aid of glossokinesthesia is beneficial for its elimination.

Auditory Dumbness.—The dumbness of hearing children when young, is a condition of retarded speech development which is due to general physical weakness. These children have good speech understanding and with careful phonetic training can acquire normal speech.

Agitophasia (Speech Agitans, Logorrhea).—This is a condition of excessive rapidity of speech in which sounds or syllables are unconsciously omitted, slurred, mutilated, swallowed, or in any way imperfectly uttered, causing at the same time the speech accent to become distorted. A pathological condition of the nervous system is usually present. Agitophasia may be associated with stuttering or agitographia, (a form of writing in which letters or parts of letters are distorted or omitted. The prognosis is favorable under proper medicopedagogical treatment.

Nervous Speech Defects.—Numerous diseases or conditions of nervous origin give rise to various disturbances of speech. These defects are chiefly *festination*, in which the last few words or syllables of a sentence are enunciated with great rapidity; *scanning speech*, in which the syllables and short words are separated by a distinct interval; *syllable stumbling*, in which there is a reduplication of syllables; and *elision*, in which one or more of the syllables of a long word are dropped. The number of diseases in which such defects occur, enumerated below, will at once show the extensiveness of speech defects in clinical medicine. Their classification is as follows:

Congenital. Imbecility, idiocy, hereditary ataxia, amaurotic family idiocy, progressive muscular atrophy, congenital hydrocephalus, spastic spinal paralysis, bulbar paralysis.

Injuries. Of crus cerebi, of pons, infantile cerebral palsy.

Inflammations. Syphilis, acute polioencephalitis, multiple sclerosis, general paresis, Bell's palsy, postdiphtheritic paralysis.

Tumors. Of the speech areas (aphasia), medulla.

Functional. Epilepsy, chorea, spasmodic tics, hysteria, insanity.

James Sonnett Greene.

Spermatorrhea.—See *Neuroses, Sexual.*

Spermatozoa.—(Greek, σπέρμα, seed, and ζῶον, an animal.) A *spermatozoon* is a free, usually motile cell that is capable of uniting with an ovum to form the germ of a multicellular organism. The penetration of the ovum by the spermatozoon and the union of the nuclei of the two cells constitute the chief processes in the act of fertilization, which is the essential feature in sexual reproduction; and the ability to produce spermatozoa or their equivalent is the essential distinction of organisms of the male sex (see *Sex*). The spermatozoon differs from the ovum in size and shape and generally by being capable of locomotion (see *Ovum*).

Historical.—Spermatozoa were observed for the first time by Ludwig Ham, a pupil of Leeuwenhoeck, who in turn communicated the discovery to the Royal Society of London in a letter dated November, 1677. The discovery of these minute living bodies in the semen of man and a number of animals aroused great interest, especially as Malpighi a few years before (1672) had published the results of his observations on the embryology of the chick, and had concluded, in contradiction to Harvey, that the embryo is preformed in the egg. Now the question arose as to whether the moving elements of the semen might be germs which enter the eggs and develop into embryos. Leeuwenhoeck took the affirmative position and had many followers, but a greater number of the preformationists took the opposite view and held those bodies to be merely internal parasites. The name "spermatozoa" was given to them by von Baer with this idea in mind. The position or the "ovists" was strengthened by Bonnet's discovery of parthenogenesis, published in 1762 (the experiments were begun in 1740), which showed that in some cases an embryo can be formed without a male parent.

The first successful step toward a real knowledge of spermatozoa by means of experiments in artificial fertilization of ova of animals was made by Jacobi, and communicated to the Berlin Academy by Gleditsch in 1764. Jacobi placed the ripe spawn of salmon and trout in water and added seminal fluid squeezed from a male. After five weeks the eggs showed signs of life. It was apparently not these experiments, however, but some unsuccessful attempts made by Malpighi much earlier that led to the truly remarkable series of experiments by Spallanzani (1786). He wisely chose the amphibia for his material. First, he showed that eggs taken from the oviduct could be caused to develop by the addition of sperm taken from the seminal vesicles, while similar eggs not so treated failed to develop.

Second, he disproved the idea current at that time that the fertilizing element was an *aura seminalis*, a seminal vapor. This was done by causing frog's eggs to adhere to a watch glass, which was then inverted over another containing some of the sperm, and both were put in a warm place. The eggs became wet by the condensation of the vapor that was distilled from the sperm, but no fertilization took place. After some of the material in the lower watch glass had been added to the eggs, however, they speedily developed.

Third, by filtering the sperm he showed that the *liquor seminalis* has no fertilizing effect, but that the residue washed from the filter paper has undiminished power. Spallanzani was prevented from reaching correct conclusions as to the nature of the spermatozoa, however, because he accepted Bonnet and Haller's theory of the preformation of the germ in the female, the truth of which he thought he had demonstrated in the amphibia. Spallanzani produced artificial fertilization also in the eggs of silk moths and in a dog.

The next important contribution to the history of the spermatozoa is furnished by the brilliant observations and experiments of Prévost and Dumas (1824). They studied the anatomy and secretions of the reproductive organs of vertebrates of all classes above the fishes, and found that spermatozoa are produced in the testes only, and that these are the only organs essential to the fertility of the male; that spermatozoa exist in all fertile males and are absent from immature and senile individuals and from infertile hybrids; and that each species has its own peculiar form of spermatozoon. Having thus shown the close relation between the spermatozoon and its host and the correlation between the presence of spermatozoa and fertility of the male, these authors proceeded to repeat Spallanzani's experiments upon frog's eggs. They made improvements upon his methods, making the experiments more exact, and they demonstrated further that the spermatozoa are capable of penetrating the jelly surrounding the eggs. Spallanzani's results in regard to the aura seminalis and the liquor seminalis were confirmed and the important conclusion added that the spermatozoa are the essential fertilizing elements.

After all this it seems very strange to find the spermatozoa included in Owen's article on "Entozoa" in "Todd's Cyclopedia" (vol. ii., 1836–39), and to read in Johannes Müller's "Physiology" (1840) that it is doubtful whether the spermatozoa are parasites or living parts of the animal in which they occur.

This uncertainty is due to the fact that the observations recorded heretofore lacked two essential points; they failed to show how the spermatozoa arise in the testis, and they failed to give any hint as to how the spermatozoa behave upon reaching the ovum. The first of these gaps was filled by a series of papers by Kölliker beginning in 1841, in which, besides describing the spermatozoa of a large number of species, largely invertebrate, he shows that they arise by the metamorphosis of cells in the tubules of the testis.

FIG. 4543.—A Typical Human Spermatozoon. *A*, View of broad side; *B*, narrow side. Both show anterior and posterior part of head; neck with inner centrosome (in two parts); middle piece, main part of tail, and end piece. There is a dark spot in anterior part of head. Magnified about 3,000 diameters. (After Retzius).

Although, according to J. A. Thomson, the union of spermatozoon and ovum was observed in the rabbit by Martin Barry, an Edinburgh medical student, in 1843, it really remained for O. Hertwig to fill the second gap many years later (1875) from observations on starfish eggs. In this favorable material he was able to demonstrate that fertilization is effected by the entrance of one spermatozoon into the egg and the union of its nucleus with the egg nucleus. Thus two centuries, less two years, elapsed between the discovery of spermatozoa and the demonstration of the part played by them in the important function of reproduction. Even then the knowledge gained was very superficial. Much has been done during the past quarter-century toward gaining a deeper insight into the nature of the spermatozoon and the process of fertilization, but there is still an inner mystery into which our minds and our microscopes are equally unable to penetrate; and, while we may expect great progress in the future, it is probable that there will always be a limit beyond which the man of science must say, "I do not know" (see *Impregnation*).

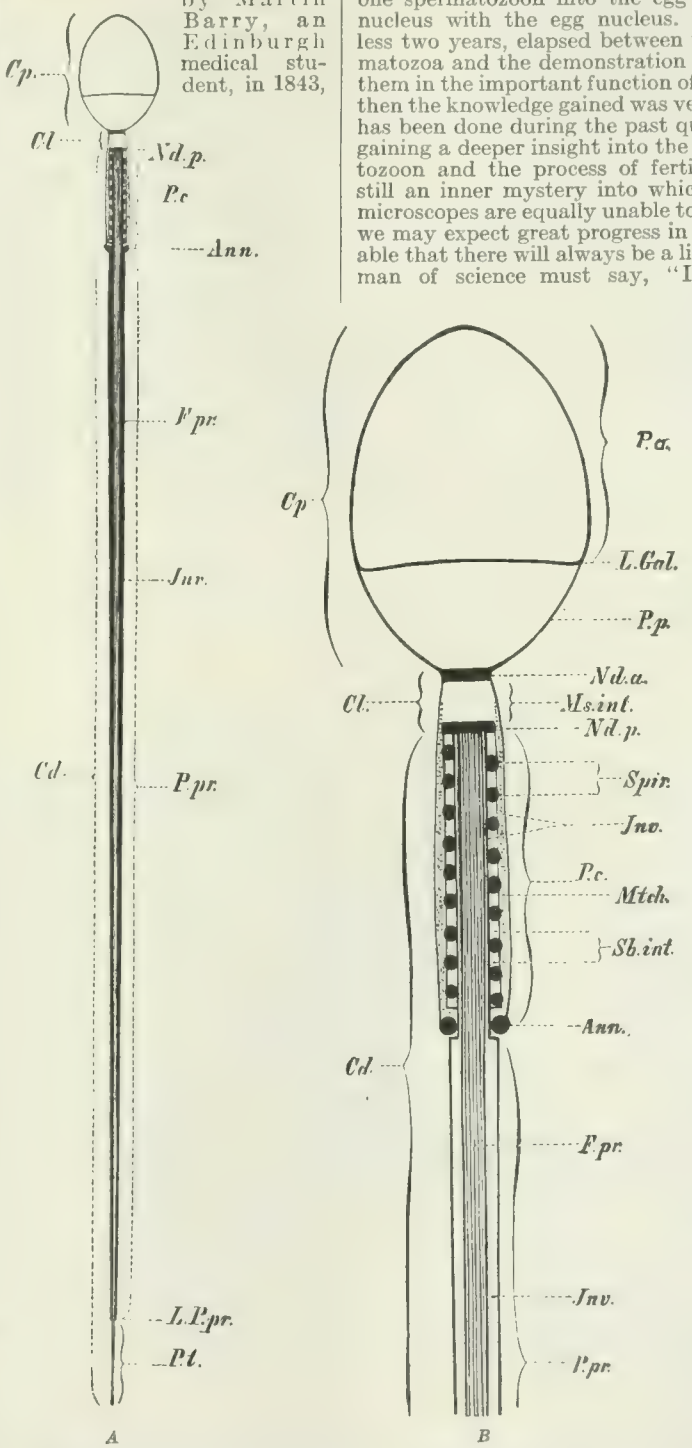

FIG. 4544.—Diagram of the Structure of the Human Spermatozoon. *A*, Whole; *B*, upper part more magnified. *Cp*, Head; *Cl*, neck; *Cd*, tail; *P.c.*, middle piece; *P.pr.*, main part of tail; *P.t.*, end piece; *P.a.*, and *P.p.*, anterior and posterior parts of head; *Nd.a.*, inner centrosome; *Nd.p.*, anterior part of outer centrosome; *Ann.*, annulus; *Spir.*, spiral filament; *Mtch.*, mitochondria; *F. pr.*, axial filament; *Jnv.*, involucrum. (After Meves, from Waldeyer.)

Morphology.—There are as many forms of spermatozoa as there are species of animals. We may take as our type the spermatozoon of man, because of its intrinsic interest as well as on account of its relatively simple structure (Fig. 4543).

In the spermatozoa of vertebrates Waldeyer distinguishes three regions—the head, the neck, and the tail. The head of the human spermatozoon is flattened. The wider face is broadly oval or nearly elliptical (Fig. 4543, *A*). Viewed from the side, it is seen to be more flattened toward the apex, the proximal two-thirds being narrowly ovate (Fig. 4543, *B*). According to Meves, the head may be divided into two parts—anterior and posterior (*P.a.* and *P.p.*, Fig. 4544). The anterior part is covered with a thin protoplasmic cap extending to the line *L. Gal.*, Fig. 4544, *B*. From its staining reactions and its history the head, with the exception of the cap and a thin covering membrane, is known to be composed of the cell nucleus with its chromatin contents. The neck of the human spermatozoon is inconspicuous (*Cl.*, Fig. 4544). It is in all forms a short region joining the head and tail, and containing the anterior centrosome (*Nd.a.*, Fig. 4544, *B*) and the homogeneous material

connecting it with the posterior centrosome (*Nd.p.*). The tail (*Cd.*, Fig. 4544) contains three parts—the middle piece, the principal part, and the end piece (*P.c.*, *P.pr.*, and *P.t.*, Fig. 4544, *A*). Throughout the length of the tail there extends an axial filament, which has been shown by maceration to be a bundle of extremely minute fibrils. The middle piece is about as long as the head and, according to Meves, has a rather remarkable structure. At its extremities are the two parts of the outer centrosome. The axial filament has its origin in the anterior part (*Nd.p.*, Fig. 4544) and passes through the posterior part, or annulus (*Ann.*, Fig. 4544). The axial filament is surrounded by an inner sheath. Outside of this is a spiral fiber lying in a clear substance. This is covered by a protoplasmic layer containing fine granules, the mitochondria. The principal part of the tail consists of the axial filament and a covering, the involucrum, which is probably continuous with the inner sheath of the middle piece. The end piece consists of axial filament alone.

Human spermatozoa are small compared to those of some other mammals, as will be seen by reference to the following table made from data given by Boston (1901):

Spermatozoa of	Total length *	Head.		Tail length
		Length.	Width.	
Man	51- 58	4 6	3 4	41 - 53
Dog (mastiff)	67- 74	4- 8	3- 4	59- 67
Rabbit	51- 66	6 9	3 4	45- 58
Horse	64- 67	6- 8	3- 4	54 - 60
Bull	87- 93	9	6	77- 83
Sheep	83	9	6	74
Cat	58- 74	0 7	3- 3	53- 66
Mouse	120–158	8- 9	3- 4	112–138
White rat	225–238	12–16		209 222
Guinea pig	113–138	6–12	7–11	102–132

Some of these figures differ considerably from those given by Waldeyer (1902, pp. 158, 159), and this is probably due to there being a large amount of individual variation among the spermatozoa from a single subject as well as variation in the types of spermatozoa produced by different males of the same species. Several authors have found in the same animal spermatozoa of two sizes, corresponding to the dimorphism with respect to the number of chromosomes (see *Sex*). Among the vertebrates the smallest spermatozoa are found in Amphioxus, 16 to 21 μ in length according to Sobotta, while the largest are produced by a European toad, *Discoglossus pictus*, the length, according to Spengel's measurements, being 2,000 $\mu = 2$ mm.

The various forms of spermatozoa are classified by Waldeyer into two principal groups and several subdivisions as follows:

I. Spherospermia.
  1. Without appendages.
  2. With appendages.
II. Nematospermia.
  1. Without lateral membrane.
    (*a*) Head rounded.
    (*b*) Head elongated.
  2. With lateral membrane.
    (*a*) Head rounded.
    (*b*) Head elongated.

To the first group, spherospermia without appendages, belong the simple spermatozoa of the nematoda. For example, Ascaris has a simple conical spermatozoon without appendages of any kind.

Spherospermia with appendages are characteristic of the decapod crustacea—the lobsters, crabs, and their allies. They present a great variety of form. There is generally a more or less rounded body with several or many spine-like projections.

The human spermatozoa belong to the group of nematospermia without lateral membrane and with rounded head. These have been sufficiently described above. In the simple spermatozoa of a medusa, Aurelia, we find an elongated head tipped with a sharp point, or *acrosome*. In some of the more complicated spermatozoa the head is very much elongated and the long sharp acrosome is provided with a barb like a minute harpoon. The lateral membrane is a fin-like fold lying on one side of the tail and it usually shows undulating movements. At its margin it encloses a fiber made up of fibrillæ, like the axial fiber. This form of spermatozoa is especially characteristic of the tailed amphibia.

Besides the normal spermatozoa there have been found in many species abnormal forms—giant spermatozoa, worm-like, double ones, etc.

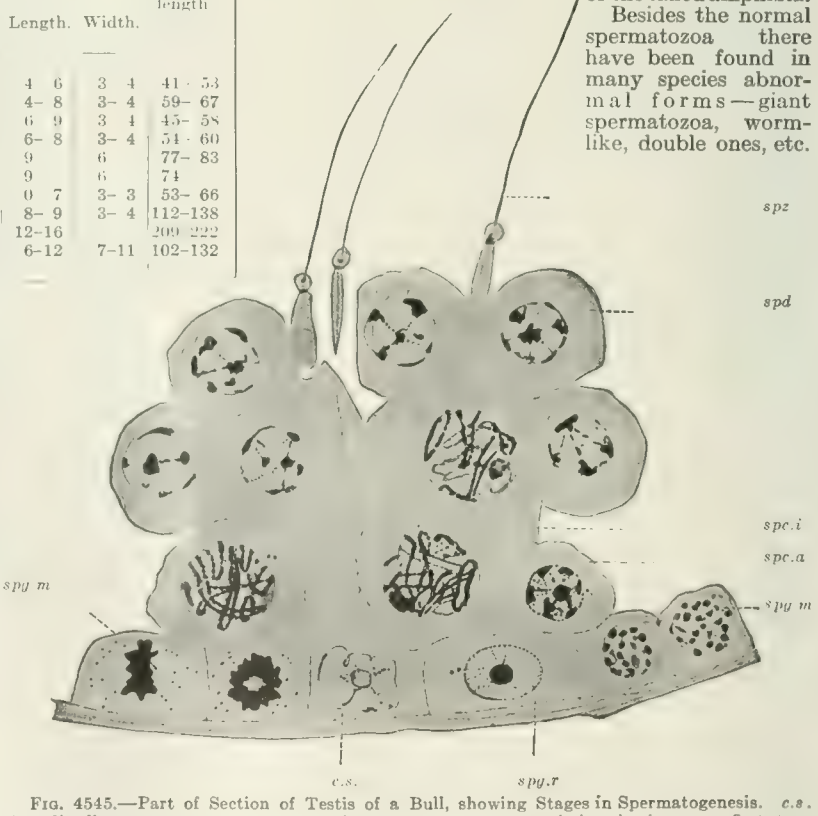

Fig. 4545.—Part of Section of Testis of a Bull, showing Stages in Spermatogenesis. *c.s.* Sertoli cell; *spg r.*, reserve spermatogonium; *spg.m.*, spermatogonia in mitosis; *spc.a.*, first stage in development of spermatocyte; *spc.i.*, spermatocyte in later stage; *spd*, newly formed spermatid just after the last maturation division; *spz*, nearly ripe spermatozoon, separated from Sertoli cell. Highly magnified. (After Schoenfeld.)

Some of these forms are clearly pathological, but in other cases there may be a normal dimorphism.

Early Development.—Each spermatozoon is produced by the metamorphosis of a cell, called a *spermatid*. The origin of the spermatids has been described in the articles *Germ-cells* and *Maturation*. The primitive germ-cells of the male produce by fission innumerable *spermatogonia*. These and the later generations

* All measurements are given in thousandths of a millimeter (μ).

of cells ending with the spermatids form the lining of the seminiferous tubules of the testis, together with certain peculiar nutritive cells known as the *cells of Sertoli* (Fig. 4545). The latter, according to Montgomery (1911), are also derived from spermatogonia.

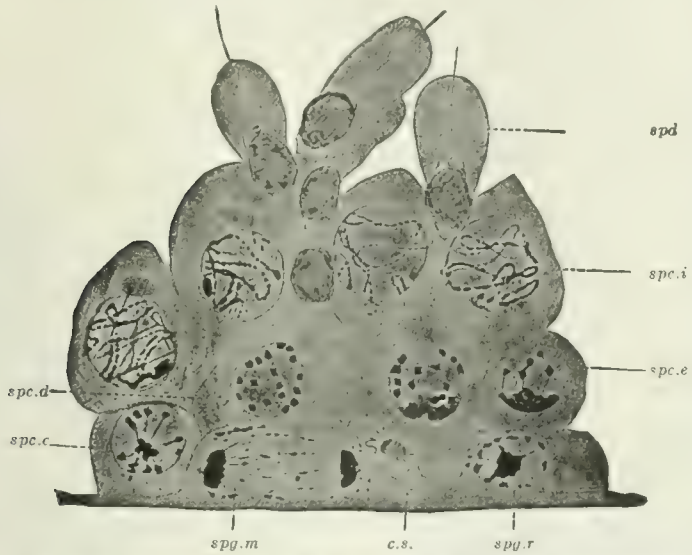

FIG. 4546.—Another Section of the Testis of a Bull. *spg.m*, Reserve spermatogonium in mitosis; *spc.c*, *d*, and *e*, spermatocytes in stages preliminary to synopsis; *spc.i*, advanced primary spermatocyte, growth nearly completed; *spd*, spermatid attached to Sertoli cell (*c.s.*) and undergoing histogenesis. Highly magnified. (After Schoenfeld.)

Histogenesis.—In the young spermatids, which are produced by the division of the secondary spermatocytes (see article *Germ-cells*), the nucleus acquires a nuclear membrane and passes into the resting condition with a chromatin reticulum. The centrosome moves from its original position and divides into two, either completely or incompletely, forming a minute dumb-bell-shaped structure. The "sphere" of denser protoplasm that collects around the centrosome after earlier cell divisions now forms independently of the centrosomes and is called the *idiosome* (*s*, Fig. 4547).

The fate of the various parts of the cell in the development of the spermatozoon is summarized by Waldeyer as follows: Out of the chromatin of the nucleus is developed the head of the spermatozoon; a part of the idiosome forms the acrosome; the centrosome takes part in the formation of the neck, the middle piece, and the axial filament; the cytoplasm gives rise chiefly to the axial filament, its mitochondria form the spiral structures, and take part in the formation of the envelope of the tail.

The nucleus first moves from its originally central position to the periphery of the cell opposite the centrosomes. Its chromatin network becomes gradually finer and more condensed until it forms an apparently homogeneous mass; at the same time the nucleus becomes smaller and gradually assumes its definitive shape.

In the meantime a part of the idiosome, often containing a vacuole, becomes attached to the nuclear membrane and moves around the nucleus to take its position at the apex and becomes the acrosome (Fig. 4547). The two centrosomes move toward the nucleus and the inner one soon becomes attached to the nuclear membrane at the posterior pole of the nucleus opposite the acrosome.

The outer centrosome becomes disc-shaped, and at a very early stage there grows out from the center of the disc, or in close connection with it, a very fine filament, the rudiment of the axial filament of the tail (*ax*, Fig. 4547). The development of the tail, as remarked by von Ebner, is one of the most difficult problems of histogenesis. It is described variously by different authors for the same or closely related forms, and the course of development appears to differ considerably in the two groups of vertebrates in which it has been most carefully studied—the amphibia and the mammals. All agree, however, that very soon the periphery of the outer centrosome becomes separated from the axial filament and forms a ring surrounding it, and in the mammalia

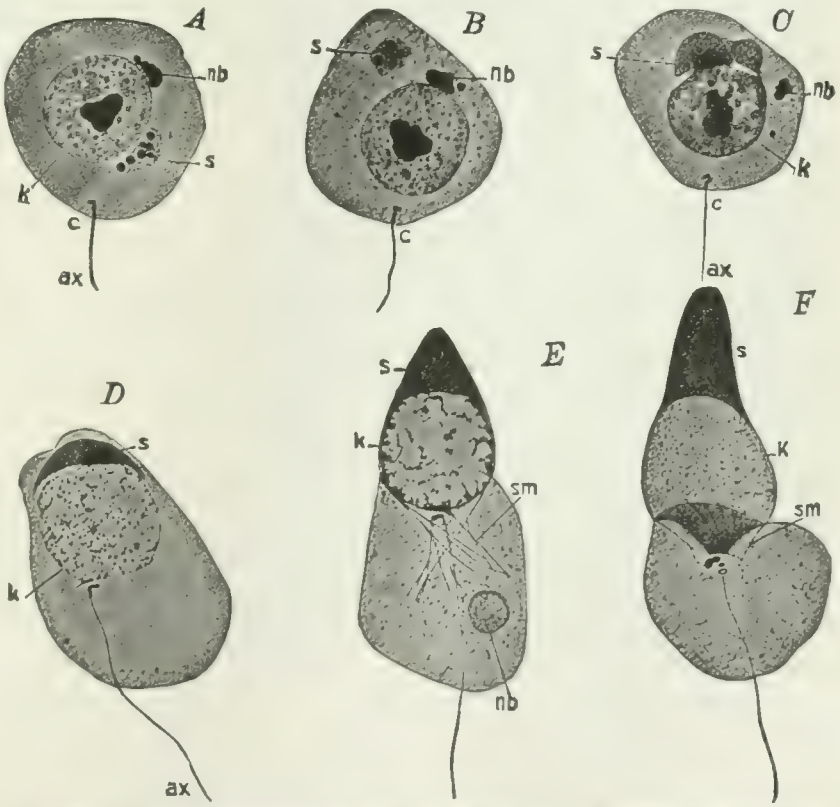

FIG. 4547.—Spermatids of the Guinea-pig, *Cavia cobaya*, in Various Stages of Metamorphosis. *k*, Nucleus; *s*, sphere; *c*, centrosome; *ax*, axial filament. Highly magnified. (After Meves, from Korschelt and Heider.)

(Fig. 4547) the central part forms the end knob of the axial filament. The axial filament has been growing meanwhile and now consists of two parts, one within the cell and the other outside. Before the division of the outer centrosome there appear a number of fine filaments with their bases attached to the nuclear membrane in a circle surrounding the centrosomes and with their ends projecting in various directions into the cytoplasm (*sm*, Fig. 4547 *E*). By the progressive differentiation of the cytoplasm between the filaments they are soon fused into a hyaline tube surrounding the axial filaments and open at the posterior end. This tube is the "manschette," or *caudal tube*, which according to Oliver (1913) forms a permanent part of the envelope of the middle piece.

The caudal tube soon separates from the nucleus and the small part of the cell between the two forms the neck of the spermatozoon. Of the two portions of the outer centrosome, the ring, *annulus*, surrounding the axial filaments moves rapidly through the caudal tube and fuses with its outer end, while the other portion becomes connected with the inner end of the tube.

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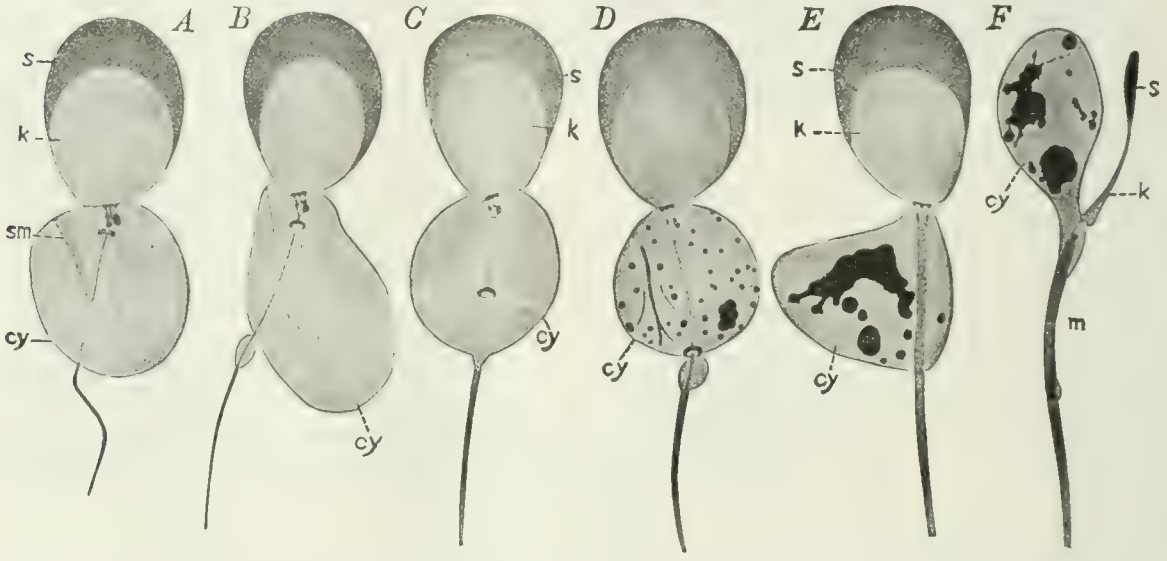

Fig. 4548.—Later Stages in the Metamorphosis of the Spermatids of the Guinea-pig. *A*—*E*, views of broad side; *F*, narrow side. *cy*, Cytoplasm: *m*, middle piece. Other lettering same as in Fig. 4547. Highly magnified. (After Meves, from Korschelt and Heider.)

As the spermatozoon begins to take shape the main part of the cytoplasm draws backward, leaving only a thin membrane on the head, and the mass of cytoplasm lies in the position of the middle piece (*cy*, Fig. 4548). Scattered thickly through the cytoplasm are fine granules with characteristic staining qualities, the mitochondria. The spinal filament is formed by the concentration and fusion of this material.

In the mammalia and some other forms there is more cytoplasm than can be used in the development of the spermatozoon. This part begins to undergo degenerative changes, and at the same time is gradually constricted off from the middle piece (*cy*, Fig. 4548 *F*). The cytoplasmic remnants may remain attached to the Sertoli cell for a time after the spermatozoa have moved away.

After leaving the testis the spermatozoa undergo a further "ripening" process, which consists chiefly in the completion of the outer envelope of the middle piece and the smoothing off of any projections or irregularities that may have remained after separation from the Sertoli cells.

It will be seen from this brief review of the development of spermatozoa that there can be no further question as to the character of these bodies. Each one contains all the essential elements of a cell.

Robert Payne Bigelow.

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Spiders.—The true spiders are included in the order Aranea in the class Arachnida among the arthropods. They have eight walking legs, the body is divided into two regions, and many species spin webs. Their chief medical interest is in the fact that they are able to inflict poisonous bites, though the amount of poison one of the common small spiders may inject into a person is usually negligible. The bites of the large tropical species are treated by proximal ligature, and with local applications alkalies, such as ammonia or carbonate of potash. See *Arachnida*. A. S. P.

Spigelia.—Pinkroot. U. S. The dried rhizome and roots of *Spigelia marilandica* L. (fam. *Loganiacæ*).

It must not contain more than ten per cent. of stems and other foreign matter. The ash should not exceed ten per cent.

This is a perennial herb, with a horizontal, crooked rhizome, and several erect, simple, somewhat quadrangular stems. Leaves opposite, sessile, ovate-lanceolate, smooth. Inflorescence terminal in a one-sided (scorpioid) spike, of half a dozen or more showy flowers. Calyx small, five-parted; corolla tubular, trumpet-shaped, with five acute, spreading lobes; bright scarlet outside, bright yellow within. Stamens five, inserted on the corolla; pistil single; ovary two-celled, several-seeded, superior. Pinkroot is a native of the Middle and Southern States, where large quantities are annually collected. Its medicinal properties have been known for upward of a century.

The description of the drug is as follows:

The rhizome is of oblique and sharply tortuous growth, somewhat branched, mostly 2.5 to 5 centimeters (one to two inches) long and two to four millimeters (one-twelfth to one-sixth inch) thick, knotty from the approximate stem bases of the upper surface, which bear cup-shaped scars, dark brown or blackish, thickly clothed underneath and at the sides with long, rather coarse, finely branched, lighter brown roots, which are usually broken shortly, not leaving a long, bare, woody central portion; brittle, showing a whitish wood and a dark or decayed pith; somewhat aromatic; taste sweetish, bitter, and somewhat pungent.

The larger, lighter colored rhizome of *Ruellia*, sp., with fewer coarse roots, from which the bark readily separates, is frequently substituted or admixed.

But little is known of the constituents of this drug. Starch, resin, gum, tannin, fat, volatile oil, and other ordinary plant substances exist, together with a small amount of the volatile alkaloid *spigeline*, which is soluble in alcohol and water, and is probably the active constituent.

Action and Use.—In overdoses spigelia is a narcotic poison. Quickening of the pulse, dryness of the throat, flushing and heat of the skin, uneasiness and delirium have followed its use. There is little doubt that in the cases in which it is most employed—cases of *lumbrici* or round worms—it is of considerable value. A fluid extract (*Fluidextractum Spigeliæ*, U. S. P.) is a good preparation, and the one generally prescribed. It is frequently combined with senna or some other cathartic, although it is better practice to administer the cathartic two or three hours later. Dose of the fluid extract, for an adult, fl. ʒss.–ij. (2.0–8.0); for small children, from fl. ʒ½ to i. (1.0–4.0).

Allied Plants.—Another spigelia, *S. anthelmia* L., growing in South America and the West Indies, has, as its name implies, similar properties and uses. Although used chiefly in its home, it has also been introduced into Europe. It is regarded, probably correctly, as more active than our own.

Henry H. Rusby.

Spigelius, Adrian.—The Latinized name of Adrian Van der Spiegel, born at Brussels, Belgium, in 1578. He began the study of medicine at Malines, and then went to Padua, Italy, to complete his medical education under Fabricius d'Aquapendente and J. Casserio. Upon the death of the latter he was invited to succeed him as Chief Professor of Anatomy and Surgery in the University of Padua. He worked with such energy and allowed himself so little rest that his health soon gave way under the strain. He died at the early age of forty-seven, before he had had sufficient time to give the finishing touches to his work on anatomy, a book of conspicuous merit. Its title reads as follows: "De humani corporis fabrica libri," Venice, 1625; later editions in 1627, 1632, 1646, and 1654. The lobus caudatus of the liver is commonly known as the lobe of Spigelius, and the linea semilunaris is also called S.'s line.

A. H. B.

Spina Bifida.—Spina bifida, a malformation, is a congenital hernia-like sac of the spinal meninges and cerebrospinal fluid, passing from the spinal canal through a congenital deficiency in the arch of one or more of the vertebræ; rarely through a vertebral body or an intervertebral ligament; it may contain, in addition to cerebrospinal fluid, nerve roots, cauda equina, or spinal cord. It is closely related to rhachischisis or amyelia, a graver malformation, just as in the head the congenital meningoceles are related to anencephalus. These two spinal malformations are described together; a mixed or intermediate type is said to occur.

Rhachischisis, like anencephalus, has no protruding, hernia-like sac; instead, the skin of the back from occiput to waist is replaced in the median line by a moist, red, glistening membrane which is the unformed cord freely exposed; it contains nerve fibers, blood-vessels, and fibrous areolar tissue; it gives off from the anterior surface pairs of nerve roots which form spinal nerves. This area medullovasculosa may either involve the whole spinal cord when the

Fig. 4549.—Longitudinal Section through Eight-months' Fetus with Total Rachischisis. Showing abnormal curves of spine.

malformation is a total rhachischisis; or a part, partial rhachischisis. Bordering the red, moist membrane is a smooth, white zone where the epidermis of the skin develops without deeper layers; this merges into true, normal skin, with hairs.

The photograph (Fig. 4548) shows that rhachischisis may accompany anencephalus, deren-

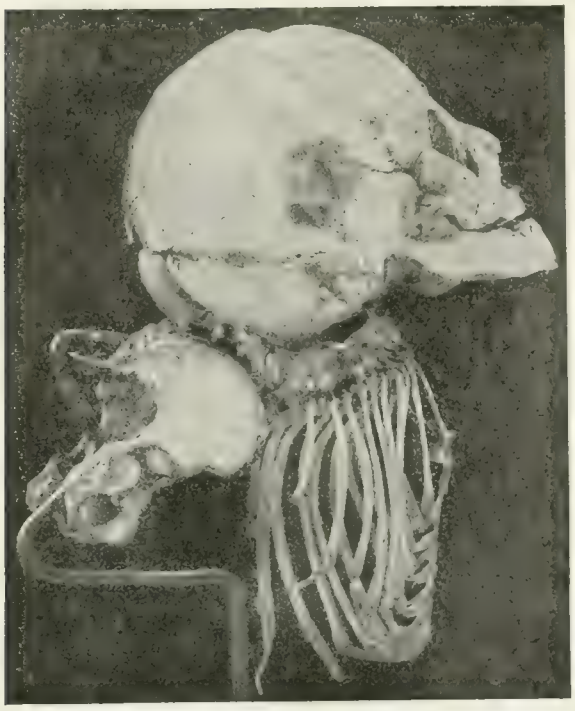

Fig. 4550.—Rachischisis with Great Shortening and Abnormal Anteroposterior Curvatures. Skull well developed. (Warren Museum.)

Fig. 4551.—Longitudinal Section through Anencephalic Fetus. Showing almost normal spinal curves.

cephalus, and hydrocephalus. Fig. 4551 is inserted for comparison—an anencephalic fetus nearly at term; the median section shows the cranial vault absent and the spinal curves normal; while in the others with rhachischisis abnormal spinal curves are plainly visible, especially in the cervical region, causing the typical frog-like pose of the head.

Nothing is attempted surgically for the amelioration of rhachischisis as the babes are either stillborn, or live few days.

Causation.—The causes producing it and spina bifida may or may not be the same, but whatever they are, they interfere with embryonic development very early, probably before embryos have been human studied. In the laboratory the impregnated ova of the sea urchin, axolotl, frog, and some fishes, may, at will, be developed into spina bifida young by immersing them soon after fertilization into certain dilute chemical solutions. Professor Mall suggests that the human ovum, faultily implanted or attached to an unhealthy uterine mucosa, may similarly develop the malformations. Others attribute the occurrence to a non-development of those mesoblastic plates which later become the laminæ and the spinous process of a vertebra. Still others think that an early excessive secretion of cerebrospinal fluid bulges the meninges, and by pressure keeps the arches from uniting.

Fig. 4552.—Cleft of Bodies of Cervical and Seven Upper Dorsal Vertebræ with Separation; Great Shortening and Deformity of the Thorax and Neck. Anterior aspect. (Warren Museum.)

Spina bifida was correctly described by Nicolai Tulpius of Amsterdam, in 1685. Two hundred years later (1885) the Clinical Society of London divided spina bifida into three types or varieties based on the location of the fluid in the sac. Sac fluid distending the subdural space was a simple spinal meningocele or hydromeningocele; in the

subarachnoid space, myelomeningocele; and in the central canal of the cord, syringomyelocele. Von Recklinghausen added a fourth or a mixed form—fluid distending both the central canal and the subarachnoid space; this is rare.

A fifth type is the anterior spina bifida; also a rare condition where the bodies of vertebræ are cleft instead of the arches; sometimes both the bodies and the arches are cleft—spina bifida anterior and posterior (Fig. 4552).

A sixth type is spina bifida occulta, where a spina bifida sac was present in the fetus, but disappeared before birth.

These six types behave differently; some are amenable to surgical treatment; others are not; we should differentiate between them in diagnosis.

Myelomeningocele.—To this type (according to Sharpe, *Annals of Surgery*, 1915, pp. 151–165) belong seventy to eighty per cent. The subarachnoid space is filled with sac fluid anterior to the cord or the cauda equina which is crowded backward out of the spinal canal, and usually adheres to the top of the sac, at which point the dura mater is absent. What may be

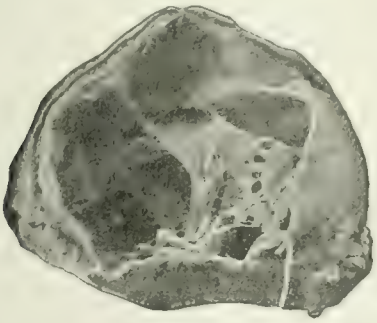

Fig. 4553.—Myelomeningocele; Sac much Subdivided. (Warren Museum.)

another form of fluid in the subarachnoid space, and may therefore be regarded as a form of myelomeningocele, is pictured in Fig. 4553. Here fluid is collected in the reticulum of the arachnoid posterior to the spinal cord: it forms a sac full of cyst-like cavities; the spinal cord or cauda equina are not in the sac, though occasionally a loop of nerve root may be found in it.

In the classical form of myelomeningocele, the spinal cord adheres to the apex of the sac wall where it loses its form, flattens and bcomes a part of the wall of the sac, so that looking within the opened sac (Fig. 4554) the nerve roots rise in a double row from the sac wall, and cross the cavity to the intervertebral foramina.

Myelomeningoceles occur in the lower half of the spine; they are very rare in the cervical region. It is typical of myelomeningoceles that the cleft arches extend through four, five, six, or seven adjacent vertebræ; that the arches are wide open from side to side; that the sac has a broad base, is irregularly ovoid and seldom projects upon the surface of the back as much as its length.

Skin covers the base of the protrusion merging into semi-transparent membrane and becoming thin and cyanotic as it approaches the membrane, which often covers half or two-thirds of the surface. Upon this membrane may be found granulating ulcers; clear, watery fluid, like cerebrospinal fluid, may exude in drops or escape through small perforations. The membrane is sometimes dense and tough, resembling old scars; often it is as thin and friable as tissue paper. Often the center is depressed giving the tumor the shape of a tomato, the umbilication indicating the point at which the spinal cord is attached. A surgical incision through the umbilication is to be shunned. The skin on the back near the base is normal, but hairy.

Where the cord is attached to the sac it is malformed and flattens out. Where fluid collects in the meshes of the arachnoid back of the cord, it crowds the cord from behind against the vertebral bodies, so that softening may take place. The lengthened nerve roots are swollen, purple from venous stasis, and often devoid of axis cylinders. These nerve lesions are permanent changes cutting off the nerve supply.

Fig. 4554.—Section through a Myelomeningocele. The lumbar enlargement is attached to the posterior wall of the sac, and has been divided. The nerve roots are seen running from this part of the posterior sac wall toward the foramina. (Warren Museum.)

The resulting motor paralysis in the legs is usually distributed symmetrically; sensory disturbances, like areas of anesthesia, may also be found and sphincter paralysis expressed by rectal or vesical incontinence—or both; trophic ulcers of the feet and legs are not uncommon; paralytic club-feet, congenital dislocation of the hip, hydrocephalus, and other malformations are common.

The span of life of untreated babies with myelomeningocele is short; nine out of ten die in their first year, mostly within two months of birth. Surgical intervention, to-day the usual treatment, decreases mortality from ninety to fifty per cent.; it aims to empty excessive fluid by incision, to replace the spinal cord and nerve roots within the spinal canal and to cover it with healthy skin, eliminating the danger of rupture of the sac and of fatal septic meningitis. Paralysis is seldom benefited by operation, and closing the sac may increase hydrocephalus or may cause it to appear. Spontaneous cure from ulceration, cicatricing, and shrinkage of the sac occasionally occurs.

Hydromeningocele, or simple spinal meningocele, represents the next commonest form occurring in eight to twelve per cent. (according to Sharpe, *loc. cit.*). The fluid is in the subdural space, the cavity is without

cord or nerves. The external form is globular, from the size of a grape to that of the child's head, and large ones may burst during birth. The base is small, the cleft arches are not spread open widely, and only one, two or, at most, three adjacent vertebræ are split. Rare cases are on record of the sac escaping through a hole in the ligamentum subflavum the spinous process being partly bifid. Normal skin covers the sac entirely or leaves only a small area of membrane. By transillumination, used as for hydrocele of the tunica vaginalis, the light is easily transmitted and there are no shadows or dark bands which one may see in myelomeningoceles from nerve roots and cross partitions.

Hydromeningocele frequents the sacral and lumbosacral region, is decidedly uncommon in the lumbar and cervical spine, and very rare in the dorsal. Hydrocephalus may be present, but paralysis almost never. Rupture of the sac is not uncommon and may lead to death from shock or septic meningitis. Spontaneous cures from shrinking have been recorded.

Surgical intervention (dissection and ligation of the neck of the sac, and closing the wound) is safe and easy even after accidental rupture. Prognosis after recovery from operation is good except for that unknowable factor hydrocephalus.

Syringomyelocele.—This type is rare, less than one per cent., even, including the mixed form of von Recklinghausen. Sac fluid distends the central canal of the cord; consequently the distended cord forms the lining of the sac. The committee of the London Clinical Society found only two cases of syringomyelocele—one lumbar and one cervical. Von Recklinghausen reported eleven of the mixed forms. In the syringomyelocele only two arches were cleft; in Recklinghausen's mixed form, four, five, or six. The external covering is skin. The translucency tested is like that for hydromeningocele which it resembles in many ways.

Other malformations are as a rule present especially in von Recklinghausen's form and the prevalence of grave deformities like congenital hernia of the liver, or of liver and intestines, and exstrophy of the bladder is remarkable. Abnormal spinal curvatures, like congenital scoliosis are common, likewise thoracic malformations, the absent, bifid or bicipital ribs. Paralysis of legs and sphincters is common. The prognosis untreated is worse than for myelomeningocele; with operation the prognosis is also poor. A syringomyelocele may come to operation, supposing it erroneously to be a hydromeningocele; when recognized the graver prognosis should be given. A search through the literature has so far failed to establish the existence of an adult with syringomyelocele.

Anterior spina bifida. This form and the anterior and posterior form are rareties.

The body of a vertebra ossifies from two centers—a right and a left one and it is common to find vertebræ ossified on the sides but cartilaginous in the median vertical plane. The anterior spina bifida sac escapes from the canal through a hole in this cartilaginous part, and protrudes into the abdomen or pelvis. The anterior type is reported in girls almost exclusively, usually it is in the sacrum. The sac fluid is said to be in the subdural space; nevertheless, paralytic club-feet, and paraplegia have been observed. Large tumors have been mistaken for sarcoma or pelvic cysts. A specimen in the Warren Museum, Boston (Fig. 4552) represents an extensive anterior and posterior cleft of the upper half of the spine, and precluded further development. The prognosis for anterior spina bifida is bad; a few operated upon have died.

Spina Bifida Occulta.—This interesting condition is not rare; it may occur in five per cent. It is little studied, often overlooked or wrongly diagnosed. Radiograms of the spine taken for other reasons, not infrequently reveal its unexpected presence. The hypertrichosis, hair over the cleft, often does not develop until after puberty. There is no protruding sac; there may be an old scar, or wrinkled pigmented skin, or a median nevus, or simply the hair. The ends of the laminæ may be palpable, or they may be concealed by a diffuse growth of fat, a congenital lipoma. Angiomata or dermoid cysts, as well as lipomata, have been found there expanding both within and outside the spinal canal, connected by a slender stem like that of a shirt stud. Some have found that the skin or fascia adhered to nerve roots or cauda equina.

Paralysis, anesthetic areas, and trophic ulcers may be present and they may not appear till late childhood or adolescence. In little children and in infancy the condition may be overlooked entirely and symptomless adults with hypertrichosis are exhibited at circus side shows as the man or woman with a horse's mane.

This delayed appearance of involvement of the spinal cord and nerve roots has been attributed to the slowly increasing intraspinal pressure from tumor growths, or to a drag upon the spinal cord from its attachment to the faster growing spinal column; for at birth the cord ends at the third lumbar and in adults at the first lumbar vertebra.

The frequency of abnormal curvatures of the spinal column in connection with deficient spinal arches may explain the unexpected detection of spina bifida occulta among scoliotics when a radiogram of the spine became a routine measure for clinic patients.

Treatment has so far been limited to the attempts of some surgeons to relieve intraspinal pressure by removing the tumor. The published results are encouraging.

Spontaneous cure of spina bifida occulta paralysis has not been observed. Trophic ulcers may heal, but are apt to return. Augustus Thorndike.

Spinal Cord and Spinal Nerves.—General Description.—The spinal cord (*Medulla spinalis*) is that portion of the central cerebrospinal nervous system which is situated within the vertebral canal (Figs. 4555 to 4558). The human spinal cord is a slightly flattened cylinder, varying in caliber somewhat at different levels. It is bent in the sagittal plane corresponding to the curvature of the vertebral column. It is from forty-three to forty-five centimeters in length, being on the average somewhat longer in the male than in the female. It is continuous above, at the lower edge of the foramen magnum, with the medulla oblongata, and extends below into the lumbar part of the vertebral canal, where it is abruptly drawn out into a terminal filament (*filum terminale*).

The spinal cord of the embryo fills the entire cavity of the vertebral canal, and this condition prevails throughout early fetal life (Fig. 4558). But in later development both the diameter and the length of the vertebral canal increase more rapidly than do those of the spinal cord. The result is that in the adult the spinal cord, exclusive of the terminal filament, usually ends at or near the level of the first lumbar vertebra. Nor does the spinal cord come anywhere near filling up the lumen of the vertebral canal. A cross-section through the vertebral canal with the cord *in situ* reveals a large space between the surface of the cord and the inner surface of the bony vertebral canal (Fig. 4556). This space is subdivided by the coverings of the cord into several spaces. One of these, between the arachnoid membrane and the pia mater, the so-called subarachnoid cavity (*cavum subarachnoidale*), is filled with the cerebrospinal fluid (*liquor cerebrospinalis*). This disproportion between the size of the cord and that of the cavity of the vertebral canal is of great significance for the protection

of the cord from injury during the various movements which the vertebral column undergoes.

The regions of the spinal cord are named according to the nerve roots with which they are connected (see below). We have, accordingly, cervical, thoracic, and

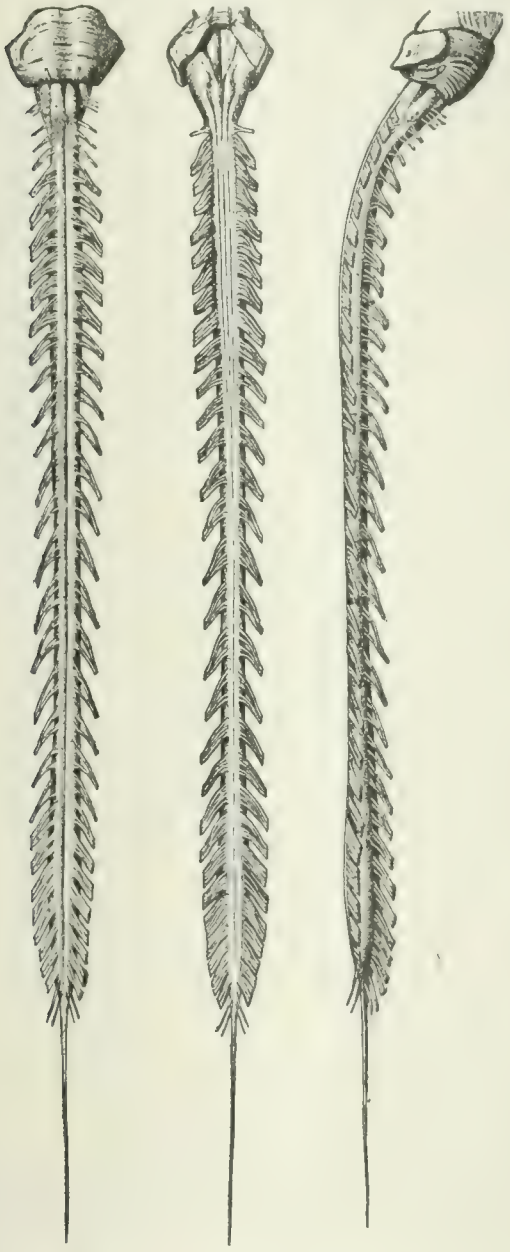

Fig. 4555.—Views of the Spinal Cord (Medulla Spinalis). *A*, From in front; *B*, from behind; *C*, from the right side. (From Toldt.)

lumbar parts. Below the latter the cord diminishes rapidly in caliber, this part being called the medullary cone (*conus medullaris*). From the lower end of the medullary cone the terminal filament extends downward as a delicate strand for a distance of from twenty to twenty-five centimeters, to end upon the dorsal surface of the os coccygis (Fig. 4557).

The spinal cord, though in general of cylindrical shape, is everywhere flattened from before backward. It is considerably enlarged in two regions. The upper

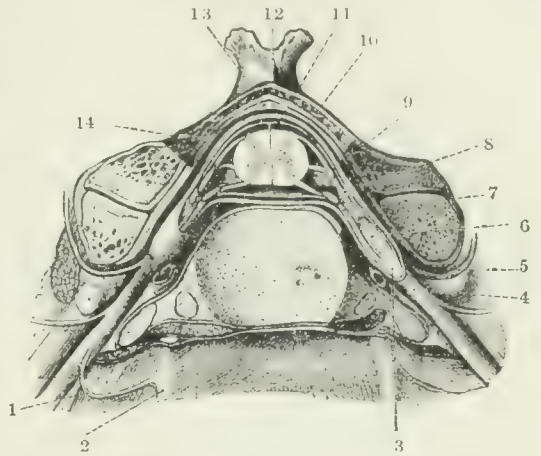

Fig. 4556.—Transverse Section through the Intervertebral Fibrocartilage between the Third and Fourth Cervical Vertebræ. The spinal meninges are shown in cross-section and their relations to the spinal nerves are indicated. (After C. Toldt, "Anatomischer Atlas," Wien, 1900.) 1, Ramus communicans; 2, trunk of the sympathetic; 3, fourth spinal nerve; 4, ramus ventralis; 5, ramus dorsalis; 6, ganglion spinale; 7, radix ventralis; 8, radix dorsalis; 9, spinal dura mater; 10, subarachnoid space; 11, spinal arachnoid; 12, spinous process of the third cervical vertebra; 13, subdural space; 14, epidural space.

enlargement is situated at the junction of the neck and thorax, and is known as the cervical enlargement (*intumescentia cervicalis*); its maximal size is opposite the fifth or sixth cervical vertebra, where the sagittal diameter is 9 millimeters and the transverse diameter 13 to 14 millimeters. The lower enlargement, at the junction of the thoracic with the lumbar portion of the spinal column, is known as the lumbar enlargement (*intumescentia lumbalis*); the maximum of this enlargement is reached at the level of the twelfth thoracic vertebra, where the sagittal diameter is about 8.5 millimeters and the transverse diameter 11 to 13 millimeters. These two enlargements correspond to the places where the spinal cord gives off nerves to, and receives nerves from, the upper and lower extremities respectively.

Upper and Lower Limits of Cord.—The upper limit of the spinal cord in man and mammals corresponds to the lateral exit of the uppermost rootlets of the first cervical nerve. This point corresponds ventralward to the lowermost bundles of the decussation of the pyramids. The lower level of the cord, that is its junction with the filum terminale, nearly always lies on a level corresponding to the lower third of the first lumbar vertebra or the upper third of the second lumbar vertebra, though in forty per cent. of the cases it may lie opposite the upper two-thirds of the first lumbar or the lower two-thirds of the second lumbar vertebra. In one case it ended five milli-

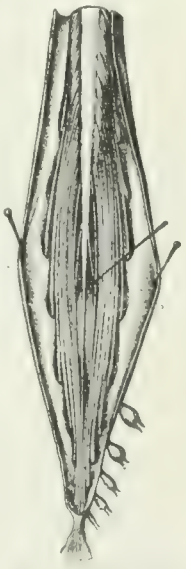

Fig. 4557.—The Lumbar Spinal Cord (pars lumbalis medullæ spinalis) with the terminal cone (conus medullaris), terminal thread (filum terminale), and the horse's tail (cauda equina). Viewed from behind. (After C. Toldt, "Anatomischer Atlas." Wien, 1900.)

meters above the lower border of the twelfth thoracic vertebra, and it has been found as far down as the lower margin of the second lumbar vertebra. (See report of Committee of Collective Investigation of Anatomical Society of Great Britain and Ireland for the year 1893–94, *Jour. Anat. and Physiol.*, vol. xxix., 1895, pp. 35–60.)

Length of Spinal Cord.—The extreme variations in the male are between 44 and 50.6 centimeters; in the female, between 39 and 47 centimeters. As to the relation of the length of the cord and the length of the vertebral column, measured from the foramen magnum to the basis ossis sacri, it may be stated that when the average length of the spinal column is designated 100, the length of the male spinal cord will be 64, that of the female spinal cord about the same. The average length of the vertebral column in the male is 70 centimeters; in the female, 68 centimeters (Ziehen).

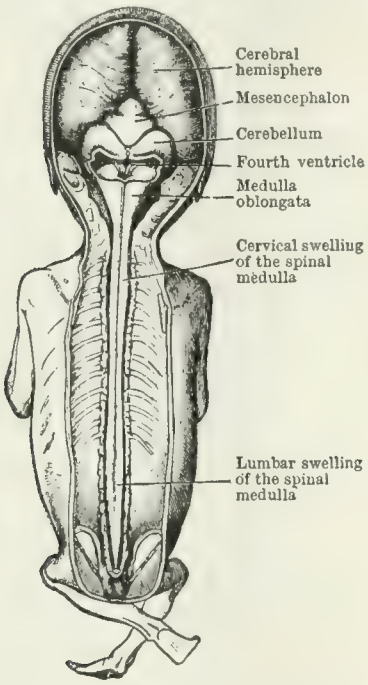

Fig. 4558.—Human Fetus in the Third Month of Development, with the Brain and Spinal Cord Exposed from Behind. (Cunningham.)

Upper Level of Conus Medullaris.—Charpy designates as the arbitrary upper limit of the conus medullaris a plane lying between the exit of the fifth sacral nerve and the nervus coccygeus. According to this the conus medullaris would measure about ten millimeters in length. Raymond states that clinicians usually regard the conus medullaris as extending farther up, usually to the plane between the third and fourth sacral nerve roots. This would make the conus medullaris considerably longer.

Segments of the Spinal Cord.—The nerve fibers which compose the spinal nerves are arranged in small fascicles or radicular threads (*fila radicularia*) which connect with the spinal cord in two rows on each side. These are the dorsal or posterior and the ventral or anterior root fibers. The dorsal and ventral rows of radicular threads as they pass out lateralward to leave the vertebral canal converge toward their respective intervertebral foramina, thus constituting the trunks of the spinal nerves. Each nerve trunk is described as composed of two roots, a dorsal root (*radix dorsalis*), comprising the radicular threads which enter it from the dorsal side of the cord, and a ventral root (*radix ventralis*), comprising the radicular threads from the ventral side of the cord. On each dorsal root just before its union with a ventral root is a small swelling containing the cell bodies of the neurones of the dorsal root fibers. This is the spinal ganglion (*ganglion spinale*). The spinal cord is divided into a series of longitudinally arranged segments, each of which is connected by means of its dorsal and ventral fila radicularia with a pair of spinal nerve trunks. The segments are named in accordance with the related spinal nerves, and the latter are named after the vertebræ contiguous to their foramina.

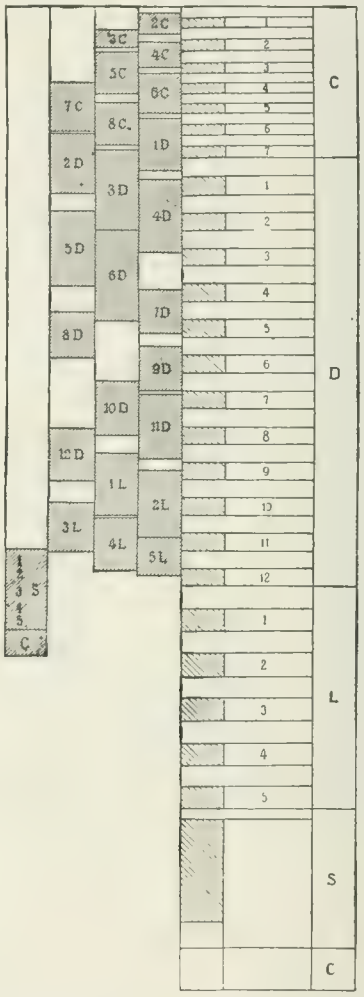

Fig. 4559.—Topographical Relations between the Spinous Processes of the Vertebræ and the Roots of the Spinal Nerves. The letters *C*, *D*, *L*, *S*, *C*, in the unshaded rectangular spaces to the right indicate the longitudinal extent of the cervical, thoracic, lumbar, sacral, and coccygeal portions of the spinal column. The rectangular spaces shaded obliquely from the left and above downward and to the right indicate the longitudinal extent of the spinous processes of the individual vertebræ, while the rectangular spaces shaded obliquely from the right and above downward and to the left, indicate the region within which the origin of the individual roots of the spinal nerves is to be sought. The horizontal extent of the rectangular space has no significance. (After Reid, *Journ. Anat. and Physiol.*, Lond., 1889, p. 341.)

Relation of Individual Spinal-cord Segments (Root Levels) to Spinous Processes.—A number of researches dealing with the problem are available. In general it may be said that in the cervical region of the vertebral column the ordinal numeral of the spinous

process is to be increased by one in order to give the ordinal numeral of the cervical nerve root arising at the level of that spinous process. In the region of the thoracic vertebræ two is to be added to the number of the spinous process in the upper half, while from the sixth to the eleventh thoracic vertebræ one must add three. The lower part of the spinous process of the eleventh thoracic vertebra and the interspace between this spine and the next lower corresponds to the origin of the third to the fifth lumbar roots; the spinous process of the twelfth thoracic vertebra and the interspace between it and the spinous process of the first lumbar vertebra correspond to the origin of the sacral roots. It is to be remembered that when the trunk is strongly flexed, the spinal cord with attached nerve roots is displaced a few millimeters upward.

The levels of the nerve roots differ somewhat in the child from those in the adult, as Chipault has pointed out. Thus in children under seven years of age we add three to the ordinal numeral for the spinous process in the region of the first four thoracic vertebræ to get the number of the nerve root of corresponding level; and in the region of the fifth to ninth thoracic vertebræ four must be added.

The lower level of the dural sac in the adult corresponds about to the level of the spinous process of the first sacral vertebra.

The topographical relations between the spinous processes and the roots of the spinal nerves are well shown in the accompanying figure copied from Reid (Fig. 4559).

Cauda Equina.—Exact measurements have been made in an eighteen-year-old individual of the distances between the root origins of the lumbar and sacral nerves and their foramina intervertebralia of exit by Testut. The distances measured are as follows:

N. lumbalis I.....	114 mm.	N. lumbalis V .	181 mm.
N. lumbalis II.....	138 mm.	N. sacralis I . .	188 mm.
N. lumbalis III.....	151 mm.	N. sacralis V . . .	280 mm.
N. lumbalis IV.....	163 mm.		

The filum terminale measures sixteen centimeters in length and extends from the third lumbar vertebra to the second coccygeal vertebra.

Length of Different Portions of the Cord.—Ravenel gives the following measurements:

	In the male.	In the female.
Pars cervicalis. .	9.9 cm.	9.6 cm.
Pars thoracalis . . .	26.2 cm.	22.9 cm.
Pars abdominalis .	5.1 cm.	5 7 cm.
Pars pelvina. . . .	3.6 cm.	3.1 cm.

The thirty-one segments corresponding to the thirty-one pairs of nerve roots have been carefully measured in six individuals by Lüderitz (for the figures his original article is referred to). The longest segment is found about the middle of the pars thoracalis and corresponds to the fifth, sixth, seventh, or eighth N. thoracalis. The shortest segment usually pertains to one of the lowermost Nn. sacrales. The difference in length of segments is dependent upon growth relations. The length of the segments increases steadily from the lower part of the sacral cord up to the middle of the pars thoracalis, the increase being at first slight, between the individual segments, but higher up it is greater. The length of the segments then diminishes until the lowermost portion of the pars cervicalis is reached. In the latter the segments measure about alike, though there are slight variations.

Weight of the Spinal Cord.—The spinal cord weighs on the average from 27 to 28 grams, with considerable individual variation. The weighings of Meckel are of interest. For the three months' fetus, 0.12 gram ($= \frac{1}{8}$ of brain weight); for the five months' fetus, 0.36 gram ($= \frac{1}{6\frac{1}{3}}$ of brain weight); for the nine months' fetus, 2.7 grams ($= \frac{1}{1\,0\frac{1}{7}}$ of brain weight); for a five months' child, 5.4 grams.

The relative weight of the human spinal cord compared with the body weight is as 1:1849.5 in the adult; in the new-born as 1:851.4. The relation of the human spinal cord weight to body weight in a whole series of animals is given in Ziehen. Keith has made many such measurements. Ziehen also gives a long table in which the relative weight of the spinal cord to the brain weight in animals is given. It is smallest in man and increases in the animal series steadily downward until fish are reached. In the adult human being the relation has been variously estimated from as 1:19 to as 1:51.13. The latest figures are those of Mies, who gives the relative weight of the cord to the brain as 1:49.80 in the female and 1:51.13 in the male.

Central Canal.—The spinal cord is a hollow tube, whose lumen in the early embryo is very wide. In later development the originally thin walls are thickened and the diameter of the lumen (now called *canalis centralis*) is greatly contracted (Figs. 4573 and 4574).

The central canal is very often invisible in the adult. Its lumen may vanish for considerable distances. It is stated that the central canal may remain open in perhaps ten per cent. of the cases throughout its whole length. Headward it is continuous with the central canal of the medulla oblongata (fourth ventricle), while caudalward it can be followed as far as the middle of the filum terminale, where it ends blindly.

The form of the canal is usually circular or elliptical; in the latter case the longer diameter is most often sagittal. In the intumescentia cervicalis it is a transverse ellipse, and in the intumescentia lumbalis a dorsoventral ellipse.

The gray matter about it has a gelatinous appearance (*substantia gelatinosa centralis*) and is rich in neuroglia and derivatives of ependymal cells.

In the lower part of the conus medullaris the central canal is expanded to form a terminal ventricle (*ventriculus terminalis*). The dorsal wall of this expansion is so thin that some have erroneously assumed that the cavity is open into the dorsal median sulcus.

The Coverings of the Cord (Meninges).—The spinal cord is surrounded in the vertebral canal by three membranes known as the spinal meninges; they are continuous above with the cerebral meninges. These three membranes are known as the *dura mater spinalis*, the *arachnoidea spinalis*, and the *pia mater spinalis*.

The dura mater is the strongest of the three and most external. The pia mater is the most delicate and the most internal, being applied everywhere closely to the cord. Between the two is the delicate non-vascular arachnoid. Between the dura mater and the inner surface of the bony vertebral canal is a cavity known as the epidural cavity (*cavum epidurale*). Between the dura mater and the arachnoid is a space called the subdural cavity (*cavum subdurale*). More important, however, is the space between the arachnoid and the pia mater. This is the subarachnoid cavity (*cavum subarachnoideale*); it contains the cerebrospinal fluid (*liquor cerebrospinalis*).

The spinal dura mater (*dura mater spinalis*) extends from the foramen magnum to the level of the second or third sacral vertebra. It differs from the dura mater of the brain in that it splits into two layers, the outer one becoming continuous with the periosteum and ligaments of the vertebral canal, and the inner one forming the dura mater spinalis proper. The latter layer is the one usually referred to when the spinal dura mater is spoken of, but it must be remembered that the outer layer must be added to it to make it homologous with the dura mater en-

cephali. In the space between the outer layer and the dura mater spinalis proper, that is in the cavum epidurale, there are fatty tissue and some plexuses of veins and lymph channels. The thickness of the dura mater spinalis in the adult averages 0.5 to 0.6 millimeter.

Some fibrous filaments from the anterior middle line of the dura run obliquely downward and ventralward to be inserted into the posterior longitudinal ligament of the spine. These are especially developed from the fourth lumbar vertebra downward, where they fuse to form a membrane, the so-called ventral sacrodural ligament (*ligamentum sacrodurale ventrale*).

The spinal dura mater forms a separate sheath for each of the two roots, the ventral root and the dorsal root, of each spinal nerve. These sheaths are continued upon the roots as far as the spinal ganglia, where they become lost in the connective tissue of the peripheral nerves and in the periosteum of the bones.

At its lower extremity the dura mater spinalis forms a sac which envelops the nerve roots of the cauda equina. This sac terminates at the level of the second or third sacral vertebra, but the dura mater is continued as a sheath closely applied to the filum terminale. This portion of it, a long, tough thread, called the filum duræ matris spinalis, is finally inserted upon the posterior surface of the os coccygis.

The dura mater spinalis is connected with the arachnoidea by means of the so-called subdural threads and with the pia mater by the denticulate ligaments (*ligamentum denticulatum*). The subdural threads are very fine and short, are connected with the outer surface of the arachnoidea, and usually carry blood-vessels. The ligamentum denticulatum is a membrane stretched out in a frontal or coronal plane between the dura mater and the pia mater, just midway between the ventral and dorsal surfaces of the cord; it passes between the ventral and dorsal roots of the spinal nerves. Its medial border is firmly attached to the pia mater. Its lateral border is toothed, the teeth being inserted at their summits into the dura mater midway between the exits of adjacent spinal nerves. Intermediate between the teeth the lateral edge of the membrane forms free arcades. The number of teeth varies from eighteen to twenty-three. In the cervical region the N. accessorius runs dorsally of the ligament.

The spinal arachnoid (*arachnoidea spinalis*) bounds the subdural cavity internally. It is to be noted that this is what is called by many anatomists the "visceral layer of the arachnoid;" below, it is reflected at the tip of the conus terminalis upon the dura mater to form the "parietal layer of the arachnoid" of various authors. This is why some writers call the cavum subdurale, situated between the parietal layer and the visceral layer of the arachnoid, the "arachnoid cavity." It is a serous cavity, like the pleura.

The arachnoid contains no blood-vessels; occasionally calcified plates are found in the membrane. The arachnoid is prolonged over the nerve roots, and over the summits of the teeth of the ligamentum denticulatum.

As a rule, it is very difficult to separate the arachnoid from the pia mater macroscopically. Key and Retzius describe the two together as the "meninx tenuis." These soft membranes, together, are also designated, the "leptomeninges," to distinguish them from the hard or tough membrane, the dura mater or "pachymeninx." If the visceral layer of the arachnoid be lifted carefully in the region of the cauda equina and cut through with fine scissors and then split longitudinally upward a little to one side of the median line, the space between the arachnoid and the pia mater, the subarachnoid cavity (*cavum subarachnoideale*), will be exposed. This space is not a free cavity, but really a communicating network of cavities, the walls of which are formed by delicate processes which extend between the arachnoidea and the pia mater. The meshes are filled with cerebrospinal fluid. It is this cavum subarachnoideale which is tapped in Quincke's lumbar puncture when the needle is introduced opposite the interspace between the third and fourth lumbar vertebræ.

The spinal pia mater (*pia mater spinalis*), a very delicate membrane, closely envelops the spinal cord. It sends a fold into the depth of the ventral median fissure and elsewhere is intimately adherent to the external surface of the cord. It is extremely rich in blood-vessels, for it is in this membrane that the arteries which supply the cord undergo multiple subdivision before penetrating into the substance of the cord. When the pia mater is pulled off the cord, a number of minute arteries and capillaries are always torn out of the white substance; many of these are so small, however, that they cannot be made out with the naked eye.

The Blood-vessels of the Spinal Cord (Fig. 4560).—The arterial supply of the spinal cord is derived from the vertebral arteries (*rami spinales Aa. vertebrales*), the ascending cervical arteries (*rami spinales Aa. cervicales ascendentes*), the dorsal rami of the intercostal arteries (*rami spinales Rr. dors. Aa. intercostales*), the dorsal rami of the lumbar arteries (*rami spinales Rr. dors. Aa. lumbales*), the iliolumbar arteries (*rami spinales Aa. iliolumbales*), and the lateral sacral arteries (*rami spinales Aa. sacrales laterales*).

Besides the rami spinales given off from the cervical portion of the A. vertebralis which pass through the foramina intervertebralia, each vertebral artery gives off a ventral spinal artery (*arteria spinalis ventralis*) (O. T., A. vertebrospinalis anterior), and a dorsal spinal artery (*A. spinalis dorsalis*) (O. T., A. vertebrospinalis posterior). The ventral spinal arteries of the two sides run medialward and caudalward and unite near the ventral median fissure somewhere between the foramen magnum and the level of the third cervical nerve. The trunk resulting from the fusion of the two, sometimes called the median anterior vertebrospinal artery (*A. vertebrospinalis ventralis mediana*), runs downward, unpaired on the ventral surface of the cord (not in the ventral median fissure), as far as the level of the fourth or fifth cervical nerve, where it ends by fusing with the *tractus arteriosus spinalis ventralis*, the unpaired ventral median trunk resulting from anastomoses between the various spinal rami which come to the cord at the levels of the nerve roots all the way down as far as the filum terminale.

The dorsal spinal artery given off by the vertebral artery is delicate, bends around the lateral margin of the medulla oblongata and runs downward near the nervus accessorius on each side. Having reached the level of the fourth or fifth cervical nerve, it fuses with the longitudinal trunk, known as the *tractus arteriosus dorsolateralis*. The latter is made up of ascending and descending branches of the spinal rami of the A. vertebralis, Aa. intercostales, lumbales, iliolumbales, and sacrales laterales.

Besides this tractus arteriosus dorsolateralis the dorsal spinal artery from the vertebral gives off segmental branches, the so-called penetrating arteries (*Aa. penetrantes*), which, passing medialward and joining with branches of the Aa. intercostales, give rise to another longitudinal trunk called the *tractus arteriosus spinalis dorsalis*. The latter does not run in the middle line, but runs lengthwise of the cord just behind the line of entrance of the dorsal roots. The tractus arteriosus dorsolateralis, on the other hand, runs ventral to and lateralward from the sulcus lateralis dorsalis or line of entrance of the dorsal roots.

The rami spinales of the rami dorsales of the Aa. intercostales, the rami spinales of the Aa. lumbales, the A. iliolumbalis, the A. sacralis lateralis, as well as of the A. cervicis ascendens all run through the inter-

vertebral foramina. On passing through the foramen, each ramus spinalis gives off two delicate branches, one to the ventral root (*R. radicina ventralis*), the other to the dorsal root (*A. radicina dorsalis*), and then, near the spinal ganglion, usually divides into two branches, one going to the front of the cord (*ramus spinalis ventralis*), the other going to the dorsolateral surface of the cord (*ramus spinalis dorsalis*). It is to be noted that there is not a ramus spinalis for every nerve-root level; and further, that sometimes when a ramus spinalis is present, it does not divide into two branches but becomes entirely a ventral ramus or a dorsal ramus, more often the latter. Thus, according to Kadyi, there are, as a rule, eight large rami spinales ventrales and as many as sixteen or seventeen rami spinales dorsales. Among the rami spinales ventrales there is usually one which is much larger than the others; this is sometimes called the *A. magna spinalis*, or *A. radicalis magna*. It may be either on the left side or on the right side, and is most often found in the lower thoracic region at the level of the ninth, tenth, or eleventh thoracic nerve. These ventral spinal rami run medialward as far as the fissura mediana ventralis, and there divide into an ascending and a descending ramus. These ascending and descending rami fuse with those of adjacent levels, thus helping to form the general *tractus arteriosus spinalis ventralis* of Kadyi, which lies in the epipial areolar tissue in the cavum subarachnoideale.

The dorsal spinal rami run also medialward to the surface of the cord, just in front of the line of entrance of the dorsal roots, and like the ventral spinal rami also divide into ascending and descending limbs, which, anastomosing with corresponding limbs of rami of adjacent levels, give rise to the longitudinal trunk known as the *tractus arteriosus dorsolateralis*. Other rami spinales dorsales run farther backward and medialward, pass between the dorsal roots of different levels, or among the fila radicularia of the dorsal roots to reach a position just medial from the sulcus lateralis dorsalis, where they divide into ascending and descending limbs, which contribute to another longitudinal anastomosis known as the *tractus arteriosus dorsalis*, to which the Aa. penetrantes from the A. spinalis dorsalis of the A. vertebralis has above been seen to contribute.

The tractus arteriosus dorsolateralis lies lateral from the dorsal root and outside the pia mater. The tractus arteriosus dorsalis lies medial from the dorsal root, but inside the pia mater. Between the tractus arteriosus dorsalis of one side and its fellow on the opposite side pass transverse anastomoses like the rungs of a rope ladder. These transverse rami are particularly noticeable opposite the cervical and lumbar enlargements.

About one-half a centimeter above the tip of the conus medullaris a large transverse anastomosing branch can be seen, connecting the tractus arteriosus dorsolateralis with the tractus arteriosus ventralis. The presence of this large branch, sometimes called the *ramus crucians*, explains why it is that fluid injected through the arteria spinalis magna may be distributed through the blood vascular network of the whole lower half of the cord on its dorsal surface.

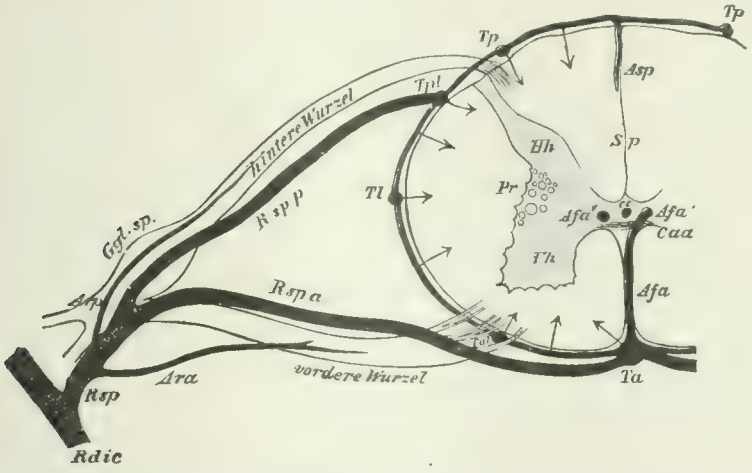

Fig. 4560.—Schematic Representation of the Arterial Vessels of a Segment of the Spinal Cord. For the sake of clearness the relative size relations of the vessels have been incorrectly drawn. *Afa*, Arteria fissuræ ventralis; *Afa'*, longitudinal central branch (ascending or descending) of *Afa*; *Afa''*, longitudinal central branch of the *Afa* next above or next below; *Ara*, arteria radicina ventralis; *Arp*, arteria radicina dorsalis; *Asp*, arteria septi mediana dorsalis; *Caa*, commissura ventralis alba; *Cc*, canalis centralis; *Ggl.sp.*, ganglion spinale; *Hh*, dorsal gray column; *Vh*, ventral gray column; *Pr*, processus reticularis; *Rdic*, rhombus dorsalis seu posterior arteriæ intercostalis; *Rsp*, ramus spinalis; *Rspa*, *Rspp*, ramus spinalis ventralis, dorsalis; *Sp*, septum medianum dorsale; *Ta*, *Tal*, *Tp*, *Tpl*, tractus arteriosus ventralis, ventrolateralis, lateralis, dorsalis, dorsolateralis; *hintere Wurzel*, dorsal root; *vordere Wurzel*, ventral root. (After T. Ziehen, in Bardeleben's "Handbuch der Anatomie des Menschen," Jena, 1899.)

The ventral spinal artery and the tractus arteriosus spinalis ventralis with which it is continuous give off two sets of branches. One set is central (*Aa. fissurales ventrales seu centrales*); the other set is lateral and peripheral (*rami laterales*).

The ventral fissural arteries (*Aa. fissurales ventrales seu centrales*), 200 to 269 in number, pass into the depth of the ventral median fissure and divide into two branches, one of the latter passing to the right, the other to the left. These branches go through the commissura ventralis alba to the gray substance. They are known as the sulcocommissural arteries (*Aa. sulcocommissurales*). They often divide into ascending and descending branches which supply the whole of the gray matter of both the ventral and dorsal gray columns, with the exception of the most peripheral part of the gray substance next to the white matter. The special branches going to the nucleus dorsalis are called the *arteriolæ columnarum Clarkii*.

The rami laterales go to the ventral roots and anastomose with the Aa. radicinæ ventrales; sometimes they form a longitudinal anastomotic chain called the *tractus arteriosus ventrolateralis*. Other branches run backward to meet branches running forward from the tractus arteriosus *dorsolateralis* and to form a lateral longitudinal anastomosis known as the *tractus arteriosus lateralis*.

The whole of the white matter and the most peripheral part of the gray matter get their blood supply from branches penetrating the cord from the tractus arteriosus ventrolateralis, tractus lateralis, tractus dorsolateralis, tractus dorsalis, and the Aa. radicinæ ventrales et dorsales. All these vessels have been grouped together by Adamkiewicz, under the name vasocorona.

From the transverse anastomoses between the tractus arteriosi dorsales of the two sides, certain unpaired dorsal sulcal arteries (Aa. sulcales dorsales) penetrate into the cord in the region of the sulcus medianus dorsalis. These are much branched and supply the white substance, but scarcely go so deep as the dorsal commissure. Branches from them may, however, reach the dorsal gray column or the nucleus dorsalis, and help to contribute to the blood supply of those parts. Minute vessels, entering the white

substance between the fasciculus gracilis (Golli) and the fasciculus cuneatus (Burdachi), tolerably constant in the upper portions of the cord, have been called the interfunicular arteries (*Aa. interfuniculares*). The branches of the Aa. radicinæ dorsales et ventrales which reach the interior of the cord are small, but they play some part in the vascularization of the ventral and dorsal gray columns.

The arteries supplying the spinal cord are *end arteries* in the sense of Cohnheim. This is true of all the branches going in from the vasocorona as well as of the branches of the Aa. sulcales ventrales et dorsales. This explains the possibility of minute infarctions in the spinal cord. Despite the manifold longitudinal anastomoses throughout the whole length of the cord between the arteries of all levels, the cutting off of the blood supply through the lumbar and sacral vessels leads irrevocably to the death of the gray matter of the lower part of the cord, as has been over and again demonstrated by the experiment in which the abdominal aorta is compressed for half an hour.

The capillaries of the cord empty into the veins which form a network in the pia. Out of this network several large veins become differentiated, and these have been given special names. Thus, on the ventral surface of the cord are found: (1) *V. spinalis mediana ventralis;* (2) *V. spinalis lateralis ventralis dextra;* (3) *V. spinalis lateralis ventralis sinistra.* On the dorsal surface of the cord a median and two lateral veins can also be made out: (1) *V. spinalis mediana dorsalis;* (2) *V. spinalis lateralis dorsalis dextra;* and (3) *V. spinalis lateralis dorsalis sinistra.*

All these veins are devoid of valves. They empty through the *Vv. spinales ventrales et dorsales* largely into the *plexus venosi vertebrales interni,* and partly through the *Vv. intercostales* into the *V. azygos.* Some of the veins pass by way of the *Vv. lumbales* into the V. cava inferior. Other veins go by way of the *V. iliolumbalis* and the *Vv. sacrales laterales* into the V. hypogastrica, and so through the V. iliaca communis into the V. cava inferior.

The veins from the gray matter empty largely through the *Vv. fissurales ventrales* into the V. spinalis mediana ventralis.

Fissures, Sulci, and Funiculi.—The external surface of the spinal cord is not perfectly smooth. There is a deep longitudinal groove on the ventral or anterior surface, the ventral median fissure (*fissura mediana ventralis*). In the median line on the dorsal or posterior surface there is no such deep groove, but only a shallow sulcus called the dorsal median sulcus (*sulcus medianus dorsalis*). The ventral spinal roots leave the spinal cord along a longitudinal area situated a little lateralward from the ventral median fissure; though there is in reality very little if any depression on the surface at the points of exit of the ventral rootlets, a shallow groove has been described here and designated the ventral lateral sulcus (*sulcus lateralis ventralis*). More dorsally, a few millimeters laterally of the dorsal median sulcus on each side and corresponding to the line of attachment of the dorsal rootlets, there is a distinct groove called the dorsal lateral sulcus (*sulcus lateralis dorsalis*).

These longitudinal sulci, running the whole length of the cord, subdivide its surface into strands which are known as *funiculi.* Of these funiculi, there are three for each half of the cord. Thus, between the ventral median fissure and the ventral lateral sulcus is situated the ventral funiculus (*funiculus ventralis*); between the ventral lateral sulcus and the dorsal lateral sulcus of the same half of the cord is situated the lateral funiculus (*funiculus lateralis*); and, finally, between the dorsal lateral sulcus and the dorsal median sulcus is situated the dorsal funiculus (*funiculus dorsalis*). In the upper part of the spinal cord the dorsal funiculus on each side is further subdivided by an additional sulcus known as the dorsal intermediary sulcus (*sulcus intermedius dorsalis*). The lateral portion of the dorsal funiculus included between the dorsal lateral sulcus and the dorsal intermediary sulcus is known as the wedge-shaped fasciculus (*fasciculus cuneatus*). The medial portion, situated between the dorsal intermediary sulcus and the dorsal median sulcus, is known as the slender fasciculus (*fasciculus gracilis*).

The Spinal Nerves.—Besides the fila radicularia of the dorsal and ventral roots of the spinal nerves, there can be made out in the uppermost part of the spinal cord a few fila radicularia coming off from the lateral surface between the ventral and dorsal lateral sulci; these unite to form on each side a nerve trunk which passes upward in the vertebral canal to enter the cranial cavity through the foramen magnum. These fila radicularia belong to the so-called accessory nerve (*N. accessorius*) or eleventh cerebral nerve.

Since the time of Sir Charles Bell, it has been customary to speak of the anterior or ventral roots as *motor roots,* of the posterior or dorsal roots as *sensory roots,* and of the spinal nerves resulting from the fusion of anterior and posterior roots as the *mixed nerve trunks* (see article *Cranial Nerves,* vol. iii., p. 321).

The mixed nerve trunk leaves the vertebral canal through the corresponding intervertebral foramen (*foramen intervertebrale*). In some parts of the cord the corresponding intervertebral foramen lies in a horizontal direction from the fila radicularia of the nerve, but in other parts of the cord, owing to greater rapidity of growth at certain periods of development of the bony vertebral canal than of the spinal cord itself, the intervertebral foramina are situated at much lower levels than are the fila radicularia of the corresponding spinal nerves. The result is that certain of the spinal nerves follow a more or less markedly oblique course between the cord and the intervertebral foramina. When this course is very oblique a considerable extent of the spinal nerve may be included within the cavity of the vertebral canal. Particularly striking is the obliquity of course and long intravertebral extent of the lumbar and sacral nerves. Indeed, some of the latter follow almost a vertical course, enveloping the conus medullaris and the filum terminale as a great bundle of nerves known as the horse's tail (*cauda equina,* Fig. 4557).

There are thirty-one pairs of spinal nerves, connected with the spinal cord. The spinal nerves are named according to their exit from the vertebral canal. The uppermost spinal nerve leaves the vertebral canal between the atlas and the os occipitale. All other spinal nerves come out through the intervertebral foramina between adjacent vertebræ, the lowermost one making its exit through the opening between the first and second portions of the os coccygis. It is customary then to divide the spinal nerves into cervical nerves (*Nn. cervicales*), thoracic nerves (*Nn. thoracales*), lumbar nerves (*Nn. lumbales,*) sacral nerves (*Nn. sacrales*), and coccygeal nerve (*N. coccygeus*). There are eight cervical nerves, twelve thoracic nerves, five lumbar nerves, five sacral nerves, and one coccygeal nerve. The portion of the spinal cord connected with the cervical nerves is known as the cervical part (*pars cervicalis*). The portion of the cord connected with the thoracic nerves is known as the thoracic part (*pars thoracalis*). The portion of the cord connected with the lumbar and upper sacral nerves is known as the lumbar part (*pars lumbalis*). That portion of the cord which is below the pars lumbalis is called the conus medullaris. The pars cervicalis includes the intumescentia cervicalis; the pars lumbalis includes the intumescentia lumbalis.

The Spinal Nerve Roots.—The ventral roots are composed entirely, or nearly so, of myelinated fibers which are axones of the neurones of the ventral gray column of the same side of the cord. They are exclusively efferent in function, and in general are of larger caliber than those of the dorsal roots.

Accurate counts of all of the myelinated fibers in the ventral and dorsal roots of a man of middle age weighing 180 pounds have been made by Ingbert. In brief he has found:

1. The total area of the cross-sections of the dorsal roots of the left spinal nerves of a large man is 54.93 square millimeters.

2. The total number of myelinated nerve fibers in the dorsal roots of the left spinal nerves of the same man is 653,627.

3. There are on the average 11,900 myelinated nerve fibers to every square millimeter of the cross-sections of the dorsal roots of man.

4. There is a close relation between the areas of the cross-sections of the dorsal roots and the number of nerve fibers which they contain (see Fig. 4561).

5. The small fascicles of a dorsal spinal root in general contain nerve fibers of small caliber.

6. The number of nerve fibers per square millimeter of the cross-section may vary considerably in the different fascicles of the same dorsal spinal root.

7. About seventy-nine per cent. of the myelinated nerve fibers in the dorsal spinal roots go to innervate the dermal surface; and about twenty-one per cent. are sensory fibers distributed to muscles and other deep tissues. The afferent fibers of spinal ganglion origin passing in the rami communicantes are not separately considered in this estimate, but are classed with those passing to the deeper tissues.

8. One cutaneous nerve fiber in the dorsal spinal roots innervates on the average 1.08 square millimeters of the skin of the head and neck, 1.30 square millimeters of the skin of the arm, 2.45 square millimeters of the skin of the leg, 3.15 square millimeters of the skin of the trunk, and 2.05 square millimeters of the skin of the entire body. These estimates are based upon the assumption that all functional types of fibers distribute as a single class; for each additional class of fibers assumed to have an independent distribution we must increase the area proportionately.

9. The total area of the cross-sections of the ventral roots of the left spinal nerves of the same man is 26.50 square millimeters.

10. The ratio of the total areas of the ventral and dorsal roots is 1:2.07.

11. In the dorsal roots the areas of the cross-sections is predominantly a function of the number of fibers, while in the ventral roots the area of the cross-section of the roots is chiefly a function of the size of the fibers.

12. The total number of the myelinated fibers in the ventral roots of the left spinal nerves is 203,700.

13. The ratio of the number of fibers in the ventral and dorsal roots is 1:3.2.

14. The ratio between the number of fibers in the ventral and dorsal roots of man is 1:3.2 (Ingbert); of the white rat, 1:2.3 (Hatai); and of the frog, 1:1.2 (Birge). From this we may conclude that probably the relative sensory supply increases as we ascend in the zoological series.

Some of the preceding data are summarized in the accompanying curves (Fig. 4561). It should be borne in mind that these enumerations include the myelinated fibers only and that in the dorsal roots there are probably more unmyelinated than myelinated fibers (Ranson).

The Spinal Ganglia.—The spinal ganglia contain the cell bodies of all afferent fibers which enter the spinal cord. The axones of these cells comprise the dorsal spinal roots. In birds and some other vertebrates efferent fibers (probably of visceral type), arising within the spinal cord, go out by way of the dorsal roots as well as by the ventral roots. The presence of such fibers in mammals is in controversy and their function is unknown, for physiological experiments have yielded no evidence of their presence.

The spinal ganglion is very complex with many different forms and sizes of cells. Its structure suggests that it might well serve as a correlation center for some types of reflexes, especially of the visceral systems, but as yet no physiological evidence of such functions has been adduced. Its neurone bodies certainly serve as the trophic centers for the fibers of the peripheral sensory nerves.

It has long been known that the number of neurone bodies in each spinal ganglion is more than twice as great as the number of myelinated afferent fibers entering the ganglion from the peripheral nerve. Moreover, the spinal ganglion cells are of two sorts, large and small, and the latter are the more numerous. Ranson has shown that more than half of the afferent fibers of the peripheral nerves related to the spinal ganglia are unmyelinated and that these latter fibers are the axones of the small cells of the spinal ganglia.

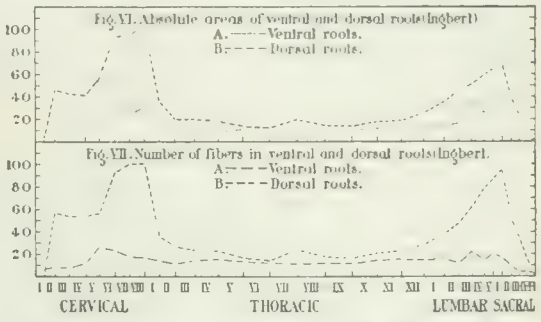

FIG. 4561.—Curves Showing (Fig. VI) the Absolute Areas of the Cross-section of the Ventral and Dorsal Roots of the Left Spinal Nerves; each sq. mm. is represented by 20 divisions on the axis of ordinates; (Fig. VII) the number of myelinated nerve fibers in the ventral and dorsal roots of the left spinal nerves; each 1,000 nerve fibers represented by 2 units on the axis of ordinates. (Ingbert, Journ. Comparative Neurology.)

These unmyelinated fibers have been neglected in all previous statistical work on the spinal nerves.

The most generalized form of adult spinal ganglion cell has an oval body, from which arises a single stout process which is intricately coiled and while still within the ganglion divides into centrally and peripherally directed processes which enter the dorsal root and the peripheral nerve respectively. The variations of this form are innumerable, some of which are seen in Fig. 4562.

A few neurones of the spinal ganglion retain the embryonic bipolar form (Fig. 4562, 8). Some also show the generalized unipolar form described in the last paragraph (Fig. 4562, 1), though this is not the most numerous type. Many of these neurones give off collateral branches which terminate within the ganglion, around the body of either the cell of origin (Fig. 4562, 2) or of some other cell (Fig. 4562, 3), or the collateral branch may end free in the connective tissue within the ganglion (Fig. 4562, 3). Some of these collaterals end by specially elaborated terminal skeins which resemble the cutaneous sense organs of touch. These are especially numerous about the periphery of the ganglion and in the dorsal root. There are also unipolar cells whose single process divides T-form, but the peripheral division does not leave the ganglion (Fig. 4562, 7). These intraganglionic endings may take various forms resembling sense organs, as in the last case, and Dogiel is of the opinion that they are really sense organs and that the ganglion is therefore sensitive to pressure or other stimuli. In other cases the process of the unipolar cell may divide and reunite several times (Fig. 4562, 4), or several processes may arise from the cell body and then unite into a single fiber (Fig. 4562, 5). Other cells are truly multipolar Fig.

4562, 9). Many variations of these forms have been described by Dogiel, Ramón y Cajal, and others.

Most of the neurones of the spinal ganglion belong to the somatic sensory system for either cutaneous or deep sensibility; but some of them are known to send their peripheral processes into the sympathetic nerves through the communicating branches. Moreover practically all of the cell bodies of the neurones of the spinal ganglion are said by Dogiel to be enveloped by a mesh of very fine unmyelinated fibers which enter the ganglion through the communicating branches from the sympathetic system, thus putting the entire visceral apparatus into the most intimate functional relation with the somatic sensory neurones of the spinal nerves (Fig. 4562, 1, 2, 3). The details of this sympathetic influence upon the somatic sensory neurones have never been worked out physiologically; but it is evidently of the utmost importance. This arrangement is probably one of the factors in the complicated clinical phenomena of referred pains. Visceral stimuli are known to exert a profound effect upon the subconscious as well as upon the conscious life, and much of that which we call temperament, mood, etc., may perhaps be traced in part to this factor.

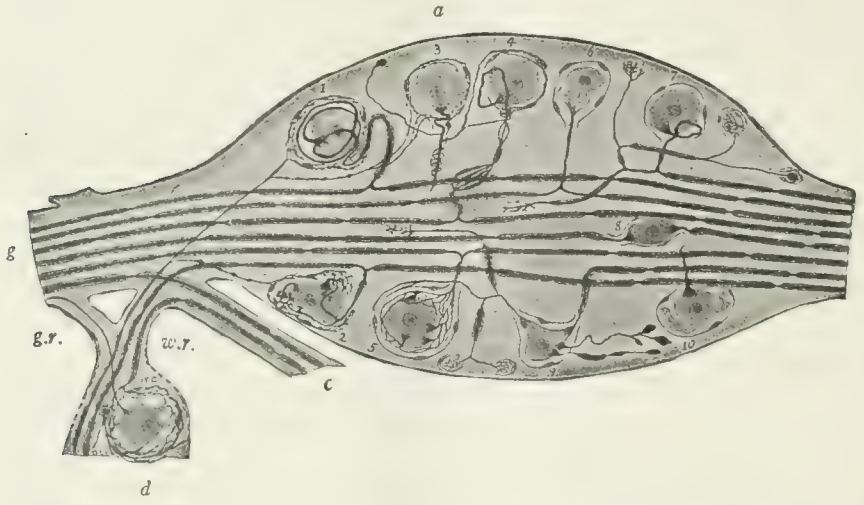

Fig. 4562.—Various Types of Neurones and Nerve Terminations found in a Spinal Ganglion. *a*, Spinal ganglion; *b*, dorsal root; *c*, ventral root; *d*, sympathetic ganglion; *g*, spinal nerve; *g.r.*, gray ramus communicans; *sy.c.*, neurone of sympathetic ganglion; *w.r.*, white ramus communicans. (Schematized from Dogiel, from Bailey's Histology.)

Topographical Relations of Gray Matter and White Matter.—If the spinal cord be cut through at different levels, it will be seen to contain a central canal (*canalis centralis*) and to be made up of gray matter (*substantia grisea*) and white matter (*substantia alba*). In general, the white matter is outside and the gray matter inside, and the latter in a transverse section assumes more or less the shape of the letter H; but the relations which exist between the white matter and the gray matter vary somewhat at different levels of the spinal cord.

A most valuable contribution to our knowledge of the details of these relations is to be found in Bruce's "Atlas of the Human Spinal Cord." It includes photographs of transverse sections through every segment of the cord. It is of the greatest convenience in helping to localize the origin of transverse sections of the human cord of unknown level.

Exact measurements of the surface amounts of the white and gray substances at different levels of the cord have been made by Stilling, who even went so far as to measure the surface areas of the individual funiculi at nearly all levels of the cord. Stilling's book on the spinal cord is a mine of valuable statistics.

In Stilling's book (1859) there are data concerning the areas of white and gray substance in cross-sections of the spinal cord of a child of five years, and these data were later used by Woroschiloff (1874) for the construction of curves. His curves are those at present employed in most text-books, too often without any accompanying statement to show that they are based on the measurement from an immature cord. Another point to be borne in mind in dealing with curves representing the true relations between the gray and the white matter is this, that the segments of the cord should be represented in their true length. The curves worked out by Krause and Aguerre would have been more valuable had they paid attention to the lengths of the segments.

Donaldson and Davis have constructed curves in which not only the area of the entire section, but also those of the white matter and the gray matter separately are represented, and in which the age of the individual and the true lengths of the individual segments of the spinal cord have been regarded. The accompanying charts make clear at a glance the results obtained (Fig. 4563). Donaldson and Davis find that the form of the cord from one to five years is nearly like that of maturity, the difference being that in the mature cord the relative enlargement of the areas of the cross-sections has become greater in the thoracic region, but less in the sacral and coccygeal. At maturity the relative enlargement of the two intumescentiæ is practically the same as at the fifth year. From the fifth year to maturity both the length and the weight of the entire cord, as well as the area of the cross-sections at the level of the several segments, are increased. The sum of the areas of the white substance at maturity is ninety-eight per cent. greater than at five years, and that of the gray substance twenty-three per cent. greater. This absolute increase must represent either enlargement of elements already completely developed or the development of elements still immature at the earlier age, or some combination of both these processes. Yet the failure of the intumescentiæ to increase in their relative area in the mature cord or in their proportional length would seem to indicate that during this period there was no increase in their relative complexity, a result which, to say the least, was unexpected.

The White Matter of the Spinal Cord.—The white matter of the ventral and lateral funiculi of the spinal cord shows in normal specimens no clearly marked subdivisions; but in the dorsal funiculus there is, as has already been mentioned, a dorsal intermediate sulcus or a connective-tissue septum (dorsal paramedian septum) marking the position of this sulcus, which separates the median fasciculus gracilis from the more lateral fasciculus cuneatus. These fasciculi are made up chiefly, though not exclusively, of the central courses of fibers of the dorsal roots, which are so arranged that those from the sacral parts of the cord lie nearest the dorsal median sulcus and those from higher levels are successively added laterally of these, an arrangement which is diagrammatically indicated in Fig. 4592.

There is considerable confusion in the terminology employed in the analysis of the spinal white matter, and the usage which follows differs in some respects from most of the current descriptions, no two of which

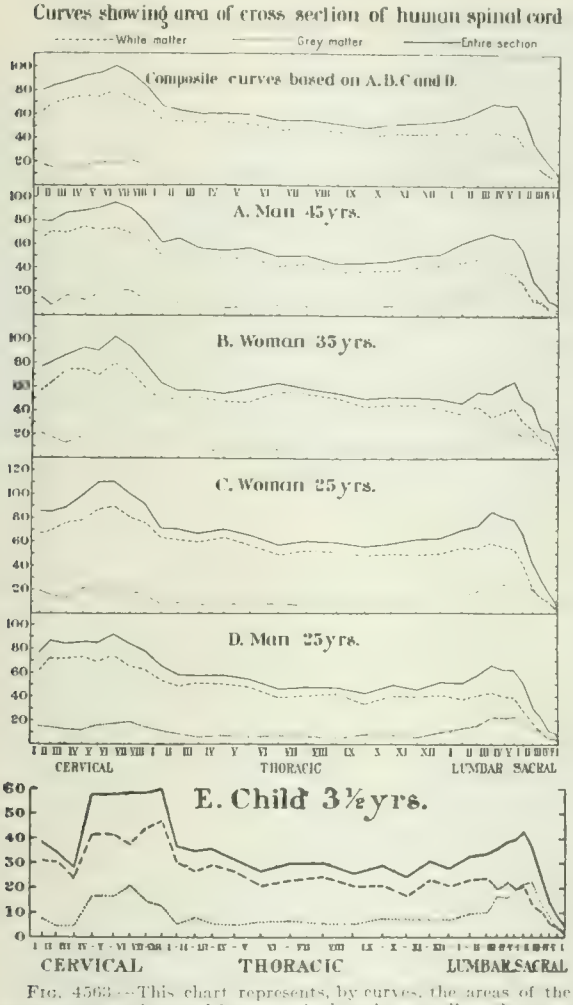

FIG. 4563.—This chart represents, by curves, the areas of the cross-sections of several human spinal cords, as well as the areas of the gray and white substances as they appear in each section. The base line in all the charts represents the length of the spinal cord for which it stands, and is divided into lengths proportional to those of the spinal-cord segments of which it is composed. On the ordinates one linear millimeter corresponds to one square millimeter of area. In all cases the measurement of the area was made at the caudal end of the segment. In the order from above downward, the curves are as follows:

Composite Curve—Based on *A*, *B*, *C*, and *D*, to give the average of the several areas in the curves named. The curves are generalized and apply to a cord of medium length—44.6 centimeters long. The influence of sex is neglected. The average age of the four cases would be thirty-three years. *Curve A*, Man of forty-five years; data for areas from Stilling. *Curve B*, Woman of thirty-five years; data for areas from Stilling. *Curve C*, Woman of twenty-five years; data for areas from Stilling. *Curve D*, Man of twenty-five years; data for areas from Stilling. *Curve E*, Child—data for areas from Stilling's observations on the cord of the two-year-old child. Length of segments from Lüderitz's observations on the cord of a three-and-a-half-year-old girl. Cord rather short. (After Donaldson and Davis.)

agree among themselves. As already stated, the white matter of each half of the cord is divided topographically by the emerging spinal nerve roots into three funiculi.

Each funiculus may be divided in a purely topographic sense into fasciculi, or collections of nerve fibers which occupy the same general region in the cross-section of the cord, such as the fasciculus gracilis of Goll and the fasciculus cuneatus of Burdach (which have already been mentioned as making up the greater part of the dorsal funiculus—see Fig. 4592) and the superficial ventrolateral fasciculus of Gowers (including among other tracts the spinal lemniscus and the ventral spinocerebellar tract of Fig. 4587). These fasciculi are usually mixed bundles containing tracts of diverse functional types. Neurologists formerly spoke of both funiculi and fasciculi as columns; but recent usage limits the use of the word column to the gray matter.

The nerve fibers of the white matter which lie nearest to the gray matter are for the most part relatively short and serve to connect various levels of the cord for the coordination of intrinsic spinal reflexes. These fibers in the aggregate are termed the *fasciculus proprius* (often called fundamental columns or ground bundles), and are separated into three divisions belonging in the several funiculi, viz., the fasciculus proprius ventralis, dorsalis, and lateralis. The more superficially placed fibers in general run longer courses and many of them connect the spinal cord with higher levels in the brain. The fasciculus proprius ventralis contains long fibers descending from the brain for motor coordination. In the medulla oblongata and midbrain these fibers form a compact bundle in the floor of the ventricle near the midplane known as the fasciculus longitudinalis medialis (old term fasciculus longitudinalis posterior, or posterior longitudinal bundle). In lower vertebrates many of the fibers of this system are of very large size (fibers of Müller), and in teleosts two of them attain to colossal size. These are the fibers of Mauthner, each of which arises from a giant cell in the medulla oblongata near the entrance of the vestibular root of the eighth nerve (see Bartlemez, 1915).

The number of myelinated fibers in various regions of the spinal cord has been estimated by Ziehen as given in the accompanying table.

Segments.	Ventral funiculus.	Lateral funiculus.	Dorsal funiculus.
Intumescentia cervicalis.	46,000	275,000	174,000
Midthoracic region.	28,000	240,000	75,000
Intumescentia lumbalis.	42,000	260,000	85,000

The fibers of the ventral roots of the spinal nerves are all or nearly all myelinated; those of the dorsal roots contain myelinated and unmyelinated fibers, the latter in larger numbers (Ranson). The unmyelinated fibers for the most part enter the fasciculus dorsolateralis (Lissauer's bundle). This fasciculus has recently been shown by Ranson to be of mixed character, containing in the cat a lateral part of both myelinated and unmyelinated endogenous fibers probably belonging to the fasciculus proprius system and a medial part, also of myelinated and unmyelinated fibers which are derived from the contiguous dorsal roots. In the latter group the unmyelinated fibers predominate and Ranson is of the opinion that these fibers terminate in relation with the neurones of the gelatinous substance of Rolando of the dorsal gray column.

Most of the myelinated fibers of the dorsal roots enter the dorsal funiculus (fasciculus gracilis from the lower levels of the cord and fasciculus cuneatus from the upper levels (see Fig. 4592), within which they course for longer or shorter distances. These fibers divide into ascending and descending branches, the descending branches passing downward for only a few segments, while the ascending branches may

extend for the entire distance from the point of entrance to the upper end of the cord (Figs. 4582 and 4591).

The true units of the spinal white matter are the *tracts, i.e.* collections of nerve fibers of similar functional type and connections. These tracts by some neurologists are termed fasciculi, and, like the other tracts of the central nervous system, they are in general named in accordance with the terminal relations of their fibers, the name of the location of their cells of origin preceding that of their place of discharge in a hyphenated compound word. Thus, the tractus rubro-spinalis arises from cells of the nucleus ruber of the midbrain and terminates in the spinal cord, and the tractus spino-cerebellaris arises in the spinal cord and terminates in the cerebellum. But, as already stated, there is no uniformity in the nomenclature of these tracts and no two authorities agree exactly in the terminology adopted. Moreover, few of the tracts have clearly defined anatomical limits, in most cases the fibers of different systems being more or less mingled.

The Gray Matter of the Spinal Cord.—The gray matter of the spinal cord, when examined in cross-section, is seen on each side to consist of a slender dorsal horn and a more massive ventral horn. When the third dimension is considered these represent longitudinal gray columns (*columna dorsalis grisea* and *columna ventralis grisea*), between which is an imperfectly separable intermediate zone and in some parts of the cord a distinct lateral column (*columna lateralis grisea*) (see Figs. 4565, 4566, and 4567). The dorsal column shows a constriction at its base, the neck of the dorsal column (*cervix columnæ dorsalis*). Near the tip (*apex*) of the dorsal column is an expanded mass of unusually transparent gray matter, the gelatinous substance of Rolando (*substantia gelatinosa Rolandi*). The dorsal column is separated from the surface of the cord by a strand of pale fibers, the fasciculus dorsolateralis or Lissauer's bundle. The ventral gray column is separated from the surface by wide masses of fibers of the ventral and lateral funiculi. In the angle between the dorsal and lateral gray columns is a network of white fibers and gray matter known as the reticular formation (*formatio reticularis*). Some of this tissue is found throughout the length of the cord, though it is more extensive in the cervical cord than elsewhere, where it is termed the *processus reticularis* (Fig. 4566).

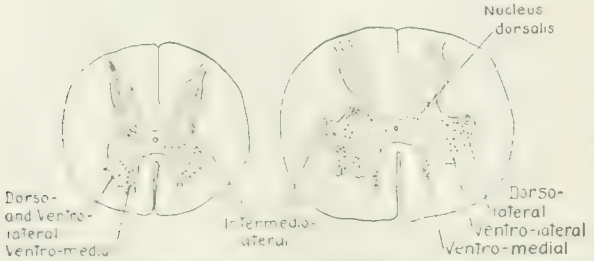

Fig. 4564.—Cross-sections through the Eighth Cervical Segment of Two Spinal Cords from New-born Infants, to illustrate the groupings of the neurones of the ventral gray columns in a normal child (on the right) and in a child in which both arms were entirely lacking (on the left). In the armless infant (abrachius) the ventromedial group is the same as in the normal, but the ventrolateral and dorsolateral groups are greatly reduced. (After Curtis and Helmholz.)

The nerve cells of the *dorsal gray column* are in general smaller than those in the ventral column. The gelatinous substance of Rolando contains an enormous number of very small nerve cells and very few neuroglia cells. Ranson is of the opinion that these cells are related to the unmyelinated fibers of the dorsal roots. The destination of their axones is unknown. Immediately internal to the gelatinous substance in the *caput* or head of the dorsal column is a region containing numerous myelinated fibers and scattered neurones of medium and small size (Figs. 4565 and 4566). The cells of this region (possibly including also those of the gelatinous substance) appear to serve as the second neurones in the conduction pathway for sensory impulses of touch, temperature, and pain and to send their axones into the ascending spinothalamic tracts of the opposite side of the spinal cord which in this article are called the spinal lemniscus (see Fig. 4587). The cells of the *cervix* or neck of the dorsal column, of the intermediate zone, and of the adjacent reticular formation are concerned chiefly with the intrinsic reflex connections of the spinal cord itself (see Figs. 4581 and 4583).

The nerve cells of the *ventral gray column* are for the most part large and the axones of these neurones form the ventral root fibers of the spinal nerves. They are arranged in groups which form longer or shorter subsidiary columns or nuclei, which are related to functional groups of muscles. Perfect agreement has not yet been reached regarding the exact pattern of this functional localization of the muscles. The anatomical arrangement is given with all desired fulness in Bruce's Atlas of the Spinal Cord, and in a later paper on the Intermediolateral Tract. In the latter work Bruce has shown that the neurones of the intermediolateral column, which in the thoracic and upper lumbar regions border the lateral column but do not form a part of it, are probably the cells of origin of the efferent preganglionic fibers which enter the sympathetic nervous system through the communicating branches (Fig. 4579).

The neurones of the ventral column proper are arranged in a ventromedial group, which runs the entire length of the cord with but small variations in size, and a number of lateral groups whose relations are very diverse in different regions. These lateral groups are greatly strengthened in the cervical and lumbar enlargements, and it is now commonly believed that they give rise to the motor fibers for the muscles of the limbs. This conclusion, so far as the innervation of the arms is concerned, has been strengthened by a case, recently reported by Curtis and Helmholz, who examined the spinal cord of an infant born without arms. Upon comparing a cross-section through the cervical enlargement of this spinal cord with that of a normal stillborn infant (Fig. 4564), it is evident that in the armless child the lateral groups of ventral column cells are greatly reduced in number, while the ventromedial groups are undiminished.

Sections of the Spinal Cord.—We shall next examine the appearances of transverse sections through the spinal cord at selected levels. A section through the middle of the cervical portion of the cord is illustrated in Fig. 4565. The ventral median fissure is broad and deep and contains a fold of pia mater containing blood-vessels. The dorsal median sulcus is deeper but not so broad; it contains no fold of pia mater and is in fact not a true fissure but is formed during embryological development by the coalescence of the lateral walls of the primitive neural tube, thus occluding the dorsal portion of its cavity.

The only nervous connection between the two halves of the cord is a narrow transverse band of nervous substance called the commissure. The ventral third of this commissure is composed of white matter and the dorsal two-thirds of gray matter In the middle of the gray commissure is the central canal (*canalis centralis*) of the spinal cord, lined by ependymal cells. The central canal divides the commissure into a ventral part (*commissura ventralis*) and a dorsal part (*commissura dorsalis*). The ventral commissure consists of white matter in front and gray matter behind. The dorsal commissure consists chiefly of gray matter, though some white fibers run through it. The dorsal median septum extends inward as far as the dorsal commissure, and the ventral median fissure likewise extends inward to the ventral white commissure.

Figure 4566 illustrates a cross-section through the cervical enlargement at the level of the sixth cervical segment. There is a notable increase in the size of the cord and a change of the gray matter. Both the dorsal and the ventral gray columns are considerably enlarged, and the ventral column has fused with the lateral column so that the latter does not appear at this level as a distinct column. The lateral diameter of the cord is increased much more than the vertical. The subdivision of the dorsal funiculus into fasciculus gracilis and fasciculus cuneatus is more evident here than at the higher level.

At the *level of the third thoracic nerve* (Fig. 4567) the size of the cord has become much reduced, and the vertical diameter is now much more nearly equal to that of the transverse diameter. The gray matter is present in much smaller amount, the ventral column has been greatly reduced in size, the lateral column is small, and the dorsal column slender and long. On the medial side of the dorsal column, just in front of its neck in the angle formed by it with the gray commissure, there is an expansion of the gray matter which was not visible in the two sections previously examined. This mass of gray matter

Fig. 4565.—Transverse Section, through the Fourth Cervical Segment of the Human Spinal Cord, the white matter colored dark by Weigert's myelin-sheath stain. (After A. Bruce, "Topographical Atlas of the Spinal Cord," Edinburgh, 1901.)

Fig. 4566.—Transverse Section through the Sixth Cervical Segment of the Human Spinal Cord. Weigert myelin-sheath stain. (After A. Bruce, "A Topographical Atlas of the Spinal Cord," Edinburgh, 1901.)

contains large cells and is known as the dorsal nucleus of Clarke (*nucleus dorsalis* [*Clarkii*]). It is sometimes known as the column of Clarke or of Stilling. It is present on each side for a long distance in the cord; thus it extends throughout the whole thoracic part of the spinal cord and into the pars cervicalis as far as the level of the eighth or seventh cervical nerve; below, it extends into the pars lumbalis as far as the first or second lumbar nerve. The beginner will find in it a useful landmark for the recognition of sections derived from the pars thoracalis.

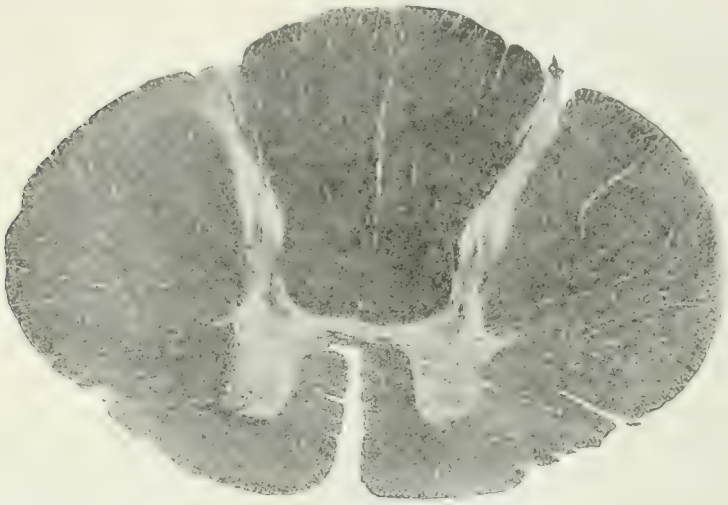

FIG. 4567.—Transverse Section through the Third Thoracic Segment of the Human Spinal Cord. Weigert's myelin stain. (After A. Bruce, "A Topographical Atlas of the Spinal Cord," Edinburgh, 1901.)

Sections of the thoracic cord below the eighth thoracic nerve show no marked alterations in the disposition of the white and gray matter until the lumbar enlargement (*intumescentia lumbalis*) is approached. Then the whole cord grows larger, both the gray matter and the white matter increasing in amount, the gray matter, however, to a greater extent than the white matter.

The relations at the *level of the fifth lumbar nerve* are well shown in Fig. 4568. The ventral and lateral columns of gray matter are again fused and form a much expanded mass in the ventral part of the cord. The dorsal column is enlarged to a greater extent here than in any other part of the cord. The enlargement involves especially its medial surface, with the result that the volume of the dorsal funiculus of the white matter is relatively small. Indeed, a striking feature of cross-sections through the lumbar enlargement is the thinness of the white envelope and the marked expansion of the gray matter. In the latter the substantia gelatinosa (Rolandi) is especially prominent.

In the parts of the cord below the lumbar enlargement this disproportion between the volume of the gray matter and that of the white matter increases. A transverse section at the *level of the third sacral nerve* (Fig. 4569) shows this distinctly, and it is even more marked in a transverse section through the lower part of the conus medullaris at the *level of origin of the N. coccygeus* (Fig. 4570). Here the terminal mass of gray matter is surrounded by only a thin film of white matter. The filum terminale is so atrophic that sections of it reveal only the central canal, lined by ependymal epithelium and surrounded by a thin layer of gray substance, and outside of all the filum duræ matris spinalis.

FIG. 4568.—Transverse Section through the Fifth Lumbar Segment of the Human Spinal Cord. Weigert's myelin-sheath stain. (After A. Bruce, "A Topographical Atlas of the Spinal Cord," Edinburgh, 1901.)

DEVELOPMENT.—The histogenesis of the spinal cord has been briefly reviewed in the article *Brain Anatomy* (vol. ii., p. 281), the early stages of this process being essentially similar in the spinal cord and brain. In the spinal cord of a human embryo of 6.9 millimeters (about four weeks) the nuclei of all of the cells are crowded together toward the ventricular surface, leaving a non-nucleated marginal layer next to the meningeal membrane (Fig. 4571). But already at this age many of these nuclei have begun to migrate outward, thus forming a *mantle layer* of more loosely arranged nuclei. The cells represented by the nuclei of the mantle layer are *neuroblasts*, or immature neurones. The neuroblasts in the ventral part of the neural tube develop more rapidly than those in the dorsal part, and many of these become neurones whose axones form fibers of the ventral roots of the spinal nerves. The remaining neuroblasts of the ventral part and all of those of the dorsal part become neurones devoted to internal adjustment, whose axones do not leave the spinal cord.

During or immediately after the closure of the neural tube a longitudinal strand of cells is separated from it to form the *neural crest*, whose development

is very briefly summarized in the article *Cranial Nerves* (vol. iii., p. 326). The cells of the neural crest have very diverse histories. Some are transformed into the neurilemma sheaths of the peripheral fibers of the dorsal roots (Harrison), some migrate peripheralward to form neurones of sympathetic ganglia, and many remain to form neurones of the spinal ganglia.

The immature spinal ganglion cells, like those of the cranial ganglia (see vol. iii., p. 330), are at first bipolar, a dendrite and an axone arising from opposite poles of the cell body. They are later transformed

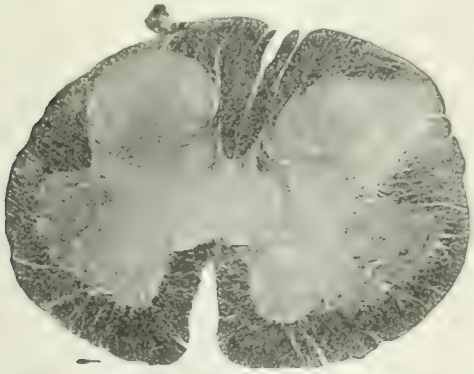

FIG. 4569.—Transverse Section through the Third Sacral Segment of the Human Spinal Cord. Weigert's myelin-sheath stain. (After A. Bruce, "A Topographical Atlas of the Spinal Cord," Edinburgh, 1901.)

into unipolar neurones by the approximation of the two processes and their final fusion for a part of their courses. Fig. 4572 illustrates the spinal ganglion of a chick embryo at the age exhibiting bipolar neurones. The peripheral process, which is a true dendrite, grows outward to come into relation with its appropriate receptor. The centrally directed process, or axone, grows inward, pierces the external limiting membrane of the spinal cord, and here bifurcates into ascending and descending branches. These nerve fibers form the beginning of the dorsal funiculus (Fig. 4572).

In later development there is a further proliferation of neuroblasts and accumulation of neurones to form the dorsal, ventral, and lateral gray columns and an accumulation of nerve fibers peripherally to form the funiculi of white matter. There is, however, no proliferation of neuroblasts in the median line, thus leaving membranous longitudinal zones above and below the ventricle, the roof plate and the floor plate respectively (Fig. 4573).

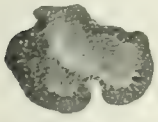

FIG. 4570.—Transverse Section through the Coccygeal Segment of the Human Spinal Cord. Weigert's myelin-sheath stain. (After A. Bruce, "A Topographical Atlas of the Spinal Cord," Edinburgh, 1901.)

The more rapid growth of the ventral gray columns and ventral funiculi causes a ventral projection on each side of the midplane separated by the ventral longitudinal fissure. The dorsal median sulcus is a very slight indentation of the dorsal surface, below which is a dorsomedian septum formed by a lateral compression of the dorsal part of the ventricle of the neural tube and fusion of the lateral walls (Fig. 4574).

Coghill has investigated the relations of the neurones in the spinal cords of amphibian embryos in the youngest stages which are capable of responding to external stimulation. In these embryos the earliest peripheral sensory neurones to mature are not those of the spinal ganglia, but a series of giant cells (first described by Rohon and Beard) within the spinal cord. In most vertebrate embryos these giant cells disappear after the neurones of the spinal ganglia have matured, though in some species, as in the marine goosefish (Lophius), they persist up to adult life.

It has been shown by Coghill that in Amblystoma the earliest somatic movements in response to external stimulation are possible only after the completion of a definite anatomical circuit in the nervous

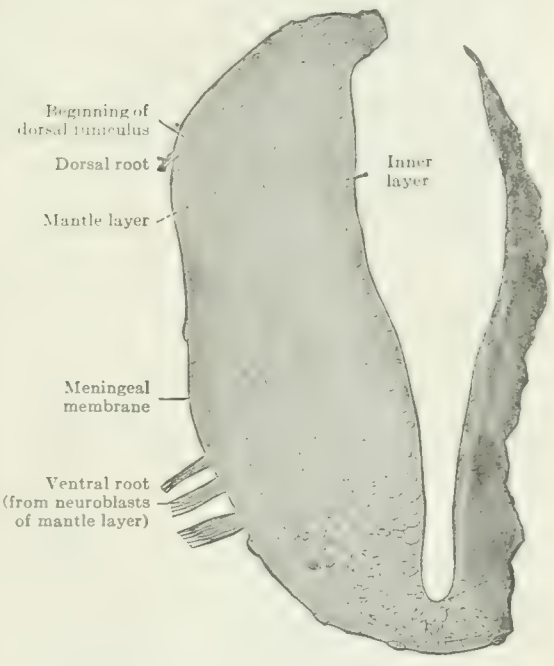

FIG. 4571.—Half of a Transverse Section of the Spinal Cord of a Four Weeks' (6.9 Millimeters) Human Embryo. *Dp.*, Roof plate; *Bp.*, floor plate. (After His.)

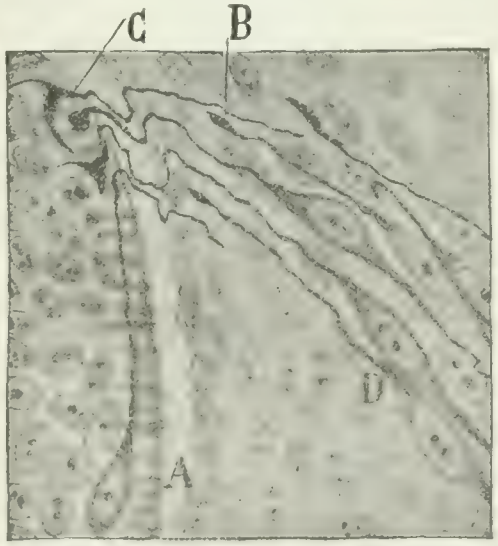

FIG. 4572.—Section through Part of the Spinal Cord and Spinal Ganglion of a Fifty-six-hour Chick Embryo (combined from two sections). *A*, Efferent neurone whose axone leaves by the dorsal root; *B*, cone of growth of central process (afferent dorsal root fibers) of spinal ganglion cell; *C*, bifurcation of afferent root fibers in the spinal cord, forming the beginning of the dorsal funiculus. After Ramón y Cajal.)

system (though the muscles may be excited to contraction by the direct application of an electrical stimulus prior to this age). The first movement which can be evoked by light tactile stimulation of the skin is a simple avoiding reaction—at first turning

the head end of the body away from the side stimulated, then a convulsive "coil reaction," then an "S-reaction," which is immediately followed by a true swimming reflex.

In the youngest stages which are capable of responding at all to external stimuli, commissural fibers cross at one region only, viz., the upper end of the spinal cord and lower end of the medulla oblongata. In older stages, this ventral commissure is extended both forward and backward from this level until finally it extends throughout the entire central nervous system below the optic chiasma, and other types of connection between the peripheral sensory and motor neurones are effected, so that local crossed and uncrossed reflexes are possible in every part of the central nervous system.

From these observations it follows that the earliest reflex responses to external stimulation require a rather complex chain of neurones, whose relations are quite different from those of the shortest definitive reflex arc of the adult animal.

In this arrangement we would emphasize the following features: (1) the fact that a single peripheral sensory neurone may be excited either by an extero-

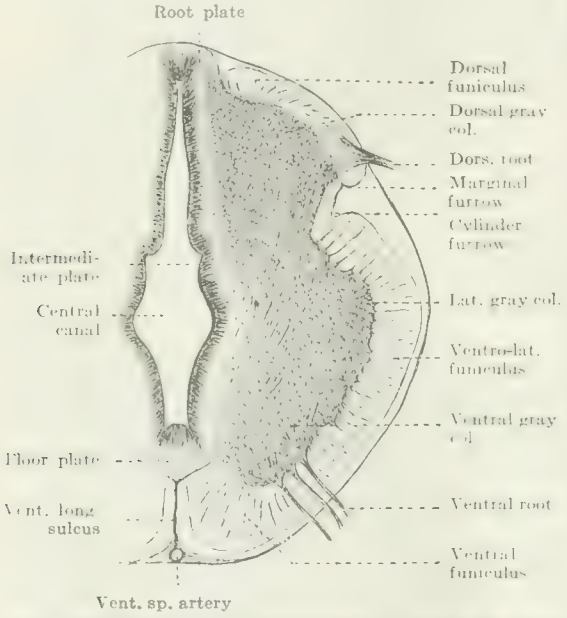

Fig. 4573.—Half of a Transverse Section through the Spinal Cord of a Human Embryo of 18.5 Millimeters (seven and one-half weeks). (After His.)

ceptive stimulus applied to the skin or by a proprioceptive stimulus ("muscle sense") arising from the contraction of the myotom during the act of swimming; (2) the fact that the peripheral motor neurones are not yet separately differentiated away from those of the central motor tract; (3) that the reflex path required for the type of crossed reaction which is first to appear is a relatively long one, all of the afferent impulses having to reach the upper end of the spinal cord before they can be transferred across the midplane into the efferent apparatus; (4) that the individual neurones of this circuit are relatively short and that many synapses are interpolated in the pathway.

In the actual operation of this mechanism it appears that a bodily movement may be initiated by a single external tactile stimulus which is transmitted inward through the cutaneous dendrite of a dorsal giant cell (Figs. 4575 and 4576) and that this movement takes the form of a swimming reflex whose rhythm begins at the head end of the body and is transmitted backward through the myotomes of the side opposite to the one stimulated. The first stage in this movement is a bending of the head away from the side touched. This curvature of the body then moves backward, involving the successive contraction of additional myotomes, and after several myotomes of the upper part of the trunk have been involved, the

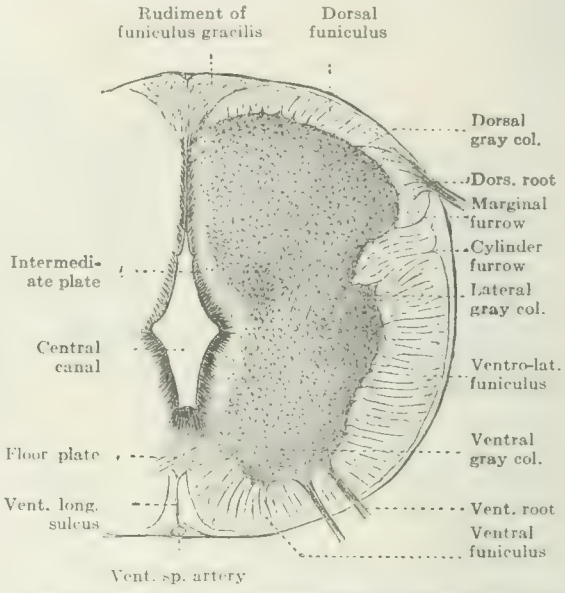

Fig. 4574.—Half of a Transverse Section through the Spinal Cord of a Human Embryo of Twenty-four Millimeters (eight and one-half weeks). (After His.)

muscular branches of the dorsal giant cells are excited by the contraction of their respective myotomes, thus exciting a proprioceptive reaction through the dendrites of the giant cells ending in the myotomes. This stimulus is likewise transmitted to the upper end of the spinal cord, passed over to the opposite side and into myotomes lying in front of those now in contraction. The effect is to turn the head to the opposite side and thus initiate a descending wave of muscular

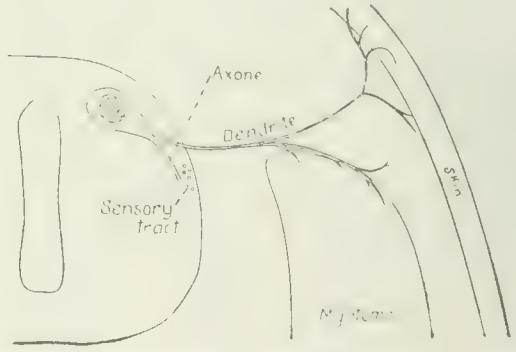

Fig. 4575.—Diagrammatic Cross-section through the Spinal Cord and Part of the Body of an Early Swimming Stage of Larval Amblystoma, to illustrate the connections of the transitory giant cells of Rohon-Beard. (Based on the researches of Coghill.)

contraction which follows the first but in the opposite direction. This process is continued and repeated as long as the swimming movement persists, thus giving rise to the serpentine swimming reflex.

This mechanism obviously is adapted to produce only one form of response to any sort of excitation applied to the trunk region of the embryo, viz., a

swimming reaction, and the same neurones are involved throughout in both the exteroceptive and the proprioceptive factors in the reaction. Physiological experiments show that this in fact is the case.

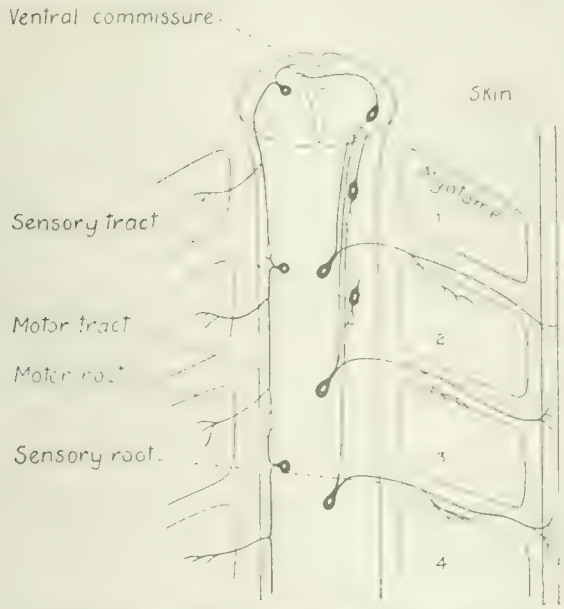

Fig. 4576.—Diagram of a Dorsal View of the Upper End of the Spinal Cord of Larval Amblystoma of the Same Age as in Fig. 4575, to illustrate the relations of the giant cells, commissural cells, and motor cells and the mechanism of the swimming reflex. (Based on the researches of Coghill.)

At a later period in development the transitory dorsal giant cells disappear and are replaced by typical spinal ganglion neurones which have meanwhile differentiated from the neural crest. And no doubt the adult Amblystoma, like the higher vertebrates, possesses distinct neurones within the spinal ganglia to serve the exteroceptive and the proprioceptive functions respectively involved on the afferent side of the swimming reflex.

In older larvæ the efferent side of the reflex circuit also shows an advance beyond that of the youngest swimming embryo, where the motor root fibers arise as collateral branches from the descending tract fibers. The details of the transformation have not been observed; but it is probable that in some of these neurones the descending tract fiber elongates and develops at the expense of the peripherally directed collaterals, while in others a collateral develops at the expense of the descending fiber, thus transforming the element into a typical ventral horn neurone.

In the spinal cords of older larvæ this mechanism is much more complex than that of the earliest swimming larva, though still very different from that known in the spinal cords of adult higher vertebrates. The spinal ganglion cells and the ventral horn cells have fully matured and Fig. 4577 shows that both crossed and uncrossed reflex connections are possible at all levels of the spinal cord. Dorsal root fibers from the spinal ganglion neurones pervade the dorsal part of the white substance and the remainder of this layer is filled with various kinds of correlation fibers. Both the correlation neurones and those of the ventral horns send enormous dendrites into all parts of the cross-section of the white substance, some even crossing to the opposite side through the ventral commissure.

From these relations it is evident that each peripheral motor neurone is under the direct physiological influence of every sort of nervous excitation which can be transmitted through the spinal cord. These excitations may come from the skin of its own or of very remote segments of the body through dorsal root fibers, or they may come from the brain through the various cerebrospinal tracts—from the visual centers through the tractus tectospinalis, from the auditory or vestibular centers through the tractus bulbospinalis, etc. Furthermore, the long ascending systems between the spinal cord and the brain (spinobulbar, spinocerebellar, and spinotectal tracts) may also discharge collaterals among dendrites of these peripheral motor neurones.

The Amblystoma larva is capable of making only the simplest responses by means of the body musculature, of which the chief is the simple swimming movement; but, unlike the younger embryos considered in the preceding paragraphs, these responses may be called forth by a great variety of means. The body musculature here is responsive to environmental influences received through many more avenues of sense, and its movements are, in addition, under the control of the higher correlation centers of the brain.

The functional connections of these exceedingly simple amphibian spinal cords forecast the histological pattern found in those of mammals. There is, first, an intrinsic apparatus of central adjustment adapted to serve the very simple total swimming movements which comprise the chief methods of response shown by these larvæ. In the second place, there are long ascending and descending fiber tracts which put this intrinsic apparatus into relation with the sense organs and higher correlation centers of the head.

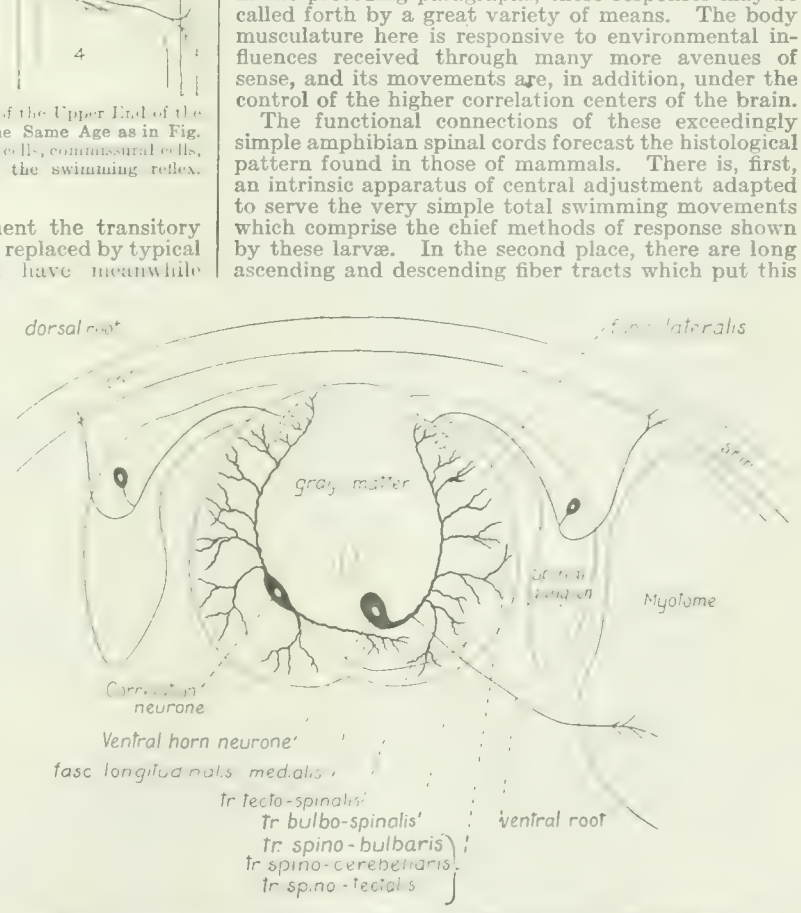

Fig. 4577.—Diagram of the Relations of Some of the Neurones of the Spinal Cord in a Half-grown Larva of Amblystoma. (After Herrick and Coghill.)

In larval Amphibia there is a single ascending con-

duction system, some of whose fibers end in the medulla oblongata (tractus spinobulbaris), others in the cerebellum (tractus spinocerebellaris), still others in the roof of the midbrain (tractus spinotectalis, and a smaller number in the thalamus (tractus spinothalamicus, or spinal leminiscus). Some of the fibers terminating in the bulb and cerebellum arise as collaterals of the longer fibers of the spinal lemniscus. From this arrangement it would appear that these ascending fibers possess but little functional specificity, their physiological effects depending largely upon the regions in which they terminate. The tracts which descend from the brain to the spinal cord arise partly in the midbrain (tractus tectospinalis) and partly from the medulla oblongata (tractus bulbospinalis), and here again there is little evidence of specificity of function, for these descending nervous impulses can do little more than modify the swimming reaction.

It is probable that the elaborate systems of sensorimotor connections which characterize the mammalian spinal cord have been derived from some such diagrammatically simple pattern as that which has just been described. As new and more complex movements are elaborated, particular chains of neurones become set apart for each specific reaction and isolated from the general nervous matrix which serves the simpler total reactions (see Herrick and Coghill, 1915).

The Conduction Pathways of the Spinal Cord.—*The Intrinsic Reflex Apparatus.*—For purposes of physiological analysis it is customary to hypothecate as the unit of behavior a simple reflex, whose mechanism in its most elementary form consists of a receptor, an afferent neurone, an efferent neurone, and the effector organ, with synaptic connection between the two neurones in the nerve center. Fig. 4578 illustrates the simplest possible mechanism of such a reflex in a segment of the spinal cord.

This schema is probably a pure abstraction, for no vertebrate spinal cord contains so simple a pattern of interneuronic connections, though this connection undoubtedly occurs as one component of more com-

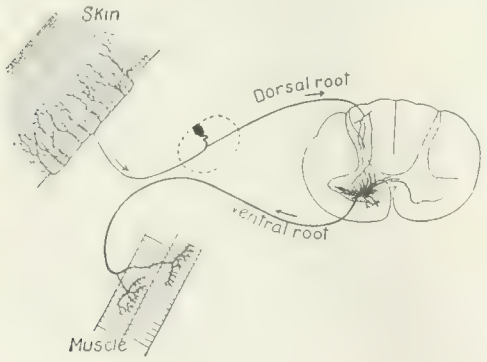

Fig. 4578.—Diagram Illustrating the Simplest Spinal Reflex Arc Consisting of Two Neurones, a Sensory Neurone Connected with the Skin and a Motor Neurone Connected with a Muscle. Physiological connection between the two neurones is effected within the spinal cord. (Modified from Van Gehuchten.)

plex patterns. From the genetic standpoint, moreover, this direct connection of the afferent with the efferent neurone is, as we have seen above, the terminal rather than the initial stage in the elaboration of the spinal reflex apparatus.

The composition of a typical segmental spinal nerve is illustrated diagrammatically in Fig. 4579. The afferent fibers enter by the dorsal root and are of two sorts, somatic and visceral. The visceral fibers come in from the sympathetic nervous system. Their central connections are not well understood; they probably terminate, at least in part, in the intermediate zone of the gray matter. The somatic afferent fibers include both exteroceptive and proprioceptive systems (cf. the article, *End-organs, Nervous*).

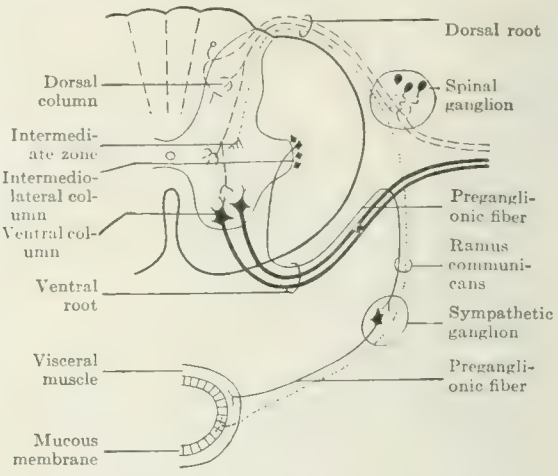

Fig. 4579.—Diagram Illustrating the Composition of a Typical Spinal Nerve in the Thoracic Region. The somatic sensory system is indicated by broken lines, the visceral sensory by dotted lines, the somatic efferent by heavy continuous lines, the visceral efferent (preganglionic fibers) by lighter continuous lines.

The efferent fibers leave the spinal cord generally in the ventral roots. In birds and some other vertebrates there is anatomical evidence that efferent fibers in small numbers leave by the dorsal roots also (Fig. 4572). The presence of such fibers in mammals is

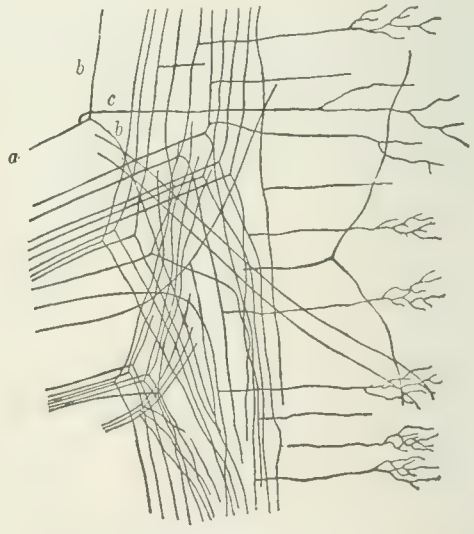

Fig. 4580.—Entrance of the Fibers of the Dorsal Roots into the Dorsal Funiculus of the Spinal Cord of an Embryo Calf. (After A. van Gehuchten, "Anatomie du système nerveux de l'homme," Louv., 2ed., 1897, p. 302, Fig. 205.) A stem fiber, *a*, is seen dividing into two branches, *b*, *b*, the ascending and descending limbs of bifurcation. From the stem fiber, *a*, a collateral, *c*, is seen to arise. A number of collaterals arising from the limbs of bifurcation of other fibers are illustrated.

in controversy and their functions are unknown; probably they are of visceral type. The efferent fibers of the ventral roots are of two sorts, somatic and visceral, the former arising from cells of the ventral gray column and the latter from cells of

the intermediolateral column. The visceral efferent fibers pass by way of the communicating branches into the sympathetic nervous system. They are the preganglionic fibers of Langley and always end in some sympathetic ganglion. Here there is a synapse and a second sympathetic neurone (postganglionic neurone) takes up the nervous impulse to transmit it to its appropriate end-organ. For further consideration of the functional analysis of the spinal nerves, see the article, *Cranial Nerves*.

The mode of entrance of the dorsal root fibers and their bifurcation into ascending and descending branches in the spinal cord is seen in Fig. 4580, and the various types of connection which these fibers make within the spinal cord are shown in Figs. 4581 and 4582.

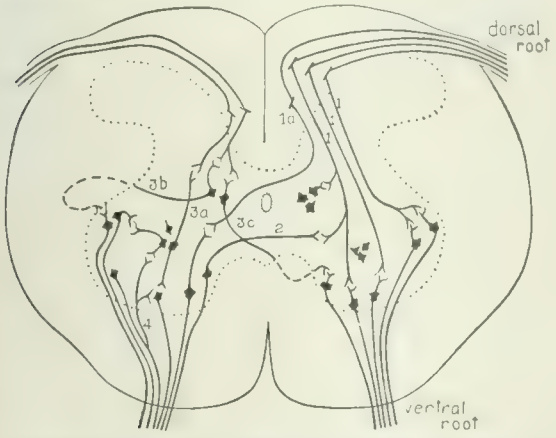

Fig. 4581.—Diagram of Some of the Types of Connection between the Sensory Fibers of the Dorsal Root and the Motor Fibers of the Ventral Root in the Spinal Cord of the Rabbit (chiefly after the researches of Philippson). The visceral connections are not included. 1. Collateral branches of the dorsal root fibers effect synaptic relations directly with dendrites of ventral column cells of the same or the opposite side. 2. Dendrites of ventral column cells may cross to the opposite side and here receive terminals of dorsal root fibers. 3. A correlation neurone may be intercalated between the two peripheral neurones in either of the first two cases. These neurones may have short axones for reflexes within a single segment (3*a*), or their axones may pass out into the white matter (fasciculus proprius) and extend for longer or shorter distances in either the ascending or the descending direction (or after branching in both directions) for connections with more remote motor centers of the same or the opposite side (3*b*, 3*c*). 4. The root fibers arising from the cells of the ventral column themselves may give off collateral branches which return to the gray matter and there arborize about other cells of the ventral column belonging to different functional groups or about correlation cells, thus facilitating the coordinated contraction of several distinct muscles in the performance of some complex reaction. The neurones of the dorsal column apparently do not play an important rôle as intercalary elements in the simpler spinal reflexes. The axones of these cells are for the most part directed upward, after decussating in the ventral commissure, and are chiefly concerned with the transmission of nervous impulses from the spinal cord to the higher correlation centers of the brain. (From Herrick's Introduction to Neurology.)

For the systems of intrinsic spinal reflexes collateral branchlets are given off from both the ascending and the descending branches of the dorsal root fibers. These collaterals may either connect directly with the neurones of the ventral gray columns at various levels, or more frequently one or more correlation neurones are intercalated between the peripheral sensory and motor neurones. Each of these types of connection is represented in a great variety of forms, some of which are illustrated in Fig. 4583.

The neurones of the dorsal column apparently do not play an important rôle as intercalary elements in the simpler spinal reflexes, these reactions being effected through the connections made directly with the ventral column or with the central groups of neurones (Fig. 4581, neurones 3*a*, 3*b*, 3*c*; Fig. 4583, *A* and *b*). The axones of the neurones of the dorsal column are apparently for the most part directed across the midplane and then upward in the spinal lemniscus; they are concerned chiefly with the transmission of nervous impulses from the spinal cord to the higher correlation centers of the brain.

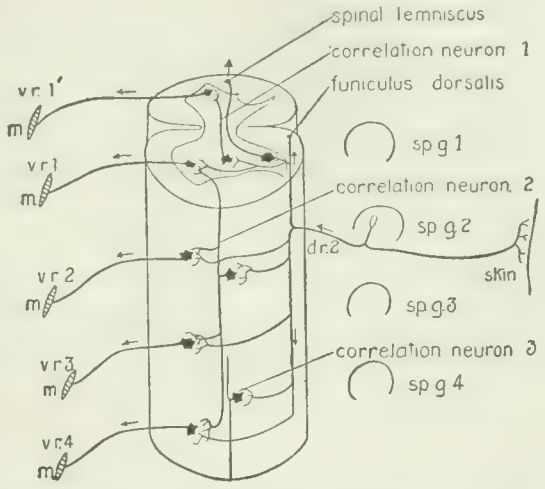

Fig. 4582.—Diagram of the Spinal Cord Reflex Apparatus. Some of the connections of a single afferent neurone from the skin (*d.r.2*) are indicated. *d.r.2*, Dorsal root from second spinal ganglion; *m*, muscles; *sp.g.1* to *sp.g.4*, spinal ganglia; *v.r.1'* to *v.r.4*, ventral roots. (From Herrick's Introduction to Neurology.)

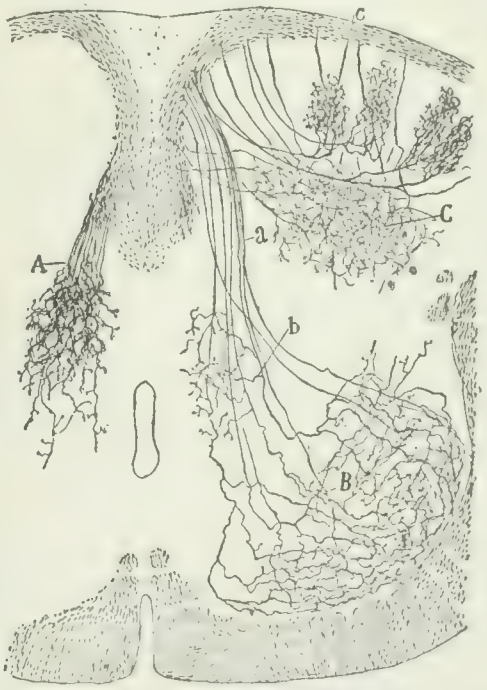

Fig. 4583.—Chief Sensory Collaterals in the New-born Rat (Golgi Stain). *A*, Collaterals for the intermediate gray nucleus; *B*, arborizations surrounding the motor nuclei; *C*, wide ramifications in the head of the posterior horn; a, sensory-motor fasciculus; b, collateral of one of the fibers destined for the intermediate gray nucleus; c, deep collaterals of the substance of Rolando. (After Cajal.)

The intrinsic spinal reflexes cannot be studied physiologically to advantage in any intact or normal higher animal because of the constant interference of the cerebral cortex and other higher centers. For such experiments the spinal cord of a laboratory animal is first severed in the lower cervical region, after which physiological experiments upon the isolated spinal cord can be made. Such an animal is the "spinal dog" upon which many important studies of the reflex types and their neurological mechanisms have been conducted.

In the dog there is a saddle-shaped area of skin over the shoulder (the "receptive field" of Fig. 4584), whose stimulation causes a characteristic scratch-reflex with the hind leg of the side stimulated. The nervous path involved is represented in Fig. 4584, *B*, *Rα-Pα-FC*. Reinforcement of the response is effected by the arrangement of neurones illustrated. Upon stimulation of two points ten centimeters apart within the saddle-shaped receptive field, the neurones *Rα* and *Rβ* are simultaneously excited. Through the propriospinal neurones *Pα*, *Pβ*, these impulses are discharged into a single efferent path, *FC*, and a

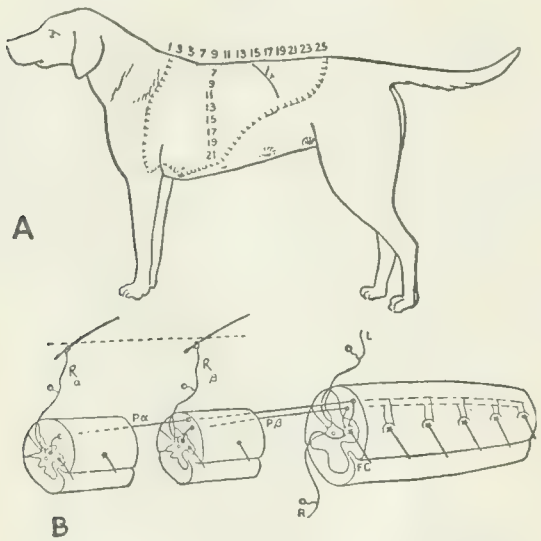

Fig. 4584.—*A*, The "Receptive Field" as Revealed after low Cervical Transection; a saddle-shaped area of dorsal skin, whence the scratch-reflex of the left hind limb can be worked; *lr* marks the position of the last rib. *B*, Diagram of the spinal area involved. *L*, receptive or afferent nerve-path from the left foot; *R*, receptive nerve-path from the opposite foot; *Rα*, *Rβ*, Receptive nerve-paths from hairs in the dorsal skin of the left side; *FC*, the final common path, in this case the motor neurone to a flexor muscle of the hip; *Pα*, *Pβ*, propriospinal neurones. (Sherrington.)

scratch reflex will be evoked, even though the stimuli employed be so weak that neither stimulus alone will produce it. The mechanism of an antagonistic reflex can be seen in the same figure. If the receptive field on the left shoulder of a dog is stimulated, so as to produce the scratch reflex of the left leg (Fig. 4584, B, *Rα-Pα-FC*), and then while this reflex is in process a stimulus is applied to the right hind foot (*R*), the latter stimulus interferes with the former and inhibits the reflex. The stimulation of the right foot normally produces a totally different response (extension of the left knee). The two afferent impulses, accordingly, are in rivalry for the same final common path (*FC*) and one finally conquers the other. For the details of these and many other very instructive experiments the original accounts of Sherrington, as given in his Integrative Action of the Nervous System, should be consulted.

Philippson (1905) has studied the locomotor reflexes of the spinal dog in great detail and finds that in this animal the cord contains the complete mechanisms for these movements and that the movements of the trot and gallop can be executed when the feet are not in contact with the ground, *i.e.* by intrinsic mechanisms. When the lumbar segments are isolated from the remainder of the central nervous system, they are capable of coordinating the movements of the hind legs involved in the two types of locomotion, the trot and the gallop; and the cervical segments similarly can coordinate these movements of the fore legs.

The Connections between the Spinal Cord and the Brain.—In the analysis of the long conduction paths between the spinal cord and the brain it is helpful to keep constantly in mind the fundamental difference between the exteroceptive and the proprioceptive adjustments (see the article, *End-organs, Nervous*, vol. iv., p. 20). The reactions to exteroceptive stimuli are in general those by which the body is kept in adjustment with the changes occurring in the surrounding environment. The proprioceptive reactions are subsidiary to these, comprising in general the adjustments within the mechanisms of response themselves. The chief proprioceptive end-organs of the trunk and limbs are the neuromuscular receptors (in the muscle spindles), the nerve endings upon the tendons, and those of the joints, with some participation by cutaneous nerves. The neurones connected with these end-organs are constantly reporting back to the central nervous system the degree of contraction of the muscles, tension on the tendons, and amount of flexion of the joints. The return motor paths of these systems are the same as those from the exteroceptive receptors, for the function of the proprioceptors is mainly to exert a regulatory influence within the motor apparatus itself. This adjustment is for the most part effected unconsciously by the mechanisms of the spinal cord, brain stem, and cerebellum, though the cerebral cortex may also participate through the mediation of sensations of posture, equilibration and movements of the body and its members in space.

The somatic sensory impulses which enter the spinal cord by the dorsal roots, accordingly, are distributed with reference to four chief types of response: (1) for local reflexes within the spinal cord, (2) for cerebellar activities of the proprioceptive type (unconscious adjustments of equilibration and the orientation of the body in space), (3) for cerebral reactions of the proprioceptive type (conscious or unconscious adjustments of equilibration, posture, etc.), (4) for cerebral reactions of the exteroceptive type (conscious or unconscious adjustments in response to external stimulation). For each of these types of reaction there is a distinct system of neurones and conduction pathways in the spinal cord whose further analysis is our next task.

In the spinal ganglia and dorsal roots the fibers of these diverse functional systems are so intimately mingled as to have baffled analysis hitherto. This is incidental to the preservation of the primary segmental pattern more perfectly here than elsewhere in the nervous system. On the peripheral side of the ganglia the functional systems are separated and arranged in accordance with the physiological pattern of the surface of the body, and on the central side of the nerve roots there has been a rearrangement of the nerve fibers belonging to these same neurones in accordance with a different physiological principle, viz., the advantage of having all fibers serving the same physiological system of receptors (touch, temperature, pain, etc.) gathered together into a single tract regardless of the peripheral source of the stimulus.

Here again, we repeat that it is important to bear in mind the distinction between the exteroceptive

and the proprioceptive systems and the fact that the central rearrangement of the peripheral nerve fibers, as soon as these enter the spinal cord and even before the first synapse is reached, is such as to segregate immediately all of the proprioceptive nervous impulses, from whatever source derived, from the exteroceptive impulses. After this primary separation has been effected, each of these great systems of conduction pathways is then further analyzed into separate tracts for fibers of diverse functions, such as temperature, touch, and pain sensibility.

We shall, therefore, find it convenient to consider the entire complex of somatic sensory pathways of the spinal nerves in four divisions which are topographically defined and which correspond with the changes in the functional patterns of the component nerve fibers as they are found at successive distances centralward from the peripheral receptors. These divisions are: (1) the peripheral division, carrying the

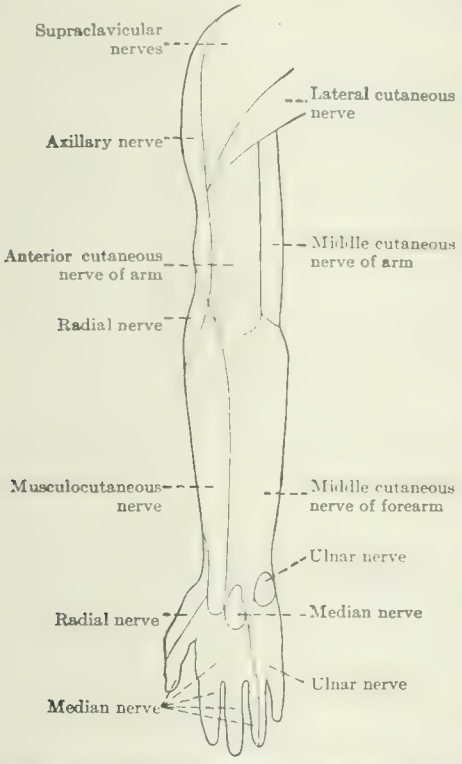

Fig. 4585.—A Diagram Illustrating the Areas of Skin Supplied by the Cutaneous Branches of the Nerves of the Arm and Hand.

nervous impulses up to the spinal ganglia; (2) the ganglia and dorsal roots of the spinal nerves; (3) the intraspinal division (including the central courses of the dorsal root fibers, the first synapse, and a part of the course of the fibers of the neurones of the second order); (4) the cerebral division.

The sensory fibers of the first division are distributed peripherally in two great groups of nerves, for deep sensibility and for cutaneous sensibility respectively. The deep, or muscular, branches of the spinal nerves are mixed in function, carrying motor fibers for the muscles and an equal or larger number of sensory fibers for muscle sense, tendon sense, and other forms of deep sensibility. The cutaneous branches of the spinal nerves serve chiefly the exteroceptive functions of touch, temperature, and pain. It should be borne in mind, however, that the deep sensory nerves participate to some extent in exteroceptive functions and the cutaneous nerves in proprioceptive functions, that is, the deep nerve endings are sensitive to external pressure and the cutaneous endings participate in the adjustments involving the sense of position, cutaneous localization, and the orientation of the body and its members in space.

In the region of the thorax the primitive segmental arrangement of the spinal nerves is preserved in the peripheral distribution of both the cutaneous and the muscular branches (see Plate LVI). The limbs in their embryological development grow out as lateral buds from the trunk, and in this process they carry with them a portion of each of the segments from which the limb buds arise. The result is that successive spinal nerve roots (from the fifth cervical to the second thoracic) innervate longitudinally arranged bands of skin on the arms. Thus, if the arms of the man shown in the plate last cited were held out in a horizontal position, the zonal distribution of spinal nerves as found in the trunk would be seen to extend outward into the arms with but slight changes in its pattern.

The nerves for the arms, however, do not pass directly from their roots to their distribution in the skin, as in the trunk, but they are first rearranged by a complicated series of anastomoses in the brachial plexus, so that the peripheral nerves as finally composed bear no simple relation to the segmental roots from which they arise. Fig. 4585 illustrates the areas of distribution of the chief cutaneous branches which supply the skin of the arm. The destruction of any one of these branches peripherally of the brachial plexus will result in anesthesia of the area of skin supplied by it, except for the margins of the area where there is an overlap of nerve endings from contiguous branches. Deep sensibility will be left intact so that, though the skin itself is anesthetic, strong pressure on the skin will be sensed and correctly localized by the deep nerve endings.

If, however, there is an injury to a peripheral sensory nerve for the arm at some point between the brachial plexus and the spinal cord, *i.e.* an injury to any spinal ganglion or root between the fifth cervical and the second thoracic segments, the anesthetic area on the skin of the arm will take a form similar to that shown on Plate LVI for the distribution area of that *root*. A study of the method of branching of the cutaneous nerves of the arm peripherally of the brachial plexus shows that no combination of peripheral injuries involving these branches could give the same pattern of anesthetic areas on the skin as would be produced by an injury to one or more spinal nerve roots. Furthermore, the destruction of any peripheral *cutaneous* branch would not disturb the underlying deep sensibility, so that strong pressure would still be sensed over the area in question, even though the skin is totally insensitive. On the other hand, the destruction of any dorsal nerve *root* which supplies the arm would result, not only in cutaneous anesthesia in accordance with the pattern shown in the plate, but also in some disturbance of deep sensibility also.

The nerves for the leg are similarly rearranged in the lumbosacral plexus, so that the cutaneous representation of the dorsal spinal roots does not bear any simple relation to the distribution areas of the peripheral cutaneous branches of the nerves for the leg.

Immediately upon entering the spinal cord the sensory fibers of the dorsal roots are again rearranged in accordance with a totally different principle, as will appear more fully beyond. These different rearrangements of the peripheral sensory nerve fibers before they enter the spinal cord and immediately within the cord must be recognized before we can continue our analysis of the peripheral sensory nerves. And since these differences have not always been taken account of in the clinical study of diseases of the spinal cord and its nerves, the pub-

lished tables and diagrams of the peripheral representation of spinal cord segments are often confused and misleading (see Barker's Nervous System, Chapter 27, Head and Thompson in *Brain*, vol. xxix., 1906, p. 602, and Brouwer, Biologische Bedeutung der Dermatomerie, in Folia Neurobiologica, Bd. ix., 1915).

The entire series of cutaneous and deep sensations was formerly treated as a physiological and clinical unit under the name of "general sensibility," but of late the importance of a more critical analysis of this complex is appreciated. Since the disturbances of peripheral sensibility are the most commonly used clinical signs in the diagnosis of nervous diseases, these relations are of great practical importance. The analysis of the symptoms resulting from injuries to these conduction pathways will usually permit of a diagnosis of the site of the injury, whether it lies in the first or second division of the peripheral nerves or in the central nervous system.

Limiting our attention now to the first or peripheral division of the spinal nerves, we shall next summarize the results of the clinical analyses of Henry Head and his colleagues. These neurologists have classified the receptors of this division into three functional groups which serve respectively deep sensibility, protopathic sensibility, and epicritic sensibility. Deep sensibility is preserved after the destruction of all afferent cutaneous nerve fibers. It is chiefly concerned, as already stated, with the proprioceptive reflexes, *i.e.* with the unconscious coordination of muscular movement and the orientation of the body and its members in space; but some of its functions may also come into consciousness as exteroceptive sensations. By these nerves pressure can be recognized and discriminated and its point of application can be localized. The movements of muscles and joints can be recognized and pain results from an extreme pressure stimulus.

Protopathic sensibility, as defined by Head and his colleagues, is subjectively a general diffuse sensibility of a primitive form. Its sense organs are arranged in definite spots, and yet these sensations have no clear local reference or sign, that is, the spot stimulated cannot be accurately localized. There are separate spots for touch, heat, cold, and pain, these spots being generally associated with the hair bulbs. In fact, the hairs are the most important tactile organs of this system and the other sense qualities belonging here are intimately associated with the roots of the hairs. Either the protopathic or the epicritic sensations may be lost in some pathological cases without the abolition of the other or of the deep sensations. The protopathic group of sensations includes cutaneous pain, especially pricking, burning, and freezing pains, and also the extreme degrees of temperature discrimination, *i.e.* temperatures above 45° C. and below 20° C.

Epicritic sensibility is a more refined sort of discrimination and is regarded as a later evolutionary type. It includes light touch, on the hairless parts of the body particularly, and the discrimination of the intermediate degrees of temperature. Cutaneous localization and the discrimination of the distance between two points simultaneously stimulated (the "compass test") are functions of this system.

If a cutaneous nerve is severed, both the protopathic and the epicritic sensibility will be abolished, while deep sensibility is left intact. After some months the severed nerve fibers may regenerate and the sensory functions of the skin are gradually restored. In this regenerative process the protopathic functions reappear long in advance of the epicritic, a circumstance which permits of careful study of the physiological characteristics of these two systems. The results of these studies can best be summarized in the form of a table taken from Head and Thompson (1906).

Loss of *epicritic sensibility* abolishes—
- Recognition of light touch over hairless parts or parts that have been shaved.
- Cutaneous localization.
- Discrimination of compass points.
- Appreciation of differences in size, including the accurate discrimination of the head from the point of a pin apart from the pain of the prick (acuæsthesia).
- Discrimination of intermediate degrees of temperature from about 25° C. to about 40° C.

Loss of *protopathic sensibility* abolishes—
- Cutaneous pain, especially that produced by pricking, burning, or freezing, together with that of stimulation with a painful interrupted current. Over hair-clad parts, plucking the hairs ceases to be painful.
- Sensations of heat from temperatures above about 45°C.
- Sensations of cold from temperatures below 20° C.

After destruction of all cutaneous afferent fibers the part is still endowed with *deep sensibility.*
- Pressure can still be recognized, and its gradual increase appreciated.
- Pain is produced by excessive pressure (measured by the algometer).
- Movements of muscles can be recognized.
- The point of application of pressure can be localized.
- The patient can recognize the extent and direction of movement produced passively in all the joints within the affected area.

This analysis was based in the first instance upon clinical data. In order to make further studies under the most favorable conditions, Dr. Head in the year

Fig. 4586.—Lateral View of Dr. Head's Left Hand One Month after the Operation which Severed the Superficial Branch of the Radial Nerve and the Musculocutaneous (External Cutaneous) Nerve near the Elbow. The area enclosed within the thin line was insensitive to epicritic tactile stimuli (light touch), and the area enclosed within the thick line was insensitive to painful and thermal stimuli also (loss of both epicritic and protopathic cutaneous sensibility). Deep sensibility was unaltered in the entire region. The triangular area marked *A* was insensitive to cutaneous pain, to cold, and to extreme degrees of heat (above 50° C.), but was sensitive to delicate stimulation with cotton wool and to moderate degrees of warmth. This was interpreted to mean that the epicritic sensibility was intact though the protopathic sensibility was lost. Where the boundaries of the area of loss of sensibility were ill-defined the limiting lines are broken.

1903 secured the services of other surgeons and had an experimental operation performed on his own body (Rivers and Head, 1908), severing near the left elbow the superficial branch of the radial nerve for the forearm and the musculocutaneous (external cutaneous) nerve. After the operation a well-defined area of the forearm and hand was found to be insensitive to protopathic and epicritic sensibility, the area anesthetic to painful stimuli (prick with a pin) being not exactly coextensive with that devoid of tactile sensibility (Fig. 4586). All forms of deep sensibility were entirely unaffected. During a period of nearly five years following the operation the physiological and psychological symptoms of the affected cutaneous area were carefully studied, a thorough examination being made weekly during most of the period of repair. In this way Dr. Head was able to watch in his own person the steps in the successive appearance of the protopathic and the epicritic functions and to

determine the part which each plays in the complex commonly called "general sensibility."

The history of the process of repair and return of function in this case may be briefly summarized as follows:

Forty-three days after the operation the regeneration of the proprioceptive nerves had begun to be apparent and the area of insensitiveness to cutaneous pain (prick) had begun to diminish.

Eighty-six days after the operation the whole forearm responded to prick and the back of the hand was becoming rapidly sensitive to this stimulus. Cold was not appreciated except in the terminal joint of the thumb, and 50° C. gave no sensation of heat.

One hundred and thirty-seven days after the operation the whole forearm had become sensitive to cold.

One hundred and seventy-three days after the operation the whole back of the hand had become sensitive to prick and in a less degree to cold. Sensibility to heat appeared shortly before this date and rapidly improved.

Three hundred and sixty-five days after the operation the first sensibility to light (epicritic) touch appeared and the protopathic sensibility had still further improved and soon became normal.

Four hundred and twenty-eight days after the operation epicritic sensibility to temperature returned on the forearm.

Five hundred and sixty-seven days after the operation epicritic sensibility had returned over the greater part of the affected area, though a small part has remained permanently in the protopathic condition.

Trotter and Davies (1909) extended the observations which Head made upon his own person by similar operations made upon themselves in which in all seven cutaneous nerves were severed and the processes of repair very carefully studied. Some of their conclusions are as follows:

In each case the area of skin supplied by the nerve showed in consequence of the operation defects in seven distinct functions: four sensory, namely, sensibility to touch, cold, heat, pain; and three motor, namely, vasomotor, pilomotor, sudomotor.

In each case the sensory changes showed a central area of profound loss; an area of moderate extent surrounding this of partial loss; and a large area in which a qualitative change could be detected. The loss of motor function showed a central area of profound loss and a surrounding area of partial loss. The seven areas corresponded on the whole fairly closely but no two of them coincided absolutely.

During a certain period following the nerve section, from about the second to the sixth week, hyperalgesia may appear. The characters of it point to its being a complication due to the presence of an irritative change rather than to its being due to any kind of sensory loss.

Sensibility to touch is subserved by a nervous mechanism distinct from that of sensibility to pressure; the former occurs in the skin only, the latter in structures deep to the skin. It is probable, however, that the skin possesses some sensibility to pressure. A touch sensation is introspectively quite distinct from a pressure sensation. The touch sensation is intimately associated with movement.

Recovery of all the functions which are dependent upon regeneration begins about the same time. The rate at which the various returning functions spread over the area is about equal, but the rate at which they progress toward normal acuity is not so.

Sensations derived from a recovering area show a remarkable qualitative peculiarity. Cold, pain and the pain element of heat are intensified, but touch is little changed, though more difficult to elicit. A large number of sensations elicited from a recovering area are referred to distant parts of the area or to the point of the nerve section. The referred sensation may be felt alone or combined with a local sensation. Peripheral reference is the earliest phenomenon of recovery and the last sign of abnormality.

It appears that in general (though with some notable exceptions) Trotter and Davies found the facts presented by their experiments to be very similar to those of Head and his colleagues, with, however, a considerable refinement of the methods of research and a corresponding enlargement of the actual findings. The interpretation of their data lead Trotter and Davies to conclusions in several respects widely at variance from those of Head. Some of these differences are suggested in the preceding summary.

As indicated earlier in this article, Head arranges cutaneous sensations in two groups called protopathic and epicritic and he is inclined to believe that each sense quality in each of these groups is served by nerve fibers distinct from the others. Trotter and Davies do not interpret their data as supporting the separate individuality of the protopathic and the epicritic types of sensibility, but seem more inclined

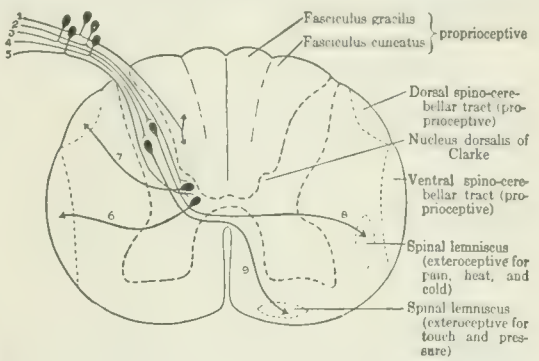

Fig. 4587.—Diagram to Illustrate the Terminations within the Spinal Cord of Some of the Types of Somatic Sensory Fibers and Their Secondary Paths. The central connections of root fibers 1, 2, and 5 provide for proprioceptive responses; those of fibers 3 and 4 for exteroceptive responses. Root fiber 1 terminates in the nucleus of the fasciculus cuneatus of the same side at the upper end of the spinal cord and conveys impulses of muscular sensibility, sense of passive positions and movement and of spatial discrimination. Root fiber 2 terminates in the nucleus dorsalis of Clarke (Clarke's column) and root fiber 5 in the same nucleus or adjacent parts of the gray substance. These fibers call forth unconscious cerebellar activity underlying the coordination and reflex tone of the muscles. Root fibers 3 and 4 terminate in the dorsal gray column and convey exteroceptive impulses. Fiber 3 typifies all fibers which carry sensibility of pain, heat, and cold; fiber 4 those which carry sensibility of touch and pressure. (From Herrick's Introduction to Neurology.)

to regard these types as physiological phases of a single group of sensations.

It has been pointed out that the type of functional distribution of nerve fibers found in the first division of the peripheral nerves is replaced in the second division by a purely segmental arrangement in which all functional systems of fibers are mingled in the spinal nerve roots. We must next consider the further rearrangement of these functional systems of fibers which takes place within the spinal cord (our third division).

The guiding principles of this rearrangement have already been briefly stated. In the first place, the proprioceptive and the exteroceptive elements of the dorsal root complex are separated and then each of these groups is further analyzed into separate conduction pathways for special systems of sensory fibers. From all systems of peripheral root fibers connections are effected for local reflexes within the spinal cord. Some illustrations of the mechanisms of these intrinsic spinal reflexes were presented in the preceding section. The ascending pathways from the cord to the brain are analyzed as follows (Fig. 4587).

The exteroceptive systems (touch, temperature, and pain) form the spinal lemniscus to the medulla oblongata, midbrain, and thalamus, the last-mentioned fibers being the tractus spinothalamicus. The proprioceptive systems are distributed partly to the cerebellum through the spinocerebellar tracts and partly to the medulla oblongata, midbrain, and thalamus through the dorsal funiculus of the cord (fasciculus gracilis and cuneatus) and medial lemniscus of the brain. The proprioceptive pathways will first be discussed.

The main ascending *proprioceptive path* is composed of the root fibers which form the dorsal funiculi of the cord. It will be recalled that immediately upon entering the spinal cord the dorsal root fibers divide into ascending and descending branches and that collaterals leave both of the branches to terminate in synaptic relations with the cells of the gray substance of the cord. Many of these collateral terminals provide for intrinsic spinal reflexes, but the main ascending branches of the proprioceptive neurones continue upward in the dorsal funiculus of the same side of the cord to its upper end (Fig. 4591).

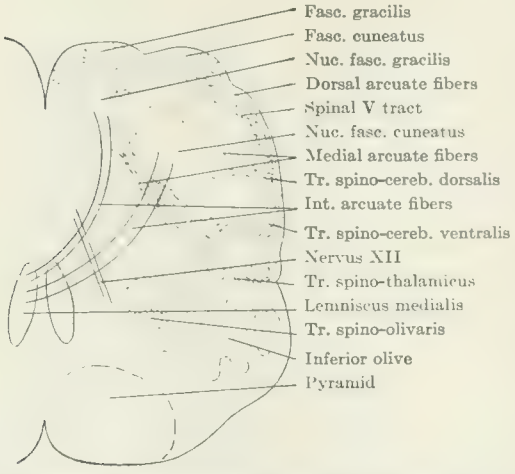

FIG. 4588.—Transverse Section through the Lowest Part of the Human Medulla Oblongata, showing by Marchi's method the degenerations resulting from a tumor in the second lumbar segment, and illustrating the tractus spinocerebellaris posterior of Goldstein (marked dorsal and medial arcuate fibers on the figure) passing from the fasciculus gracilis and cuneatus to the spinocerebellar tracts. (Based on the researches of Goldstein, 1910.)

Here they terminate in the nuclei of the fasciculus gracilis and fasciculus cuneatus, which are masses of gray matter lying at the boundary beween the spinal cord and medulla oblongata. The dendrites of the neurones of these nuclei effect synaptic connections with these terminals and their axones form the medial lemniscus of the brain, or fillet. The fibers of the medial lemniscus decussate immediately after leaving the nuclei of the dorsal funiculus, thus forming the decussation of the lemniscus. The longest fibers of the medial lemniscus system reach the thalamus of the opposite side and after a synapse here their nervous impulses may be carried forward into the cerebral cortex through the sensory thalamocortical radiations.

The cortical proprioceptive pathway in its simplest form may consist of only three neurones: (1) A peripheral spinal neurone, whose cell body lies in some spinal ganglion, whose peripheral fiber terminates in some organ of musculotendinous sensibility or similar receptor, and whose axone terminates at the upper end of the cord in the nucleus of the fasciculus gracilis or cuneatus of the same side. (2) The body of the second neurone lies in one of the nuclei last mentioned (marked nucleus of dorsal funiculus on Fig. 4591) and its axone enters the medial

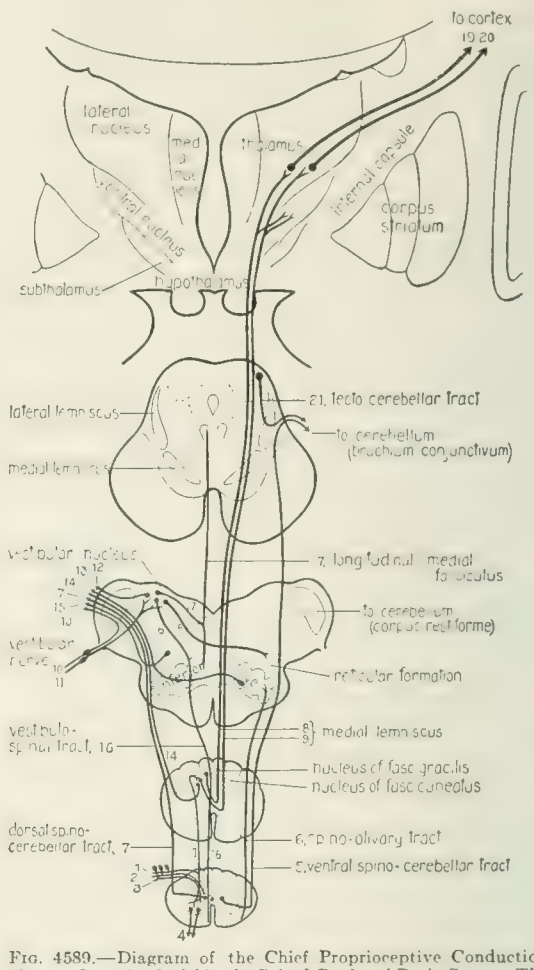

FIG. 4589.—Diagram of the Chief Proprioceptive Conduction Pathways Contained within the Spinal Cord and Brain Stem. The mesencephalic root of the trigeminal nerve is omitted and not all of the cerebellar connections are indicated. The connection to the cerebellum from the nuclei of the fasciculi gracilis and cuneatus (neurone 14) is controverted, but it is well established that similar connections are effected immediately below this level from the dorsal funiculus of the cord (cf. Fig. 4588). The figure illustrates cross-sections of the central nervous system in the lower cervical region of the spinal cord, at the level where the cord passes over into the medulla oblongata, at the level of the roots of the VIII cranial nerve, through the inferior colliculus, and through the thalamus. 1. Peripheral neurone entering the dorsal funiculus and also effecting intrinsic spinal reflex connections. 2. Peripheral neurone entering the nucleus dorsalis of Clarke. 3. Peripheral neurone effecting connections with the intrinsic correlation neurones of the spinal cord. 4. Peripheral motor neurones of spinal nerve. 5. Ventral spinocerebellar tract. 6. Spinoolivary tract. 7. Dorsal spinocerebellar tract. 8, 9. Medial lemniscus. 10. Vestibular root fiber passing directly into the cerebellum. 11. Vestibular root fiber entering the vestibular nucleus. 12. Vestibulocerebellar tract. 13. Olivocerebellar tract. 14. Path from the dorsal funiculus (or its nuclei) to the cerebellum. 15. Path from the reticular formation to the cerebellum. 16. Vestibulospinal tract. 17. Path from the vestibular nucleus to the fasciculus longitudinalis medialis. 18. Path from the vestibular nucleus to the reticular formation. 19, 20. Thalamic radiations to the cerebral cortex. 21. Tectocerebellar tract. (From Herrick's Introduction to Neurology.)

lemniscus and terminates in the thalamus of the opposite side. The neurone of the third order lies in the thalamus and sends its axone through the

internal capsule to the somesthetic area of the cerebral cortex.

The reflex connections of the proprioceptive type for motor coordination in the spinal cord, medulla oblongata and midbrain are undoubtedly very primitive. But comparative anatomy suggests that the thalamic and cortical connections of the medial

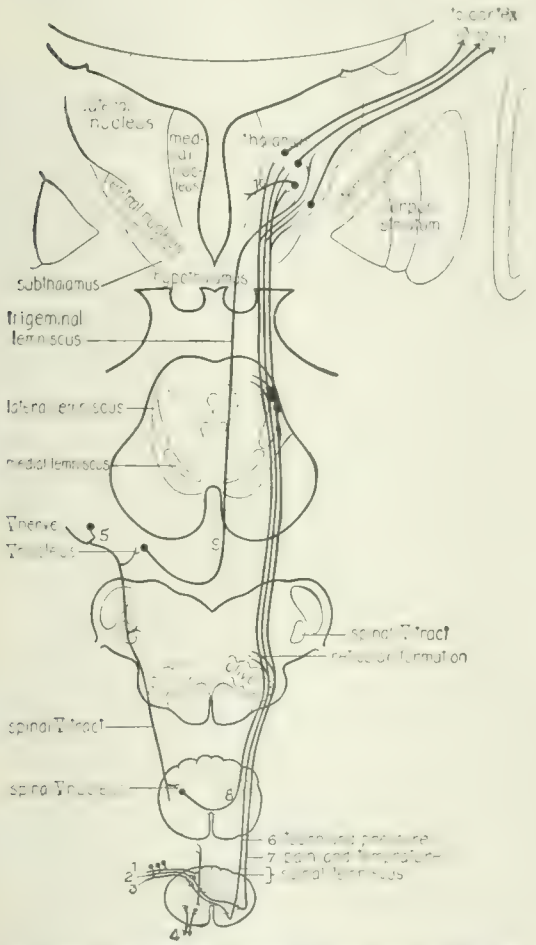

Fig. 4590.—Diagram of the Exteroceptive Conduction Pathways Contained within the Spinal Cord and Brain Stem. The figure illustrates cross-sections of the central nervous system in the lower cervical region of the spinal cord, at the level where the cord passes over into the medulla oblongata, at the level of the roots of the VIII cranial nerve, through the inferior colliculus, and through the thalamus. 1. Connections of peripheral neurone of touch, temperature, or pain for intrinsic spinal reflexes. 2. Peripheral neurone of pain or temperature. 3. Peripheral neurone of touch and pressure. 4. Peripheral motor neurones of spinal nerve. 5. Peripheral cutaneous neurone of trigeminal nerve. 6. Secondary neurone of touch and pressure in spinal lemniscus. 7. Secondary neurone of pain or temperature in spinal lemniscus. 8. Secondary neurone from lower part of spinal V nucleus entering the spinal lemniscus. 9. Secondary neurone from chief sensory V nucleus entering the trigeminal lemniscus. 10. Intrinsic correlation neurone of thalamus for thalamic reflexes. 11, 12, 13. Thalamocortical radiations to the postcentral gyrus. (From Herrick's Introduction to Neurology.)

lemniscus system are phylogenetically more recent, and clinical evidence shows that these later connections are concerned with the conscious adjustments of the positions and orientation in space of the body and its members and with various types of spatial discrimination, rather than with simple reflexes. The cerebellum, on the other hand, was developed very early in vertebrate evolution as the general overlord of the proprioceptive system.

There are three spinocerebellar pathways belonging to this system, (1) the ventral spinocerebellar tract, (2) the dorsal spinocerebellar tract, (3) a cerebellar connection from the dorsal funiculus (Figs. 4587, 4589 and 4592). The peripheral proprioceptive nervous impulses destined for the first and second of these tracts enter by way of the dorsal roots and near their level of entrance are discharged into the nucleus dorsalis of Clarke. After a synapse here, the axones of the neurones of the second order pass to the lateral surface of the cord and then upward to the cerebellum. The fibers of the dorsal cerebellar tract arise from the nucleus dorsalis and pass upward without decussation; this path is therefore often called the direct cerebellar tract (also called Flechsig's tract and, incorrectly, in the BNA

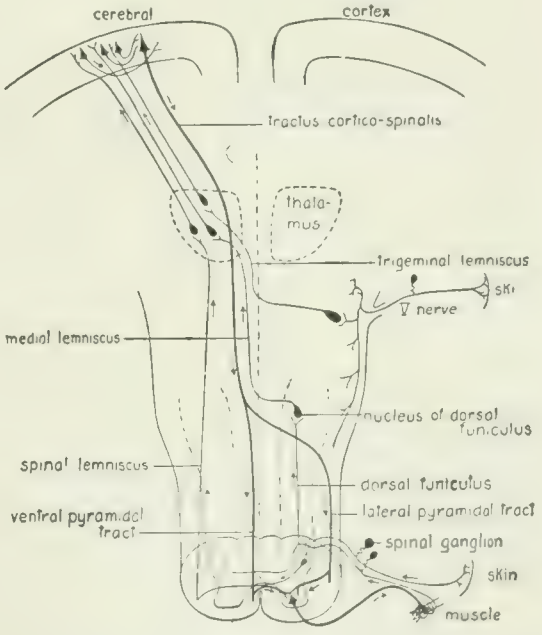

Fig. 4591.—Diagram of the chief Connections between the Spinal Cord and the Cerebral Cortex. The spinal lemniscus complex carries the ascending exteroceptive systems (touch, temperature, and pain); the dorsal funiculus and medial lemniscus complex carries chiefly ascending proprioceptive systems (a nerve of muscle sense is the only member of this group included in the drawing). The diagram also includes the sensory path from the skin of the head to the cerebral cortex through the nervus trigeminus and the trigeminal lemniscus. The pyramidal tract (tractus corticospinalis) is the common descending motor path for both exteroceptive and proprioceptive nervous impulses from the cerebral cortex. (From Herrick's Introduction to Neurology.)

tables the fasciculus cerebellospinalis). The fibers of the ventral cerebellar tract (part of Gowers' tract and of the fasciculus anterolateralis superficialis of the BNA), according to the older descriptions, arise from neurones of the intermediate region under the dorsal gray column, chiefly in the lower levels of the cord, and most of them cross to the opposite side of the cord before turning upward. But the recent experiments of A. N. Bruce have convinced him that all of the fibers of this tract have the same origin as do those of the dorsal tract, viz., from the nucleus dorsalis of the same side.

The third group of spinocerebellar fibers, from the dorsal funiculus, is much less perfectly known than are the other two. Some neurologists deny their existence altogether. Goldstein (1910) has recently shown that some fibers from both the fasciculus

gracilis and the fasciculus cuneatus pass lateralward in the upper levels of the spinal cord and lower part of the oblongata as dorsal external and medial arcuate fibers (Fig. 4588) to enter the dorsal and ventral spino-cerebellar tracts, and thus reach the cerebellum of the same side. He terms this the tractus spino-cerebellaris posterior. It is not known whether these are root fibers or fibers of the second order. Fibers have often been described as arising in the nucleus of the fasciculus gracilis and fasciculus cuneatus to enter the cerebellum through the restiform body, but the existence of these fibers is very doubtful. The chief proprioceptive pathways are assembled in Fig. 4589.

Turning now to the *exteroceptive fibers* of the spinal nerves serving the sensations of touch, temperature and pain, attention should again be called to the fact that these fibers are derived chiefly from the cutaneous branches of the spinal nerves, though some come also from the deep branches and convey the sensory impulses excited by deep pressure and deep pain. Unlike many of the proprioceptive fibers which run upward in the dorsal funiculus to its upper end before terminating, these exteroceptive fibers all terminate in the gray substance within a very few segments of their points of entrance. The neurones of the second order lie in the dorsal gray column and their axones immediately cross to the opposite side of the cord where they ascend in one of the tracts which make up the spinal lemniscus, or tractus spinothalamicus (Figs. 4587, 4590, 4591, and 4592).

Furthermore, it is important to note that as the fibers of the spinal lemniscus decussate, a few at a time throughout the length of the cord, they are segregated functionally and all fibers concerned with sensations of touch and pressure enter the ventral funiculus (ventral spinothalamic tract), while those concerned with pain and temperature enter the lateral funiculus (lateral spinothalamic tract, Figs. 4587 and 4592). And in the lateral funiculus the fibers conveying impulses of pain are more or less separated from those for heat and cold. From this it follows that small circumscribed injuries in the white substance of the spinal cord may destroy all sensibility to pressure in a part of the body below the site of the injury, without any disturbance whatever of pain or temperature sensibility, or of pain or temperature without any involvement of the other sense qualities.

Some peculiar combinations of symptoms arise from the fact that, whereas the ascending proprioceptive impulses (so far as these are consciously perceived) pass up in the dorsal funiculus of the *same* side for the entire length of the cord, the impulses of the exteroceptive impulses, within a few segments of their point of entrance into the cord, are transferred to the *opposite* side to ascend in the spinal lemniscus tracts. From this it follows that a localized central injury involving the dorsal gray column and dorsal funiculus of one side only will cut off all ascending proprioceptive impulses which pass through the dorsal funiculus from lower levels on the same side of the body as the lesion, and at the same time will abolish both proprioceptive and exteroceptive functions in a circumscribed region of the same side of the body whose exteroceptive neurones of the first order discharge into the injured part of the dorsal gray column.

The dorsal funiculi of the spinal cord have until recently been regarded as the chief ascending pathway for all forms of sensibility, and much of the clinical practice now in vogue is based upon this assumption. But evidently such an assumption is untenable. The dorsal funiculi seem to be concerned chiefly with the proprioceptive group of reactions. These may be unconscious reflexes of motor coordination and the maintenance of equilibrium, or they may come into consciousness as sensations of position and orientation of the body and its parts and of spatial discrimination. Purely exteroceptive stimuli, whether transmitted by the deep nerves or by the cutaneous nerves, may be carried for a few segments in the dorsal funiculi; but they are soon filtered off into the gray matter of the dorsal column, and after a synapse here they are sorted into functionally distinct tracts on the opposite side of the cord. The tactile elements of the mixed peripheral root fibers entering the dorsal funiculus are drawn off later than are the elements for thermal and painful sensibility; and some of the components commonly reckoned with cutaneous exteroceptive sensibility remain in the dorsal funiculus for its entire length. These are chiefly two-point discrimination, and discrimination of size, shape, form, and texture of surfaces. These all involve a comparison and discrimination in consciousness of spatial factors and are therefore bound up with those fibers which serve the proprioceptive reflexes, which are unconscious spatial adjustments.

In addition to the ascending systems between the spinal cord and the brain already considered, there are others which serve purely reflex functions of various sorts, such as the tractus spino-olivaris of Goldstein (Fig. 4592) between the cord and the inferior olive of the medulla oblongata. The descending tracts from the brain to the cord (Figs. 4591 and 4592) include the great pyramidal tracts (tractus corticospinalis) and various reflex pathways from the brain stem, such as the tractus tectospinalis and the tractus rubrospinalis from the midbrain, and the tractus vestibulospinalis from the nuclei of the VIII cranial nerve.

We cannot include here a full discussion of the conduction pathways of the spinal cord. In Fig. 4592 the locations of some of the more important tracts of the cervical cord are diagrammatically indicated. A list of these and some other tracts follows. The names here employed in some cases differ from those of the official list by the German Anatomical Society, the BNA terms being here italicized.

Ascending Tracts.—*Fasciculus gracilis* (column of Goll) and *fasciculus cuneatus* (column of Burdach). These are mixed bundles which in the aggregate make up the greater part of the dorsal funiculus (old term, posterior columns). They are made up chiefly of the ascending branches of dorsal root fibers (Fig. 4582), those in the gracilis from the sacral, lumbar, and lower thoracic nerves (Fig. 4592, *S*, *L*, *T* 5–12) and those in the cuneatus from the upper thoracic and cervical nerves (*T* 1–4, *C*) as indicated in Fig. 4592. These fasciculi terminate respectively in the nuclei of the fasciculus gracilis (clava) and cuneatus (tuberculum cuneatum) at the lower end of the medulla oblongata and conduct chiefly impulses of the proprioceptive reflexes and those concerned with sensations of posture, spatial discrimination and the coordination of movements of precision.

Fasciculus dorsolateralis (tract of Lissauer, Lissauer's zone), made up chiefly of unmyelinated fibers from the dorsal roots, together with myelinated and unmyelinated correlation fibers of the fasciculus proprius system.

Tractus spinocerebellaris dorsalis (*fasciculus cerebello-spinalis*, direct cerebellar tract, Flechsig's tract). These fibers arise from the neurones of the *nucleus dorsalis* (Clarke's column of gray matter between the dorsal and ventral gray columns in the thoracic region) of the same side and enter the cerebellum by way of its inferior peduncle (*corpus restiforme*).

Tractus spinocerebellaris ventralis (part of Gowers' tract, or the *fasciculus anterolateralis superficialis* of the BNA). These fibers also arise from the nucleus dorsalis of the same side (A. N. Bruce) in

the lower levels of the spinal cord and enter the cerebellum by way of its superior peduncle (*brachium conjunctivum*).

The spinal lemniscus. Under this name are included several tracts to the midbrain and thalamus. These fibers arise from neurones of the dorsal gray column, cross in the ventral commissure, and ascend in the lateral and ventral funiculi of the opposite side, partly superficially mingled with those of the ventral spinocerebellar tract and partly deeper in the fasciculus proprius. This system of fibers includes a tractus spinotectalis to the roof (tectum) of the midbrain and a tractus spinothalamicus to the ventral and lateral nuclei of the thalamus. The deeper fibers of the latter tract are arranged in two groups, the tractus spinothalamicus lateralis for sensory impulses of temperature and pain, and the tractus spinothalamicus ventralis for sensory impulses of touch and pressure.

Tractus spino-olivaris, fibers arising from the entire length of the spinal cord and terminating in the inferior olive (Goldstein).

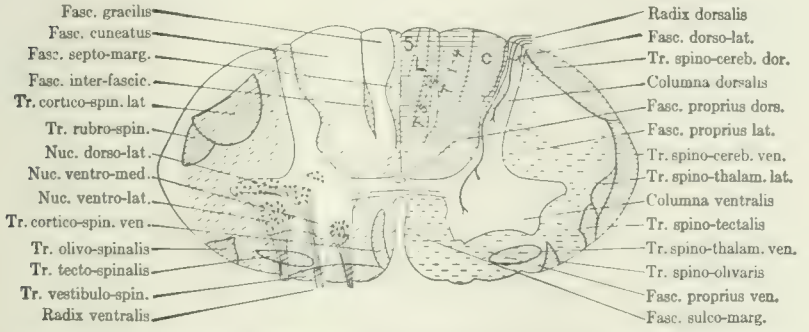

FIG. 4592.—Diagram of a Cross-section through the Human Spinal Cord at the Level of the Fifth Cervical Nerve, to illustrate the arrangement of the fiber tracts in the white matter and of the nerve cells in the gray matter of the ventral column. On the right side the area occupied by the dorsal gray column (posterior horn) is stippled; on the left side some of the groups of cells of the ventral gray column (anterior horn) are indicated. In the white matter the outlines of some of the more important tracts are schematically indicated, ascending fibers on the right side and descending fibers on the left. The same area of white matter is in some cases shaded on both sides of the figure. This indicates that ascending and descending fibers are mingled in these regions. It should be emphasized that none of the tracts are so sharply delimited as here figured, but that their boundaries are indefinite with much mingling of fibers of diverse sorts in the same area of the cross-section. (From Herrick's Introduction to Neurology.)

DESCENDING TRACTS.—Tractus corticospinalis (*fasciculus cerebro-spinalis*, pyramidal tract). This system of fibers conducts voluntary motor impulses from the precentral gyrus of the cerebral cortex to the motor centers of the spinal cord. It divides at the upper end of the spinal cord into two tracts, the larger division immediately crossing through the decussation of the pyramids to the opposite side of the spinal cord, where it becomes the tractus corticospinalis lateralis (*fasciculus cerebrospinalis lateralis*, lateral or crossed pyramidal tract). A smaller number of these fibers pass downward into the spinal cord from the medulla oblongata without decussation to form the tractus cortico-spinalis ventralis (*fasciculus cerebrospinalis anterior*, direct pyramidal tract, column of Türck). These fibers cross in the ventral commissure a few at a time throughout the upper levels of the cord, and finally terminate in relation with the motor neurones of the opposite side. Both parts of the pyramidal tract, therefore, decussate before their fibers terminate.

Tractus thalamo-spinalis. Fibers from the thalamus to the spinal cord were described by Meynert in the fasciculus proprius ventralis and by von Bechterew in the fasciculus proprius lateralis. This connection is denied by others for mammals. There is certainly an important descending system from the thalamus, but whether these fibers reach as far down as the spinal cord must be regarded as unsettled.

Tractus rubrospinalis (tract of Monakow). From the nucleus ruber of the midbrain to the lateral funiculus of the cord for thalamic and cerebellar reflexes.

Tractus tectospinalis (predorsal bundle, tract of Löwenthal). These fibers arise from the roof (tectum) of the midbrain and enter the ventral funiculus of the cord. Part of the fibers of this system pass downward without decussation; others, while still within the midbrain, cross to the opposite side under the aqueduct of Sylvius, forming the dorsal decussation of the tegmentum or fountain decussation of Meynert.

Tractus vestibulospinalis, from the primary centers of the vestibular nerve in the medulla oblongata to the spinal cord, for equilibratory reflexes.

The two tracts last mentioned, together with several others, compose the *fasciculus marginalis ventralis*.

Tractus cerebellospinalis. There has been much controversy regarding the existence of a direct pathway from the cerebellum to the spinal cord without interruption in the brain stem. It seems well established that fibers arising from neurones of the dentate nucleus pass out through the brachium conjunctivum and enter the ventrolateral region of the spinal cord (fasciculus marginalis ventralis).

Tractus olivospinalis (Helwig's bundle, tractus triangularis). These fibers descend from the inferior olive of the medulla oblongata to the lower cervical or upper thoracic segments of the spinal cord in the lateral funiculus.

Fasciculus longitudinalis medialis (posterior longitudinal bundle). Fibers of this important system of the brain stem are known to enter the fasciculus sulcomarginalis of the ventral funiculus of the cord.

Tractus bulbospinalis. This general term may be applied to fibers other than those described above, which descend from the medulla oblongata to the lateral and ventral fasciculus proprius of the cord. Fibers of this sort arise from the motor tegmentum of the medulla oblongata, and others less certainly established have been described as arising in the nuclei pontis and nuclei arcuati.

THE FASCICULUS PROPRIUS.—The fasciculus proprius system of fibers (also called ground bundles and fundamental columns) comprises chiefly short ascending and descending fibers arising from neurones of the spinal gray matter, for intrinsic spinal reflexes. In general these fibers border the gray pattern, but in the dorsal funiculus some are aggregated in the tractus septomarginalis and the fasciculus interfascicularis (comma tract, tract of Schultze), these two tracts also containing descending branches of the dorsal root fibers. Some fibers of the fasciculus proprius ventralis lie adjacent to the ventral fissure and are termed the fasciculus sulcomarginalis, these fibers forming the direct continuation into the cord of the fasciculus longitudinalis medialis (posterior longitudinal bundle) of the brain.

NOTE.—In the preparation of this article free use has been made

of Dr. L. F. Barker's article, *Spinal Cord*, in the second edition of this HANDBOOK.

C. JUDSON HERRICK.

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Spinal Cord, Combined Degenerations of the.—Introduction.—The attitude toward the so-called combined scleroses of the spinal cord has changed with increasing postmortem study and with the general acceptance of the neurone doctrine as applied to pathological processes. The term "system or systemic disease," as formerly applied by Charcot and others, should be modified to include only degenerations of neurones, "systemic neurone disease," whereas the various degenerations, involving chiefly the white matter of the cord, irrespective of neurones, should be differently classified. A failure to recognize this fact, even on the part of recent writers, has led to a very considerable degree of confusion in the nomenclature, especially since lesions of varying extent and character may give rise to very similar clinical symptoms. With the more accurate study which the new conception of the anatomy of the nerve cell has rendered possible, and with a large number of postmortem investigations, it is apparent that the "combined scleroses" are more frequently diffuse in distribution than limited to fiber tracts of functional identity. If, then, the term "combined sclerosis," or "combined disease of the dorsal and lateral tracts," be used, it should be understood that there is no implication that the neurones as such are primarily involved, although the lesions may lie, in part great, in the lateral and dorsal portions of the cord. Doubt has been thrown upon the existence of a true systemic degeneration of the peripheral sensory neurones (dorsal tracts), and the central motor neurones (pyramidal tracts) in the form of a combined disease (Goldscheider), except in certain hereditary affections (Friedreich's ataxia, cerebellar ataxia) and in dementia paralytica. It is certainly far less frequent than formerly believed. In the following discussion, therefore, I shall place chief stress upon diffuse lesions of the cord, predominantly located in the dorsal and lateral tracts, and giving rise to the symptoms of ataxic paraplegia. This is no way denies the possibility of the existence of combined disease which is actually systemic in character.

The following provisional groups may be made:

I. Diffuse (combined) degeneration of the cord; combined sclerosis.

II. True combined dorsal and lateral systemic (neurone) disease.

III. Combined systemic disease. (*a*) Result of congenital defect (Friedreich's ataxia, cerebellar ataxia). (*b*) In dementia paralytica.

I. *Diffuse (Combined) Degeneration of the Cord; Combined Sclerosis; Subacute Spinal Ataxia; Subacute Combined Degeneration of the Spinal Cord; Funicular Myelitis; Combined System Disease.*—Under these varied titles has been included a type of affection which is sufficiently characteristic to have a definite place among the diseases of the spinal cord. Attention has been drawn to the combination of sclerosis of the dorsal and lateral tracts by Kahler and Pick, Westphal, Strümpell, and Oppenheim; the association of such alterations with pernicious anemia and cachectic states has become familiar through the work of Lichtheim, Putnam, Dana, Minnich, Nonne, Burr, Bastianelli, Russell, Batten, Collier, more recently by Billings, Henneberg, Nonne and Fründ, Lenel, and many others. The identity of the lesions in these various conditions is still in dispute; that they vary in detail is of course natural and inevitable; that they represent a general group of alterations which may later be subdivided is, however, at present a supposition, justified by the facts at our disposal. No attempt at subdivision—as, for example, lesions due to anemia or lesions dependent upon general cachexia or toxemia—will be attempted in what follows. Anemia has undoubtedly been given a place of undue importance in relation to these lesions. The insistence upon other and more general causes is due primarily to Putnam's work, published in 1891.

Pathological Anatomy.—The alterations in the cord in this type of disease consist macroscopically in degenerations of the white matter, chiefly in the dorsal and lateral tracts, irregular in distribution, and either not involving whole groups of fibers or extending beyond the confines of such tracts. The dorsal tracts, for example, are affected irregularly, groups of fibers in the immediate neighborhood of much degenerated areas are spared, and the root zones are rarely involved, in striking contrast to the systemic degeneration of tabes. The region of the pyramidal tracts is often much involved, but the alterations always extend beyond the confines of these tracts, chiefly along the peripheral portions of the cord, and on either side of the ventral fissure. The alterations are least marked in the lumbar region, and increase markedly in extent in the upper thoracic and cervical regions. Even to the naked eye the stained section often presents a peculiar, vacuolated appearance. Microscopic examination of the lesions shows the alterations to be essentially limited to the cord, with exceedingly slight alterations of the oblongata or hemispheres. The lesions are characterized by disintegration of myelinated fibers, overgrowth of neuroglia, in part sufficient to form a dense sclerosis and in part slight, vacuolation being due apparently to dilating and degenerating myeline sheaths, many fat granule cells, irregularity of distribution, often with very small foci of degeneration, scattered irregularly through the white matter, and at times focal softening. The gray matter has been found involved in certain cases, but usually is not, the nerve roots are not involved; there is no evidence of meningeal thickening, and the blood-vessel walls rarely show changes. The pathological features common to the general group may, therefore, be summarized as follows:

1. A diffuse degeneration for the most part limited to the cord, often in more or less discrete patches.

2. A constant involvement of the dorsal and lateral columns, without strict regard to neurone systems.

3. A predominance of the lesion in the cervical and thoracic regions.

4. The common freedom from degeneration of nerve roots, both motor and sensory, and peripheral nerves.

5. The essential non-involvement of gray matter.
6. Insignificant vessel changes.

The reason for the peculiarly constant location of the lesions is probably to be sought in the distribution of the blood supply to the cord, a theory first advanced by Marie. Those who cling to the systemic character of the affection are inclined to search for a more subtle explanation, but the involvement of the cord alone, the tendency toward a peripheral distribution of the lesions, the non-involvement of gray matter, and the frequent occurrence of the disease in impoverished blood states, all indicate the rôle of the blood-vessels and their contained blood. Certain writers have maintained a double lesion, one of diffuse character and the other systemic, with possible secondary degenerations.

Etiology.—The persons in whom the disease occurs in typical form are usually of middle age, weak constitution, often with neurotic personal or family antecedents, of poor nutrition, cachectic in appearance, and of reduced bodily vigor. It is considerably more frequent in women than in men, according to Putnam's statistics. A recent statistical study, however, by G. H. Bigelow of 127 cases from the Neurological Department of the Massachusetts General Hospital, in which the clinical diagnosis of ataxic paraplegia was made, gives a very decided proponderance of men over women, a ratio of about two to one. These statistics likewise show, contrary to the generally accepted opinion, that syphilis occurs in a large proportion of the cases, forty-three in the series studied, which must be regarded as much more than a coincidence. A frequent though by no means universal accompaniment or possible cause of the disease is anemia of the pernicious type. This association has led to the popular but wholly erroneous assumption that the alterations of the spinal cord described above are peculiar to anemia. Lead poisoning, malaria, grave secondary anemia, pellagra, and other debilitating influences have also been given as causes, and the disease has at times occurred in otherwise healthy individuals. Overwork, excessive anxiety, gastrointestinal disorders, may have a predisposing influence. Further than this our accurate knowledge does not go. Whether or not a subtle toxemia, of a character as yet not understood, may ultimately be found responsible is possible, but far from being proved. It may at least be said with assurance at the present time that a well-characterized affection of the cord occurs in cachectic individuals toward middle life, leading to diffuse, quasi-systemic degenerations, depending, in part at least, upon the distribution of the vascular supply.

Symptomatology.—In general, during the early stages, the symptoms are somewhat vague in character and may simulate functional disorders. The most conspicuous early symptom is paresthesia of the extremities, noticed earlier in the feet. Disordered sensations may occur in other portions of the body—genitals, distributions of cranial nerves—but are much less usual. This paresthesia is frequently very distressing. Disorders of micturition (twenty-two cases in the Massachusetts General Hospital series) and rarely of defecation may occur. Objective disorders of sensation are not conspicuous, though they certainly occur, and in a well-reported group of cases (Russell, Batten, Collier) take an important place in the later stages of the clinical picture. Disorders of motion are of the character of a slight spastic paraplegia, with exaggerated deep reflexes, and the Babinski phenomenon. As the disease progresses, the symptom-complex assumes the general character of an ataxic paraplegia, with a predominance of ataxia or paraplegia depending upon the greater involvement of the dorsal or lateral columns (ataxia, twenty-two cases; weakness, thirty-one cases; paresthesiæ, forty-nine cases, Massachusetts General Hospital series). In later stages, as the lumbar portion of the cord is invaded, the knee-jerk may be abolished, and the patient be reduced to a helpless paraplegic condition, with loss of sphincter control. Arm symptoms occur less frequently, but still in a definite proportion of the cases. In a broad classification predominant spastic or ataxic conditions occur in about equal number. The mind is rarely affected, and the cranial nerves show no noteworthy involvement. Pigmentation of the skin, epileptic attacks, excessive diarrhea or constipation, atrophy of the optic nerve, Argyll-Robertson pupil, mental instability, dissociation of sensation, pain in the back and limbs, transient edema, muscular atrophy, altered electrical reactions, have all been described as occasional symptoms.

Certain writers, notably Bastianelli and Russell, Batten and Collier, have attempted to classify cases either by etiology (Bastianelli) or by symptomatic course (Russell, et al.). The latter divide the disease sharply into three stages: first, slight ataxic paraplegia, constituting one-half to three-quarters of the duration of the illness; second, sudden loss of sensation, with increasing motor paresis, leading to inability to walk or stand, marked spastic paraplegia; third, stage of flaccidity, flaccid paraplegia, complete flaccid motor paralysis, complete anesthesia, with loss of deep reflexes, incontinence, wasting of muscles, and loss of faradic reaction. In the experience of others these sharp divisions cannot be maintained; such a course evidently marks a variety of the general affection, which is highly important, but cannot be regarded as characteristic of the entire group. In general, it must be said that on the symptomatic side attempts to deduce a perfectly characteristic clinical picture have as yet failed, although the grouping of the symptoms of primary paresthesia, ataxic paraplegia increasing rather rapidly in intensity, followed by a stage of more or less complete motor and sensory paralysis, in the absence of lancinating pains and Argyll-Robertson pupil, point strongly toward combined lesions of the character under consideration.

Diagnosis, Course, and Prognosis.—The diagnosis in the later stages should not be difficult, and in the early stages should be assumed as probable in cases in which an otherwise unexplained and persistent paresthesia, especially of the legs, is associated with slight ataxia and a tendency toward spasticity with exaggerated deep reflexes, particularly if the patient be of middle age, with evidences of cachexia. Multiple sclerosis may simulate this affection at various stages, but in general the former disease may be distinguished by the youth of its victims, the characteristic speech defect and tremor, with a marked preponderance of motor over sensory involvements. Myelitis should also receive consideration in the differential diagnosis. Uncomplicated tabes should give rise to no confusion.

The course of the disease is from six months to two years, with frequent instances of much longer duration. As a rule, the patients are already in a debilitated condition when the symptoms manifest themselves, a fact which evidently must have a more or less direct bearing upon the outcome.

The prognosis is always bad, both from the point of view of the general condition of the patient and also because of the usually rapidly advancing cord degenerations.

Treatment.—Attention should first be directed toward the discovery and amelioration of the underlying condition causative of or associated with the alterations in the cord. Anemia, whether of the so-called pernicious variety or secondary, general debility, and disordered bodily functions in general, should be treated by the recognized means at our disposal. It is possible that much might be done in the earliest stages to avoid or modify the serious and ultimately irremediable cord degenerations. If they

have developed, however, and the patient is ataxic, or ataxic paraplegic, recourse should certainly be had to the Frenkel exercises, modified to meet the indications in individual cases. The usual drugs—iron, strychnine, arsenic, the iodides, etc.—may be given, but with small hope of permanent benefit.

II. *Combined Dorsal and Lateral Systemic (Neurone) Disease.*—In spite of the doubt which has been thrown upon the existence of a true neurone degeneration involving dorsal and lateral tracts, cases have been reported clinically, and in a few instances anatomically verified, of the existence of such a combined lesion (Oppenheim). Degenerations of the columns of Goll and Burdach, the pyramidal tract, the direct cerebellar tract, and less frequently of Gowers, and the uncrossed pyramidal tracts, have been described, with the assumption that these tracts were degenerated as systems and not as a part of a more general process.

Such cases of primary degeneration of lateral and dorsal neurone systems give rise to the symptoms of tabes and lateral sclerosis, the one or other type of symptom predominating in direct relation to the extent of the dorsal or lateral pathological change. Symptoms of tabes, with lancinating pains and Argyll-Robertson pupil, but with exaggerated knee-jerk, should always give rise to a strong suspicion of a combined systemic degeneration, giving the general clinical picture of ataxic paraplegia. Should the definite signs of tabes, including loss of knee-jerk, be associated with muscular weakness, a similar diagnosis of combined lesion is justified. The signs of tabes, on the other hand, may be in great measure subordinated to those of lateral degeneration—spastic paraplegia. In this case slight disorders of sensation, sharp pains, condition of the pupils, bladder weakness, should be carefully investigated to determine the possible involvement of sensory neurones. Ataxic paraplegia, as commonly observed, is no doubt usually due to the more diffuse process described above. The important differential point is the existence of a true tabes, which does not occur in the diffuse combined lesions.

The treatment is as indicated for the foregoing disease, and for Friedreich's ataxia.

III. *Combined Systemic Disease.*—(*a*) *Result of congenital defect (Friedreich's ataxia); cerebellar ataxia; hereditary cerebellar ataxia;* (*b*) *in dementia paralytica.*

(*a*) *Friedreich's Ataxia.*—See article on this subject.

Cerebellar Ataxia.—Hereditary cerebellar ataxia, type Nonne-Marie, bears a close resemblance to Friedreich's ataxia, except for the facts that the knee-jerks are increased, the pupils are immobile, there is atrophy of the optic nerve, there are marked disorders of sensibility, and club-foot and kyphosis do not develop. Lesions of the cerebellum and other portions of the brain have been found, and in one case (Menzel) a combined system disease of the cord.

(*b*) *Combined Systemic Disease in Dementia Paralytica.*—Alterations of the spinal cord (Westphal), in the form of degeneration of the pyramidal tracts or of the dorsal, sensory tracts, or of both, are frequent in dementia paralytica. Whether the alterations in the pyramidal tracts are to be regarded as primary neurone degenerations or as secondary to changes in the cortex remains in doubt.

Gowers' Ataxic Paraplegia.—In 1886 Gowers drew attention to a condition presenting the symptoms of degeneration in the dorsal and lateral tracts, to which the clinical name ataxic paraplegia was given. The classification of this condition is difficult, but from the description of the pathological alterations it should rather be included among the diffuse combined degenerations than among the true systemic diseases. After what has been said it does not require separate description.

E. W. Taylor.

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Spinal Cord, Congestion of the.—Our actual knowledge regarding spinal congestion is very limited, and hypothetical statements that it is the basis of many nervous symptoms are unwarranted. The diseases in which it is uniformly found after death are those in which the patient has died in convulsions complicated by asphyxia, or in the early stages of myelitis. The only positive evidence that a spinal congestion has existed during life is the discovery of distended capillaries, accompanied by small capillary hemorrhages. Without the latter the congestion found may have been a postmortem occurrence, due to the position of the body on the back.

The *causes of active congestion* are excessive muscular exertion, violent sexual excesses, poisoning by strychnine, alcohol, and carbonic oxide, the sudden arrest of menstruation or the stoppage of hemorrhage from piles, and possibly exposure to cold. Traumatism of the vertebræ, especially general concussion of the spine, such as occurs in railway injuries, probably causes active spinal hyperemia, in a few cases examined capillary hemorrhages having been found in the cord after death. It is probable that spinal congestion is usually localized in the lower half of the cord, though the entire organ may be affected. An active hyperemia of the anterior cornua is the first occurrence in poliomyelitis anterior, and this is usually quite extensive, while the actual process of inflammatory degeneration is subsequently limited to a small area. The latter produces the permanent atrophic paralysis of infants; to the former must be ascribed the temporary paresis of the first stage of the disease, which is always more extensive than the permanent paralysis.

The *causes of passive congestion* are the same as those producing this effect in the brain or other organs (*q.v.*).

The *symptoms* of spinal congestion are a sensation of weight and fatigue in the legs and back, increased by any effort, so that continued exertion is impossible; pains, numbness, formication, and sensations of heat and cold, with increased susceptibility to changes of temperature and to pain and touch in the extremities; weakness, but not paralysis, in the entire muscular system, attended by an increase of reflex excitability; a diminution of sexual power, and a diminution of control over the bladder and rectum not sufficient to be termed incontinence. Any symptoms more serious than these, such as severe tearing pains in the back and general hyperesthesia, or such as girdle sensations, incontinence, and actual paralysis, must

be ascribed to congestion of the spinal meninges as well as of the cord, or to disturbances of a grave nutritive kind initial to an actual myelitis. These symptoms are always bilateral and usually more marked in the lower half of the body, although the arms may become involved. They usually come on suddenly after some known cause; but occasionally a chronic congestion is suspected, which lasts for months, and is attended by symptoms of neurasthenia.

The *diagnosis* of spinal congestion is an uncertain one. When symptoms such as those described appear, and do not go on to more serious conditions, but gradually pass off, and no adequate cause can be found, the diagnosis can be made. If, however, serious symptoms of myelitis ensue, it must be admitted that the disease was myelitis from the outset and not a simple hyperemia. A long duration of symptoms of spinal congestion points rather to the existence of capillary hemorrhages, attended by small foci of inflammatory degeneration, or to nutritive changes in the spinal cord.

The *prognosis* should always be reserved, in view of the uncertainty of diagnosis and the possibility of myelitis.

The *treatment* should consist of absolute rest in bed, in a prone position; the application of cool cloths, wet with an evaporating lotion, to the spine, or an ice-bag or the ether spray; saline purgatives; and full doses of ergot with small doses of belladonna.

M. Allen Starr.

Spinal Cord, Diagnosis of Local Lesions in the.—The spinal cord is a long, cylindrical organ, made up of numerous segments, each of which not only has a function of its own, but also bears an important part in relation to the functions of other segments. Each segment of the cord consists of a mass of gray matter, surrounded by a series of white tracts, from which passes out a pair of spinal nerves. In some of the lowest order of vertebrata the comparative independence of each segment is indicated by the fact that the spinal cord consists of a series of bulbous enlargements joined together by only a few connecting fibers. And even in man there are some evidences that the functions of each segment of the cord are independent of all others. But in the higher vertebrata the various segments are closely united to one another, and are also connected with the brain, which controls them all by means of the white tracts surrounding the gray matter. Hence, in addition to its own special function as a nervous center, each segment has functions of transmission of impulses to adjacent segments and to distant parts of the nervous system. Therefore, in dealing with local lesions in the spinal cord, the first point to determine is whether the lesion involves the nerve centers of a single segment, or the tracts which pass through that segment to other centers. In the first case, when the gray matter of a single segment is affected, the symptoms are limited in extent and in number, consisting of localized paralysis, limited anesthesia, loss of certain reflexes, disturbance of certain automatic actions, and local vasomotor and trophic disturbances. In the second case, when the white matter of a single segment is affected, the symptoms are widespread and numerous, consisting of partial or complete paraplegia, anesthesia of the lower half or even of the entire body, loss of control over reflex and automatic activity, and extensive vascular and trophic changes. And when both gray and white matter of a single segment are totally involved, there will be a combination of local and general symptoms, the distribution and extent of which will depend wholly upon the particular level of the segment of the cord which is affected. It is therefore evident that the first step in the diagnosis of local lesions of the spinal cord is the determination of the functions of the various segments, and of the various tracts which pass through them.

I. The Functions of the Segments of the Spinal Cord.—Each segment of the spinal cord consists of that portion of the entire organ which gives origin to one pair of spinal nerves. There are, therefore,

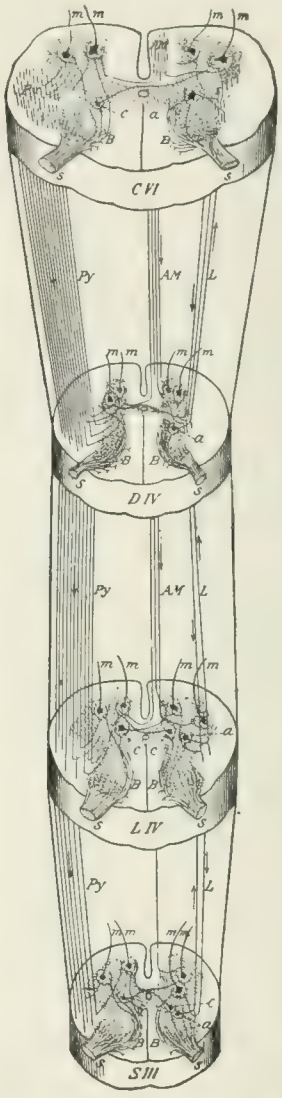

Fig. 4593.—Diagram of Four Segments of the Spinal Cord to Show the Motor Mechanism. *C VI*, Sixth cervical, *D IV*, fourth dorsal, *L IV*, fourth lumbar, *S III*, third sacral segments; *s*, sensory nerve root whose fibers enter the root zone of the column of Burdach, *B*, and then pass into the gray matter terminating about (1) motor cells whence motor fibers (*m*) issue as motor nerve roots; or (2) about association cells (*a*) whose fibers pass in the lateral column *L*, to other levels of the cord, or (3) about commissural cells (*c*), whose fibers cross the cord associating the two sides. *Py*, Pyramidal tract; *AM*, anteromedian tract conveying motor impulses from the right hemisphere of the brain to the motor cells of the cord.

thirty-one segments in the human cord. There is no natural division between adjacent segments, but if a cord with its nerves be carefully removed, there will be no difficulty in cutting it up into segments, each of which will receive two afferent and give off two efferent nerves. Each segment is made up of two symmetrical halves, naturally separated by

LOCALIZATION OF THE FUNCTIONS OF THE SEGMENTS OF THE SPINAL CORD.

Segment.	Muscles.	Reflex.	Sensation.
Second and third cervical	Sternomastoid, trapezius.	Hypochondrium (?).	Back of head to vertex.
	Scaleni and neck.	Sudden inspiration, produced by sudden pressure beneath the lower border of the ribs.	Neck.
	Diaphragm.		
Fourth cervical	Diaphragm.	Pupil, fourth to seventh cervical.	Outer part of shoulder.
	Deltoid.	Dilatation of the pupil produced by irritation of neck.	
	Biceps, coracobrachialis.		
	Supinator longus.		
	Rhomboid.		
	Supra- and infraspinatus.		
	Levator anguli scapulæ.		
Fifth cervical	Deltoid.	Scapular.	Back of shoulder and arm.
	Biceps, coracobrachialis.	Fifth cervical to first dorsal.	Outer side of arm and forearm.
	Supinator longus.	Irritation of skin over the scapula produces contraction of the scapular muscles.	
	Supinator brevis.		
	Deep muscles and shoulder blade.	Supinator longus.	
	Rhomboid, teres minor.	Tapping its tendon in wrist produces flexion of forearm.	
	Pectoralis (clavicular part).		
	Serratus magnus.		
Sixth cervical	Biceps, brachialis anticus.	Triceps.	Outer side of arm and forearm.
	Pectoralis (clavicular part).		
	Serratus magnus.	Tapping elbow tendon produces extension of forearm.	Outer half of hand.
	Triceps.	Posterior wrist.	
	Extensors of wrist and fingers.	Sixth to eighth cervical.	
	Pronators.	Tapping tendons causes extension of hand.	
		Scapulohumeral.	
		Tapping the lower edge of the scapula causes adduction of the arm.	Front, back of arm and forearm. Middle and ring fingers.
Seventh cervical	Triceps (long head).	Anterior wrist.	
	Extensors of wrist and fingers.	Seventh to eighth cervical.	
	Pronators of wrist.	Tapping anterior tendon causes flexion of wrist.	
	Flexors of wrist.		
	Subscapular.		
	Pectoralis (costal part).		
	Latissimus dorsi.		
	Teres major.		
Eighth cervical	Flexors of wrist and fingers.	Palmar, eighth cervical to first dorsal.	Forearm and hand; ulnar area.
	Intrinsic muscles of hand.	Stroking palm causes closure of fingers.	
First dorsal	Extensors of thumb.		Inner side of forearm.
	Intrinsic hand muscles.		
	Thenar and hypothenar eminences.		
Second and twelfth dorsal	Muscles of back and abdomen.	Epigastric, fourth to seventh dorsal.	Skin of chest and abdomen, in bands running around and downward, corresponding to spinal nerves.
	Erectores spinæ.	Tickling mammary region causes retraction of the epigastrium.	
		Abdominal, seventh to eleventh dorsal.	
		Stroking side of abdomen causes retraction of belly.	
First lumbar	Quadratus lumborum.	Cremasteric, first to third lumbar.	Skin over groin and in front of scrotum.
	Transversalis, Obliqui.	Stroking inner thigh causes retraction of scrotum.	
	Iliopsoas.		
	Sartorius.		
Second lumbar	Iliopsoas, sartorius.	Patella tendon.	Outer side of hip. Front of thigh.
		Striking tendon causes extension of leg.	
	Quadriceps femoris.		
Third lumbar	Quadriceps femoris.		Front of thigh. Inner side of leg.
	Inner rotators of thigh.		
	Obturator.		
	Adductors of thigh.		
Fourth lumbar	Abductors of thigh.		
	Abductors of thigh.		
	Flexors of knee.	Gluteal.	
		Fourth to fifth lumbar.	
		Stroking buttock causes dimpling in fold of buttock.	Outer and back side of thigh and front of leg to ankle.
Fifth lumbar	Glutei.	Achilles tendon.	Dorsum of foot.
	Biceps femoris.	Overextension causes rapid flexion of ankle, called ankle clonus.	
	Semi-tendinosus.		
	Popliteus.	Babinski reflex. Scratching sole of foot causes extension of great toe.	Leg and foot, outer part.
	Outward rotators of thigh.	Fifth lumbar to first sacral.	
	Flexors of knee.	Plantar.	
First and second sacral	Biceps femoris.	Tickling sole of foot causes flexion of toes and retraction of leg.	
	Semi-membranosus.		
	Extensor longus digitorum.		
	Gastrocnemius.	First to third sacral: Mendel's reflex, tapping the tendon of the toe causes flexion or extension of the toes.	Back of thigh and leg in saddle-shaped area. Inner side of foot.
	Tibialis posticus.	Gordon's reflex; deep pressure on the muscles of the calf causes extension of the toes.	
	Tibialis anticus.		
Third sacral	Peronei.	Oppenheim's reflex; stroking the outer side of the leg near the tibia causes retraction of the toes.	Back of buttock, seat.
	Intrinsic muscles of foot.		
Fourth and fifth sacral	Sphincter ani et vesicæ.	Fourth and fifth sacral: Bladder and sacral centers.	Perineum, anus.
	Perineal muscles.		Back of scrotum.

the anterior fissure and posterior septum, but joined by a commissure.

The afferent or sensory nerves enter the posterior surface of the segment, and, passing through the white matter, end in the gray. The efferent or motor nerves pass out from the anterior surface of the segment, having their origin in the anterior gray horn, and traversing the white matter bordering these horns. The diagram (Fig. 4593) shows four such segments at different levels of the cord with their afferent (*s*) and efferent (*m*) nerves as well as the motor tracts to and association tracts between the various segments.

A. The Gray Matter.—The size and shape of the area of gray matter, seen in horizontal section of the cord, differ in almost every segment, the differences between adjacent segments being more marked in the cervical and lumbar enlargements than in the dorsal region. The shape of the area of gray matter in the dorsal region resembles that of the letter **H**, and, accordingly, anatomists describe two lateral halves with a central gray commissure between them, and in each half an anterior and a posterior horn. In the enlargements of the cord the mass of the horns is much larger than in the dorsal region, and the shape varies in each segment. The amount of gray matter in any segment depends upon the number of cells in the anterior and posterior horns. These cells are not scattered irregularly through the gray matter, but are collected into groups. These groups are quite distinct in the anterior horns, in some cases

Fig. 4594.—Showing the Different Grouping of the Cells in the Gray Matter of the Spinal Cord at Three Different Levels. (Drawn from photographs.)

being small, and found only in a single segment; in others being long, and extending through several segments. This varying arrangement of the anterior groups at different levels is seen in the figure (Fig. 4594). The function of the cells in the anterior horn is to govern the motion and nutrition of the muscles.

The more exact localization of motor functions in the groups of cells in the cervical and lumbar enlargements has been attempted by various writers. Fig. 4594 shows the groups found at three different segments of the cord. There are some of these groups—viz., the inner anterolateral and posterolateral groups—which develop early in fetal life, and are common to man and the less highly developed vertebrates. These are thought to govern the fundamental movements common to man and animals, and earliest acquired in children, viz., flexion and extension, abduction and adduction of the limbs. Other groups, viz., anterior and median groups, are found only in monkeys and man, and the central groups in man alone. These are also found to develop later than the others. They are therefore thought to govern the accessory movements, which are more specialized and depend on finer adjustment, such as the act of walking upright, pronation and supination, and the finer motions of the hands and fingers, actions which are learned some months later than those of a fundamental kind. In some cases of disease, limited to these groups of cells—*e.g.* poliomyelitis anterior—the symptoms have been found to justify this distinction, loss of power and atrophy of certain muscles being produced by a lesion in certain groups of cells. The connection of the different groups, in various segments, with individual muscles, as far as at present known, is shown in the table accompanying this article. (See page 859.)

The arrangement of cells in the posterior horns is different from that in the anterior horns. There is a column of cells extending through the lower dorsal region, known as the vesicular column of Clarke, and situated in the median and inner part of the horn (see Fig. 4593, *c*). The column begins in the third lumbar segment, and extends upward to the seventh dorsal segment. Its probable function is to receive these impulses from the muscles and joints which guide the automatic and voluntary acts tending to preserve the balance in standing and walking. There is a continuous column of cells in the middle of the posterior horn, not collected together into groups, but scattered through the neuroglia and gelatinous substance of the posterior horn. These cells are very small in size, and thus contrast markedly with those already described. It is probable that the gelatinous mass in the posterior horn has something to do with the sensory function, for it is present in the nervous system wherever a sensory nerve ends. The sensations of touch, temperature, and pain are carried into the posterior horns by the posterior nerve roots, which terminate in the gelatinous substance and in cells which lie about the central canal of the cord in the gray matter at the junction of the posterior and anterior horns (Fig. 4595, *X*).

All the cells of the gray matter give off branching processes which interlace, forming a dense network of nerve fibrillæ around the groups of cells. This interlacing mass of fibers is composed partly of the dendrites of cells which collect impulses, and partly of the axones of cells which send out impulses. These axones in their passage through the gray matter send off little fibrillary branches termed collaterals, which terminate in end-tassels about other cell bodies. Through this gray matter impulses pass in all directions, uniting the functions of the various cell groups, and of the sensory and motor areas of the cord. It is probable that impulses coming to the segment, either from the periphery or from the brain, are conveyed directly to the cells of the segment, and are distributed through the medium of the branches of the cells to several groups of cells.

Furthermore, each segment controls in some degree the processes of nutrition in the part of the body with which its sensory nerves are connected.[1] It regulates the vasomotor tone in the organs and limbs, and it influences processes of growth and repair in the skin and mucous membranes. But the existence of trophic cells in the cord has not been proven. Nor can the automatic mechanisms of the cord be assigned to definite cells. They can only be referred to the gray matter of certain segments.

The function of the gray matter of the individual segments is shown in the preceding table. The facts upon which this table has been prepared are gathered from comparative anatomy, from physiological experiment, and from pathological observation. The level of the segment is given; the muscles governed by the groups of cells in it are mentioned so far as they are at present known; the reflex and automatic mechanisms governed by each segment are recorded, and the manner of producing the reflex acts; and the area of skin which sends its sensory nerves to the individual segments is described. Plate LVI shows the area of skin related to each segment.

B. The White Tracts.—The gray matter of the spinal segment is surrounded by white nerve tracts, whose function is the transmission of impulses between adjacent and distant segments, and between the various segments and the brain. These tracts are quite numerous, and although in the normal adult cord they cannot be distinguished from one another, there are several means by which their limits are determined. Thus in fetal cords of various ages different tracts can be distinguished by

EXPLANATION OF
PLATE LVI.

EXPLANATION OF PLATE LVI.

The segments of the spinal cord are numbered: *CI* to *CVII*, *DI* to *DXII*, *LI* to *LV*, *SI* to *SV*; and these numbers are placed, in the plate, on the region of the skin supplied by the sensory nerves of the corresponding segment. In order to determine, in any given case of spinal-cord disease, the level of the cord affected, it is necessary to test the sensations and to compare the area of anesthesia with the diagram here given. It is to be remembered, however, that the skin of the body is plentifully supplied with sensory nerves which anastomose freely at their terminations, and the researches of Sherrington have demonstrated that each part of the skin is supplied with sensory nerves from two adjacent segments of the cord. Hence a condition of anesthesia in the skin indicates a suspension of function of two segments of the cord at least, for if one segment alone were affected the segments above and below it would be capable of supplying the skin with sensation.

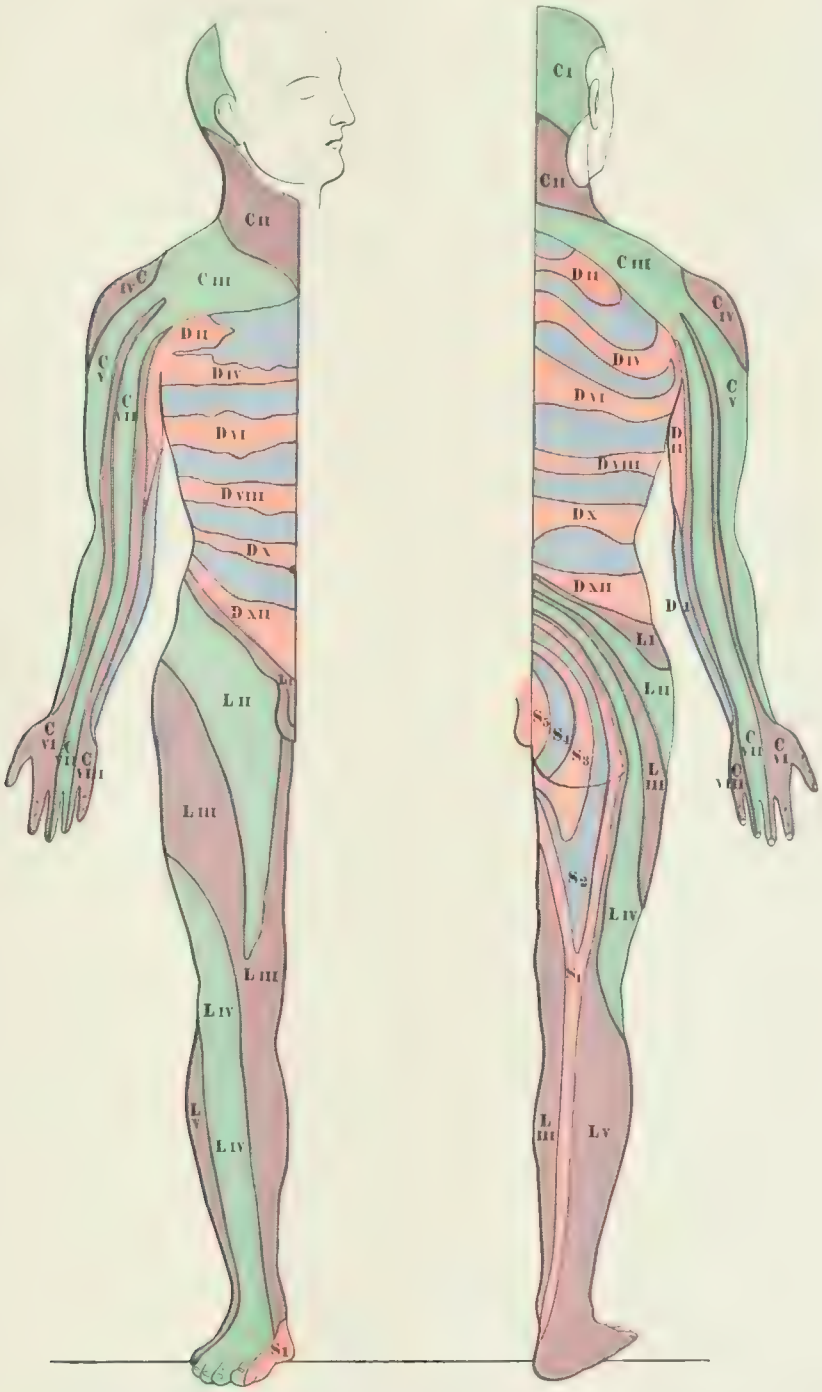

PLATE SHOWING THE AREAS OF THE SURFACE OF THE BODY WHICH ARE RELATED TO THE VARIOUS SEGMENTS OF THE SPINAL CORD

c, cervical: *d*, dorsal: *l*, lumbar: *s*, sacral. When a segment of the cord is destroyed the surface of the body is anæsthetic in the area corresponding to that segment.

(*From Dr. M. Allen Starr*)

the fact that they develop at different times. And in diseased cords pathological processes are often strictly confined to certain tracts. This is especially true of the processes known as secondary degenerations, by means of which the exact boundaries, the length,

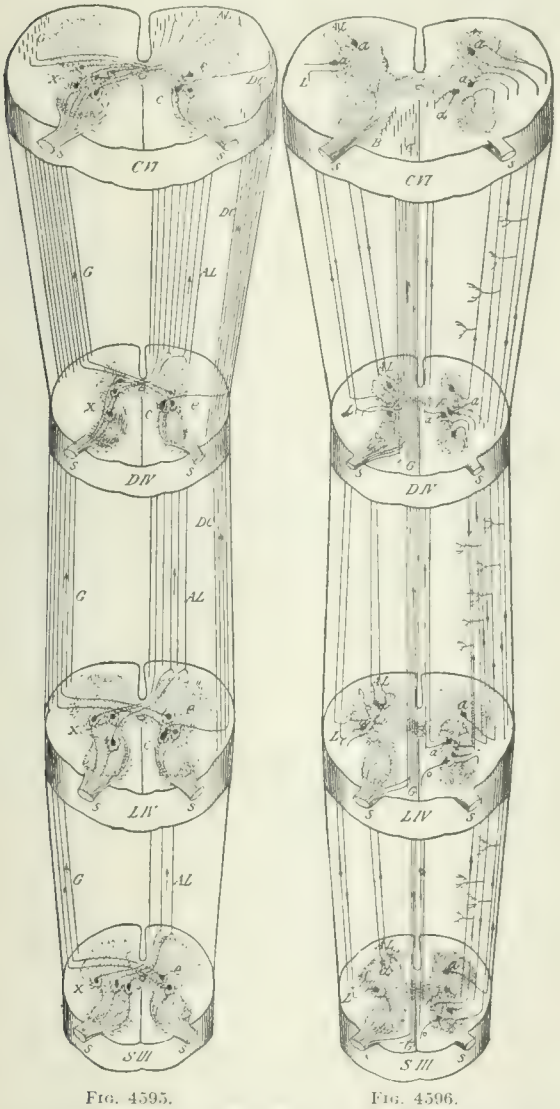

Fig. 4595.

Fig. 4596.

Fig. 4595.—Diagram of Four Segments of the Spinal Cord to Show Sensory Mechanism and Conduction. *S*, sensory nerve root; *G*, column of Gowers; *AL*, anterolateral column; *DC*, direct cerebellar column; *C*, cells of the column of Clarke sending fibers to *DC*; *X*, cells of the sensory gray matter sending fibers to *AL*; *e*, cells of the sensory gray matter sending fibers to *G*.

Fig. 4596.—Diagram of Four Segments of the Spinal Cord to Show Sensory Conduction and Association Fibers. *S*, Sensory nerve root; *G*, column of Goll; *B*, column of Burdach; *L*, lateral column; *AL*, anterolateral column; *a*, association cells sending axones into various columns which ascend or descend, terminating in end-tassels about other cells in the gray matter. These axones send off collaterals at many levels. In this cut, as well as in Figs. 4593 and 4595, the direction of impulses is indicated by the arrows.

and the function of the various tracts have been ascertained. The older division of the columns of the cord into anterior, lateral, and posterior must be set aside in favor of the late divisions founded on these facts.

In a cross-section of the cord at the cervical region the following tracts are seen in each half of the segment:

1. *The Motor Tracts* (Fig. 4593, *Py*, *AM*), two in number, which come through the anterior pyramids of the medulla, from the motor region of the cerebral cortex on either side of the fissure of Rolando. It will be remembered that the pyramids of the medulla decussate partially just at the upper limit of the spinal cord.[2] The majority of the fibers of each pyramid cross the median line to the lateral column of the spinal cord. The remainder pass directly onward into the anterior column. Those that cross over are called the crossed pyramidal tract. Those that do not cross are called the direct or anterior pyramidal tract, or column of Türck. The latter lies along the side of the anterior fissure of the cord, and is called the anterior median column (Fig. 4593, *AM*). The former lies in a triangular space in the posterior part of the lateral column, bounded by other tracts on all sides (Fig. 4593, *Py*). These motor tracts differ somewhat in size in different cords. When only a few fibers from the medulla cross over, the anterior median column is large and the opposite lateral pyramidal tract is small; but this is the exception. As a rule the lateral tract is three times the size of the anterior one. They differ also in length; for the anterior median column only extends to the lower lumber region, but the crossed pyramidal tract extends to the very lowest segment of the cord. They both send in their fibers to the anterior gray horns of the cord at all levels, and therefore decrease in size as they pass downward. They both transmit voluntary impulses from the brain to the anterior motor cells of the cord (Fig. 4593, *m*), a single nerve fiber in the motor tract carrying an impulse which reaches several groups of cells. They both degenerate downward after any lesion which cuts them off from their nutrient cells in the cerebral cortex. If that lesion is in the brain on one side, the anterior median column on that side, and the crossed pyramidal tract on the opposite side, will be degenerated in the cord. If the lesion is in the cord on one side, both motor tracts on that side will degenerate downward. If the lesion divides the entire cord, the degeneration will be bilateral in both columns. These motor tracts transmit not only voluntary impulses, but also inhibitory impulses, which hold in check the reflex activity of the spinal centers. Hence a lesion in their course produces not only paralysis, but also a loss of control over the bladder and rectum, and an increase in the spinal reflex activity.

2. *The Association Tracts* (Fig. 4596).—Each spinal segment has been shown to have functions of its own. But the different segments always act in harmony, and in hardly any act, either motor or sensory, is any segment independent of the rest. Hence a large part of the white matter of the cord contains fibers, shorter or longer, joining the various segments with one another, and associating their actions. The cell bodies which give origin to these fibers lie in the various parts of the gray matter, and send fibers both up and down in all the columns. These fibers give off collaterals in their course. The fibers lie about the anterior horns of the cord, on their different sides, making up together a large anterolateral column which has been divided into an anterior column (Fig. 4596, *AL*), and a general lateral column, the latter having a portion between the crossed pyramidal tract and the outer surface of the gray matter which has been called the lateral limiting layer (Fig. 4596, *L*). Some association fibers also pass in the posterior columns adjacent to the posterior commissure. All these tracts are about the same size at all levels of the cord, thus differing from the motor tracts, which decrease in size from above downward, and from the sensory tracts, which increase in size from below upward. They degenerate but a short distance in any transverse lesion of the cord. They

degenerate both upward and downward. It should not be forgotten that the anterior nerve roots pass out of the cord through the anterior column, and that many of these roots pass upward or downward for some distance before making their exit. Hence the anterolateral column is not wholly made up of association tracts. There is no form of disease limited to the association tracts exclusively, hence it is impossible to bring any known symptoms into connection with the lesion when they are affected in a general myelitis.

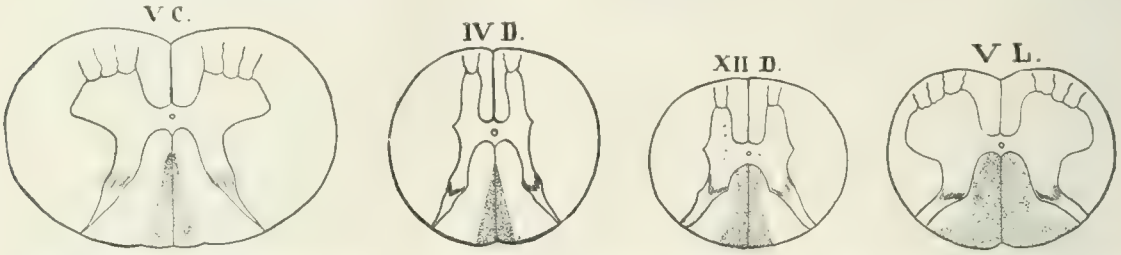

FIG. 4597.—Area of Ascending Degeneration in the Posterior Columns after Compression of Cauda Equina, Involving the Sciatic Nerve Roots only.

3. *The Sensory Tracts.*—These occupy the posterior columns of the cord, of which there are two on each side of the posterior median septum, viz., the posteroexternal column, or column or Burdach, and the posteromedian column, or column of Goll. They also pass in the lateral columns of the cord, in the anterolateral ascending tract or column of Gowers, and in the direct cerebellar column. The column of Burdach is made up very largely of the posterior nerve roots which enter it and pass upward or downward for some distance before leaving it, to end in the posterior gray horn, or to enter the column of Goll (Fig. 4596, *B*). The column of Goll is made up wholly of long fibers extending from the posterior nerve roots to the medulla (Fig. 4596, *G*). The exact areas taken up respectively by the short posterior roots and the long fibers differ greatly at different levels, and they have only recently been determined by a study of the tracts degenerated after transverse lesions at different levels. These recent investigations deserve a moment's notice.

lumbar region, a smaller area in the dorsal region lying wholly in the column of Goll, and the posterior median portion only of the column of Goll in the upper dorsal and cervical regions (see Fig. 4597). When all the nerve roots of the cauda equina, including both sacral and lumbar nerves, are compressed and destroyed, the ascending degeneration occupies a somewhat larger area than in the first case, involving both posterior columns as high as the middle of the dorsal region and a large part of the column of Goll in the cervical region (see Fig. 4598). When a transverse lesion of the cord in the dorsal region cuts off all sensory conduction from below the level of the middorsal region, the area of ascending degeneration is still larger than in the first two cases, and in the cervical region involves the entire column of Goll (see Fig. 4599). When the cord is divided in the lower part of the cervical enlargement, the ascending degeneration involves a very large area, including both the entire column of Goll and a part of the column of Burdach in the upper cervical region (see Fig. 4600).

From these facts it becomes evident that the

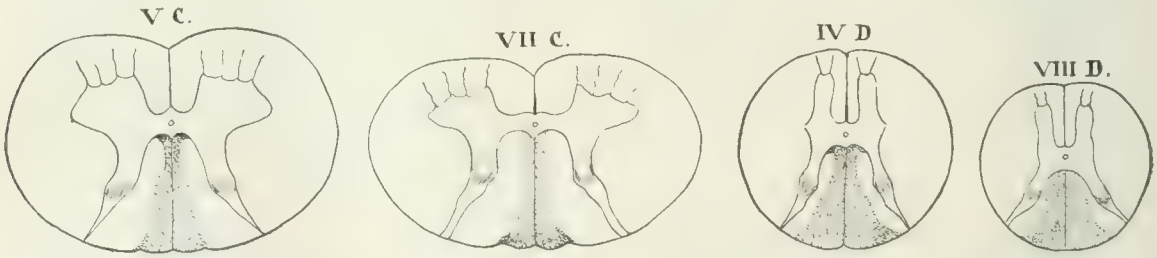

FIG. 4598.—Area of Ascending Degeneration in the Posterior Columns after Compression of Cauda Equina, Involving all the Sacral and Lumbar Nerves.

If the posterior nerve roots are divided between the posterior spinal ganglia and their entrance into the cord, an ascending degeneration occurs in the cord. It is by observing the course of this ascending degeneration that the upward continuation of the sensory nerves has been determined.[3] The area of the posterior columns of the cord which degenerates upward differs in different cases. When the sciatic nerve roots alone are divided, or the sacral portion of the spinal cord is destroyed, the ascending degeneration occupies a large area of the posterior columns in the posterior nerve roots contain a number of fibers which, after entering the cord, turn upward and pass on to the medulla oblongata, each successive set from below upward lying a little in front of, and outside of, the preceding set, and gradually filling out the entire column of Goll and a portion of the column of Burdach. This is shown in Fig. 4596, *G*, *B*, at level C *VI*. In a cross-section in the upper cervical region it can, therefore, be affirmed that the fibers in the posterior median part of the column of Goll transmit sensory impulses from the legs; that the fibers in the median and lateral portion of the column of Goll transmit sensations from the thighs and pelvis; that the fibers in the anterior portion of the column of Goll transmit sensations from the body exclusive of the arms; and that the median part of the column of Burdach transmits sensations from the arms. Experimentation on animals has proven that the nerve fibers entering the cord in the posterior nerve roots,

and passing upward in this manner to the medulla, degenerate upward upon the side on which they enter. There is no reason, therefore, to believe that in man there is any decussation, in the spinal cord, of the fibers thus far described. But since all sensations, except those of muscular sense, are known to cross over to, and ascend in, the opposite side of the cord in man, immediately after their entrance, it follows that the fibers thus far considered have for their function to transmit the sensations of muscular sense. And this conclusion is further established from the facts gathered from the pathology of locomotor ataxia. For in this disease, in which the muscular sense is the one most seriously impaired, the same areas of degeneration are found. There is, first, the sclerosis in the root zone of the column of Burdach, involving the nerve roots in it, and secondly, the secondary degeneration in the column of Goll, whose extent is determined by the extent of the primary lesion. The higher the primary lesion advances, the greater the area of the column of Goll involved. Since cases have been observed in which the sensations of touch, of pain, and of temperature, and of the muscular sense, have been affected singly, it follows that the tracts conveying these sensations must be separate from one another. The fibers so far described terminate in the nuclei of Goll and Burdach. But from these nuclei the fibers of the interolivary tract and lemniscus arise, fibers which are known to decussate in the sensory decussation of the medulla, and are known to transmit sensations of muscular sense exclusively. Hence the conclusion seems warranted that the sensory tract for muscular sense lies in the column of Goll for all parts below the arms, and in the median part of the column of Burdach for the arms.

describe various manners of termination. Some fibers end directly in the posterior gray horn; others pass through it to reach the anterior gray horn; others, still, cross over through the posterior gray decussation to the other side of the cord. Many fibers enter the column of Burdach and pass directly through it to enter the gray matter in the vicinity of the vesicular column of Clarke; others ascend some distance in the column of Burdach before they enter the gray matter, and a few turn downward in the column of Burdach before ending in the gray matter. The fibers turning downward are collected into a small bundle, named the comma-shaped bundle of Schultze, from the shape of its area in cross-section. From the fact that general myelitis involving the posterior gray matter is always attended by sensory symptoms, it is concluded that many sensations are sent to the cells of the posterior horns. From the cells in the posterior gray matter some nerve fibers pass backward into the columns of Goll and Burdach, and mingle with the fibers of those columns, presumably ascending with them to the medulla. It is not improbable that these fibers transmit sensations of touch. Even in the most extreme cases of secondary ascending degeneration in the posterior columns, after division of the nerve roots, many fibers in those columns escape. It is therefore certain that some of the fibers making them up have their origin and nutrient cells in the gray matter of the posterior horns, rather than in the posterior spinal ganglia. Hence the facts do not exclude the possibility of the transmission upward of

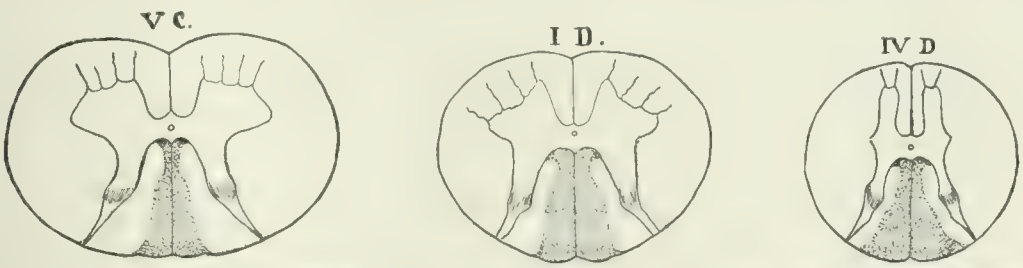

Fig. 4599.—Area of Ascending Degeneration in the Posterior Columns after a Transverse Lesion of the Middorsal Region.

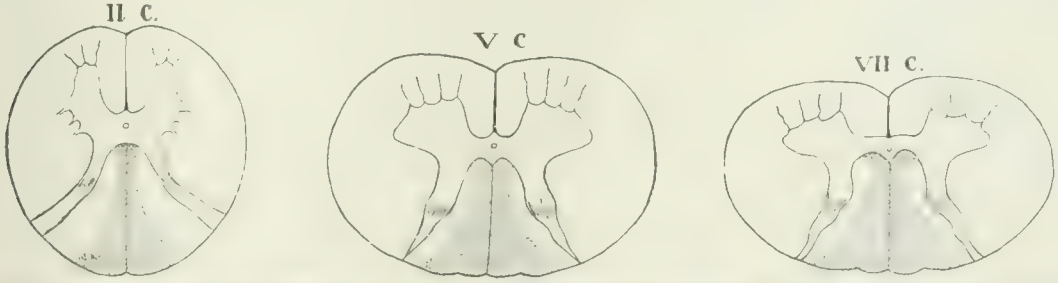

Fig. 4600.—Area of Ascending Degeneration in the Posterior Columns when the Lower Cervical Region of the Cord is Involved by a Transverse Lesion

With regard to the sensory tracts for touch, pain, and temperature, our knowledge is much more indefinite. These sensations enter the cord by the posterior nerve roots. But these roots do not send all of their fibers upward in the path already described. And if the area of the cord occupied by the column of Goll in the cervical region be compared with the entire area of the posterior nerve roots, it will be seen that a mere fraction of the fibers entering the cord by these roots ascends to the medulla. The large remainder terminate in the cord. Anatomists sensations of touch in the posterior columns of the cord after such sensations have crossed the median line in the gray matter. And that they are transmitted in this region the older physiological experiments established. Other physiological experiments point to a transmission of sensations of touch in the lateral columns of the cord. And Gowers has established the existence of a tract in the periphery of the anterolateral column, lying anterior to the direct cerebellar tract, which degenerates upward after transverse lesions. This is called the anterolateral ascending tract. Its fibers arise from cells in the gray matter (Fig. 4595, *e*), cross to the other side, passing through the anterolateral column, and turn up-

ward in this column. This column ascends through the anterolateral part of the medulla and pons. Some of its fibers have been traced into the lemniscus and some into the cerebellum. There are other fibers which arise from cells in the posterior gray matter of the cord, and crossing to the opposite side, ascend in the anterolateral column (Fig. 4595, *X*, *AL*) of the cord.

The sensations of temperature and pain are uniformly preserved or lost together, hence it is concluded that they pass in the same tract. No definite position can be assigned as yet to that tract. In syringomyelitis, in which the lesion is limited to the central gray matter of the spinal cord between the anterior and posterior horns, a loss of temperature and pain sensations in all parts at and below the level of the lesion has been observed, and it has been concluded that these sensations are transmitted by the gray matter. Gowers believes that they pass in his anterolateral tract, but the conclusion rests upon too small a number of observations to be hastily adopted. It seems to be likely that the transmission of sensations through the cord is not merely attained by these long tracts, but that they pass chiefly through a series of the association tracts already described, which are scattered through all the columns. A given sensation sets up many reflex and vasomotor impulses in the cord in addition to being sent to the brain to awaken a perception. Hence it is likely to pass by a broken rather than a continuous tract. But the exact course of sensory impulses is not yet determined with accuracy.

4. *The Direct Cerebellar Column.*—The last column of the cord to be described is one lying upon the outer surface of the lateral column, and extending from the lower dorsal region to the corpus restiforme of the medulla, and thence to the cerebellum. Its termination in that organ has led to its name—the direct cerebellar tract. It is made up of fibers whose origin is in that column of cells which lies in the median part of the posterior horn known as the vesicular column of Clarke (Fig. 4595, *c*, *DC*). The cells are found only in the dorsal region, hence all the fibers in this tract come from the dorsal segments of the cord. They reach the lateral periphery of the cord by passing diagonally through the lateral column. They are supposed to transmit sensations upward from the Clarke column of cells to the cerebellum, because they degenerate upward after a transverse lesion of the cord. The function of both the cells and the tract is uncertain. From recent investigations by Gaskell, however, it seems possible that the vesicular column of Clarke is connected with the vasomotor and sympathetic nervous systems by means of very small nerve fibers extending from the sympathetic ganglia into the cord. If this is so, the function of the direct cerebellar tract is to transmit those rather indefinite sensations from the viscera, or to act as a tract for unconscious sensations or centripetal impulses necessary in a central regulation of visceral and vascular action. The hypothesis that they convey muscular-sense sensations from the trunk is more widely held, yet it is to be remembered that these must be of little importance in lower animals, who do not walk erect—in which animals, however, this column is well developed. That they subsense the function of maintaining the balance and have to do with muscular sense is, however, generally accepted.

II. Symptoms Leading to the Diagnosis of Local Lesions in the Spinal Cord.—Such being the functions of the various parts of the spinal cord, it remains to discuss the symptoms arising when various parts are diseased. And it will be as well to approach this subject from the side of the symptoms rather than from that of the lesion, since it is the object to determine the lesion in any case.

1. *Spinal Paralysis.*—The motor tract conveying voluntary impulses from the brain to the muscles consists of two elements: first, the cerebrospinal element, and, secondly, the spinomuscular element. Each element consists of a set of nerve cells and their outgoing fibers, which not only transmit impulses from the cells, but are nourished by them. The cells of the cerebrospinal element lie in the cerebral cortex. Their fibers make up the motor tract through the brain and through the direct and crossed pyramidal tracts of the spinal cord.[2] These fibers terminate about the motor cells of the anterior horns of the cord at various levels, some of them reaching its very lowest part. Any lesion in the cells of the cortex, or in the course of the fibers, which cuts them off from those cells, results in the degeneration downward of the cerebrospinal element to its termination in the motor cells of the spinal cord. The *first form of spinal paralysis* is due to a lesion at the spinal part of this cerebrospinal element of the motor tract. If the cord is divided by a transverse lesion at any point, the function of this element of the motor tract is thereby suspended. As a result, voluntary motion is arrested in the parts below the lesion. If the lesion involves but one-half of the cord, it is the limbs on the side of the lesion which are paralyzed. If it involves the entire cord, both sides are paralyzed. The extent of the paralysis depends upon the level of the lesion; the higher the lesion the more extensive the paralysis. The degree of the paralysis will depend on the character of the lesion, slight compression of the cord at one point by a tumor, or a pachymeningitis, or a projecting vertebra, being followed by some stiffness of movement and rigidity of the muscles, with weakness, rather than by absolute loss of power in the parts below the level of the pressure. The cerebrospinal element of the motor tract also transmits the inhibitory impulses which continually keep the spinal reflex and automatic mechanisms in check. A lesion of this tract, therefore, produces not only weakness and paralysis, but also increase of the deep reflexes, and impairment of control over the bladder and rectum. The muscular action of the limbs, being no longer controlled by the brain, is governed wholly by the centers in the spinal cord. These act in response to sensory impulses, or spontaneously, without check, and hence the preponderating strength of flexor over extensor muscles tends to produce a position of adduction and flexion of the limbs which are paralyzed, and a heightened muscular tone, which tendency to rigidity. The nutrition of the paralyzed muscles may suffer somewhat from disuse, and from the attendant vasomotor paresis, but no rapid atrophy is noted when the cerebrospinal element of the motor tract is alone involved. And it is also to be noted that the paralysis affects the entire limb or limbs, and not any special group of muscles. In these cases the faradic electric contractility remains normal in the paralyzed limbs.

A typical example of this form of spinal paralysis is seen in compression of the spinal cord, below the lesion, and in lateral sclerosis or spastic paraplegia (*q.v.*).

The *second form of spinal paralysis* is due to a lesion in the second element of the motor tract, viz., the spinomuscular element. This consists of the cells of the anterior gray horns of the cord, and the anterior nerve roots which pass out through the anterior columns of the cord. Destruction of the cells suspends both voluntary and reflex motor impulses to the muscles. The cells not only control the motion, but also the nutrition, of the nerves to which they give origin, and of the muscles to which these nerves go. Therefore destruction of the cells produces atrophy of the muscles with which they are connected. If the destruction is gradual, the atrophy is gradual, as in progressive muscular atrophy. If the destruction is rapid, the atrophy is rapid, as in infantile paralysis. The degree of the atrophy de-

pends upon the degree of destruction of the group of cells which govern the particular muscle affected. If the group is wholly destroyed, the muscle becomes totally atrophied. In addition to paralysis with atrophy, there is in the second form of spinal paralysis, a change in the electric reaction of the paralyzed muscles. They lose their contractility to the faradic current, and alter their contractility to the galvanic current, responding in a sluggish manner, and to the positive more readily than to the negative pole. This is called the reaction of degeneration (*q.v.*).

The extent of the paralysis depends upon the extent of gray matter affected, and a reference to the table of the localization of functions already given (page 859) will enable one to determine the effect of a lesion at any particular segment, or through a group of segments, of the spinal cord. A typical example of the second form of spinal paralysis is found in infantile paralysis or poliomyelitis anterior. The muscles in this disease are paralyzed, atrophied, exhibit the reaction of degeneration, and lose their reflex excitability. An entire limb is rarely affected, certain groups of muscles being usually paralyzed together, *e.g.* the deltoid, biceps, brachialis anticus, and supinator longus (upper arm group), or the extensors of the wrist and hand muscles (lower arm group); or the glutei and thigh muscles (thigh group); or the anterior tibial and peroneal groups of the leg (leg group). The muscles affected are not those which are supplied by a single peripheral nerve—a fact which enables a diagnosis between a lesion in the spinal cord and a lesion in a peripheral nerve to be easily made—but those which act together to produce a definite physiological act.

The contrast between these two forms of spinal paralysis can be seen at a glance in the following table:

First Type of Spinal Paralysis.	Second Type of Spinal Paralysis.
Lesion in pyramidal tracts.	Lesion in anterior gray horns.
Paralysis usually on both sides equally, in legs or in legs and arms, never in arms alone.	*Paralysis* may be limited to any single limb, and rarely affects both limbs equally.
All muscles are about equally affected. No muscles are entirely normal.	Certain groups of muscles only are affected. Others escape wholly.
Muscular tone is heightened.	Muscular tone is diminished.
Tendency to rigidity appears.	Muscles are relaxed.
Reflex excitability is increased.	Reflex excitability is lost.
Atrophy is absent or is slight, and merely due to disuse, hence is gradual in progress. It affects the entire limb.	*Atrophy* is always present in the paralyzed muscles. It advances rapidly, and may become extreme.
Electric contractility is unchanged.	*Electric contractility* is changed. Reaction of degeneration is present within two weeks of the onset.
Vascular tone is diminished, cyanosis and edema may occur.	*Vascular tone* is diminished, but edema does not occur. Paralyzed limb is cool, but sweat is not increased.
Paralyzed limb is cold, and sweat may be increased.	
Trophic disturbances in the skin are not infrequent.	*Trophic disturbances* in the skin do not occur.
The control over the bladder and rectum may be diminished or lost.	The control over the bladder and rectum is not permanently impaired.
Example: Spastic paraplegia.	Example: Infantile paralysis.

The *third type of spinal paralysis* is a combination of the first and second types. When a transverse lesion of the spinal cord entirely destroys a single segment, it produces paralysis of the first type in the parts below the level of the lesion by cutting off the tracts to those parts, and paralysis of the second type at the level of the lesion by destroying the gray motor cells at that level. The general effect of such a lesion depends entirely upon the level at which it occurs; the higher the lesion, the greater the extent of the first type of paralysis. The distribution of the second type will depend on the level of the segment involved. The greater the extent of the lesion at the level affected, the greater the extent of the second type of paralysis. An example of this is also found in amyotrophic lateral sclerosis. When a longitudinal lesion of great extent occurs—such as the general destruction of the cord in general myelitis—the second type of paralysis is the form which is found, but all the muscles are affected, not merely a few groups. The bladder and rectum are also affected, and bedsores are frequent.

In any case of spinal paralysis, if the electric condition of the muscles paralyzed be ascertained by the aid of a faradic battery, and the diagnostic points here brought together be applied, reference to the table of the localization of functions will enable the exact level of the lesion to be determined.

Spinal Anesthesia.—The course of the sensory tract in the spinal cord is still somewhat imperfectly understood. It is known that all sensory impulses reach the spinal cord through the posterior nerve roots, which partly enter the apex of the posterior horn, and partly enter the column of Burdach, and pass upward as already described. The sensations of muscular sense ascend on the same side as that on which they enter. Those of touch, temperature, and pain cross over, as soon as they enter, to the opposite side and ascend in it. The various views regarding the tracts transmitting these sensations have been already stated.

In transverse lesions of the spinal cord the area of anesthesia present in the skin depends upon the level of the lesion. The various areas of the body which are related to the various segments of the spinal cord are shown in the plate (Plate LVI). A lesion at any given segment will cause anesthesia in the surface of the body related to that segment. If it is a transverse lesion of the cord it will cause anesthesia in all parts of the body below the level of the area of anesthesia caused by destruction of the affected segment. This plate has been made up from a study of a large number of cases with autopsy, and may be taken as a reliable guide to the level of the lesion. Transverse lesions higher than the fifth cervical segment cause sudden death from paralysis of the phrenic nerves. Limited areas of anesthesia in the skin, at any part of the body, not corresponding to these areas, are to be ascribed rather to lesions in the peripheral nerves than to any local lesions in the cord itself; for posterior poliomyelitis as a distinct lesion is unknown. When a transverse lesion involves but one-half of the spinal cord, the anesthesia is found upon the side opposite to the lesion, below the level of the lesion, and extends around the trunk in a band at the level of the lesion, the width of the anesthetic band depending upon the longitudinal extent of the lesion. On the side of the lesion below the level of the anesthetic band the skin is hypersensitive to touch. Such unilateral lesions produce a loss of muscular sense on the hyperesthetic and paralyzed side, not upon the side of the anesthesia—a fact which proves that the sensations of muscular sense do not decussate within the cord. This is the syndrome named after Brown-Séquard.

Hyperesthesia sometimes occurs from spinal lesions, but is quite rare. It indicates an irritation of the sensory tracts in the cord by hyperemia, or by pressure, rather than destruction of those tracts. Gowers suggests that this hyperesthesia may be due to an increased irritability of the part of the cerebral cortex to which the injured tracts pass, as well as to an intensification of the impression passing in them. *Pain* is a rare symptom in spinal-cord disease, excepting in locomotor ataxia. And here it is to be ascribed to irritation of the posterior nerve roots within the cord, similar in character to their irritation without the cord, as occurs in meningitis and in diseases of the vertebral column. Its location on the surface is an indication of the level of the nerve root irritated, and by comparison with the plate this level can be diagnosticated. *Numbness* is a frequently mentioned symptom of spinal-cord disease, and has some value in local diag-

nosis, as the area of the skin in which the numbness is felt depends upon the level of the cord affected. Hence, when the numbness is limited to certain parts, especially to the extremities, a reference to the plate will indicate the segment of the cord which is diseased. Thus, in locomotor ataxia the beginning of numbness or pain in the little fingers indicates that the disease has advanced up the spinal cord and has reached the first dorsal and lowest cervical segments.

Spinal Ataxia.—This symptom always indicates an affection of the posterior nerve roots before or in their passage through the column of Burdach. Incoordination is due to an interference with the reception of sensations of muscular sense which are sent in from the skin, joints, and muscles. These sensations may be intercepted as they pass through the nerves, for ataxia is a symptom of toxic multiple neuritis; they may be intercepted as they pass through the column of Burdach, as is the case in locomotor ataxia; they may be intercepted as they pass up the cord in the column of Goll; they may be intercepted in the brain by lesions in the lemniscus (see *Brain*) or in the cerebellum. It is probable that a portion of the muscular sensations are sent to the gray matter of the cord, producing the reflex action of balancing, and unconscious coordination, and that the remainder are sent upward to the brain. For the incoordination in cerebral disease, when the latter only are disturbed, is less severe and intense than in spinal-cord disease, where all are implicated. Ataxia from neuritis is usually accompanied by tenderness in the nerves and muscles. Ataxia from cerebellar disease is only present in the act of walking, and is attended by vertigo. Ataxia from spinal disease is not attended by these two symptoms, but is usually accompanied by severe lighting pains and by loss of deep reflexes, together with other characteristic symptoms of locomotor ataxia. (Vide *Tabes Dorsalis.*)

It must be stated here that in lesions of the spinal cord, as in those of the nerves, the motor symptoms are usually more pronounced than the sensory symptoms; and even when the spinal cord is greatly compressed or disintegrated, sensory impulses may continue to pass after motor impulses are entirely arrested.

Disturbances of the Spinal Reflex and Automatic Action.—Whatever view may be held regarding the nature of spinal reflex action, it is well established that certain structures are necessary to its production. It is necessary that a sensory nerve from the surface of the body be capable of transmitting impulses to the spinal cord. It is known that the fibers transmitting the centripetal impulses from the skin enter the apex of the posterior horn, while those transmitting impulses from the tendons enter the median surface of the posterior gray matter after traversing the lateral part of the column of Burdach called the root zone. It is also necessary that the network of nerve fibers through which impulses pass from the posterior gray matter to the cells of the anterior horn be intact. Finally, it is necessary that the groups of cells in the anterior horn, and the motor nerves from them to the muscles, be in a normal state, or capable of exercising their functions. These structures, together, make up a reflex arc, and a lesion in any part of this arc will arrest the reflex activity. Thus neuritis, outside the cord or due to meningitis, may interfere with the conduction of impulses to and from the cord; posterior sclerosis may arrest centripetal impulses as they reach the root zone; general myelitis may destroy the network of fibers within the gray matter; and anterior poliomyelitis may destroy the motor cells in the anterior horn. All these diseases, therefore, may cause a loss of tendon reflex. There are reflex activities governed by almost every segment of the cord, as may be seen in the table; and the particular reflex which is suspended in disease will depend wholly on the location of the lesion. Hence the loss of any one or more reflexes gives important information as to the seat of the lesion. And this can be ascertained after examination of the patient by a reference to the table. It has been already stated that an inhibitory influence is exerted by the brain upon spinal activity, and that this influence is conducted to the spinal motor cells through the motor tracts in the lateral column. Anything which impairs the conduction of impulses through this tract will result in removing restraint from the spinal reflexes and allowing them full sway. Hence an increase in deep spinal reflexes indicates a suspension of function in the lateral pyramidal tracts. A transverse myelitis, therefore, will cause an increase of the reflexes below the level of the lesion, and a loss of the spinal reflex governed at the level of the lesion. This has been already mentioned in connection with spinal paralysis. The skin reflexes are, however, not increased by lesions in the pyramidal tract.

The automatic activity of the cord includes the mechanisms of micturition and defecation. These mechanisms are complex reflexes, several sensory impulses combining to produce a compound motor effect, a part of which is inhibitory and a part of which is active. Thus, in micturition, the sensations of pressure on the sensitive neck of the bladder, and of distention of the entire organ, produce an inhibition of the motor impulses which normally hold the sphincter tight, and set in activity the motor impulses which contract the detrusor urinæ, thus emptying the bladder. The same is true, *mutatis mutandis*, of the other automatic acts. The structures necessary for any one of these acts are similar to those underlying the simple spinal reflex, and the same lesions arresting it may arrest these acts. But the result of such arrest is more serious, for, in the case of the bladder or rectum, retention or passive incontinence of urine or feces may follow. And if the inhibitory impulses from the brain to these centers are cut off, the voluntary control over these mechanisms is impaired, and the acts cannot be initiated voluntarily, and active incontinence may result. The location of the bladder and rectal mechanism is in the lower sacral region. Hence, when this part is the seat of a lesion, or is cut off from the brain by a lesion at a higher level in the motor tract, incontinence, either active or passive, or retention, may result.

The mechanism of the sexual act lies in the sacral region, and is quite analogous to the art of micturition.

A part of the automatic mechanism of respiration is governed by the cervical and dorsal regions of the cord, and is interfered with in disease in those regions. Lesions of the upper cervical region paralyze the diaphragm and thus cause death.

Disturbance of vasomotor and trophic functions of the cord may occur from various forms of lesion. Anterior poliomyelitis produces atrophy of the muscles paralyzed, and a sufficient affection of the vasomotor system to cause objective, as well as subjective, coldness in the limb; and when the lesion lies deep in the anterior horn, an arrest of development of the bones of the limb affected. General myelitis is usually associated with a tendency to bedsores upon the parts exposed to pressure, which cannot be avoided by the most scrupulous cleanliness, and to cystitis, and these are ascribed to a disturbance of trophic impulses to the skin and bladder. Posterior sclerosis is sometimes associated with trophic changes, such as perforating ulcers, joint affections (Charcot's arthropathies), and eruptions on the skin. In a few cases of leprosy serious lesions of the posterior gray horns have been observed. In general myelitis there is a partial vasomotor paralysis, indicated by cyanosis, sluggish circulation, edema, and coldness, with abnormal sweating in the paralyzed parts. But any definite statement regarding the exact localization of vasomotor or trophic functions in the spinal cord

cannot be made as yet. And recently many vasomotor and trophic symptoms, formerly supposed to be due to spinal lesions, have been found to be produced by disease in the peripheral nerves. It is, however, established that trophic lesions are most frequently observed when the gray matter of the spinal cord in the vicinity of the central canal, including the vesicular column of Clarke, is the part diseased; or when all

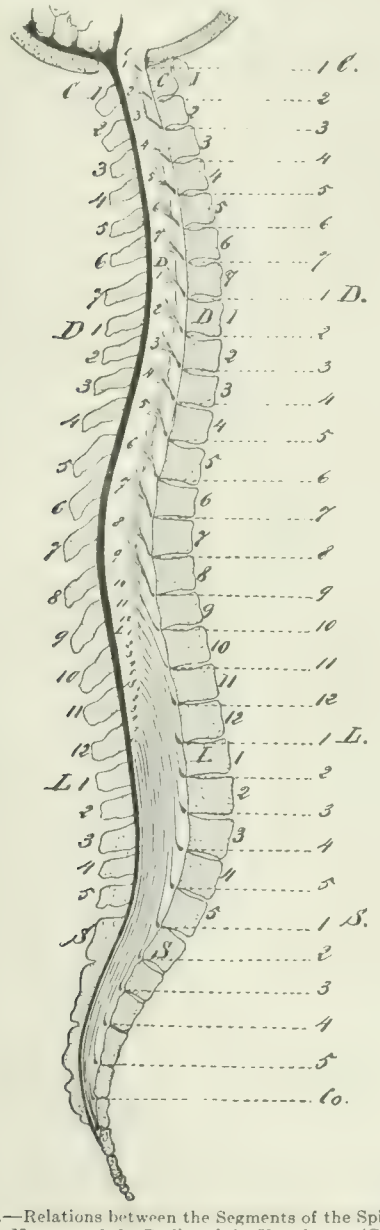

Fig. 4601.—Relations between the Segments of the Spinal Cord and their Nerves and the Bodies of the Vertebræ. (Gowers.)

sensation is cut off from the paralyzed limbs by a transverse lesion.

The regulation of bilary and urinary excretion is presided over by centers in the medulla, and the nerve tract thence to the liver and kidneys is traced through the cervical region of the spinal cord to the first dorsal segment, where it enters the sympathetic chain of ganglia. A lesion in the lateral column of the cervical cord, by involving this tract, may cause a vasomotor paralysis of either the liver or the kidneys. In the former case diabetes mellitus is produced; in the latter, diabetes insipidus results. It is therefore necessary, in lesions of the spinal cord, to examine the amount and constituents of the urine.

In any case of spinal disease in which it is desirable to localize accurately the lesion, it is suggested that a written summary of the symptoms be compared with the table of localization of the functions of the cord, when it will become evident, by contrasting the normal with the abnormal conditions, what part of the cord is affected. As Bramwell justly observes, "the essence of the clinical examination of the spinal cord consists in the systematic and separate examination of each spinal segment, by observing the motor, sensory, reflex, vasomotor, and trophic conditions of its body area." Such an examination will lead to accurate diagnosis of local lesions.

But one point remains to be mentioned, that is, the relation of the various segments of the cord to the bodies and spines of the various vertebræ. As the cord extends only to the level of the second lumbar vertebra, its various segments do not lie opposite to the vertebræ from which they are named. The accompanying diagram of Gowers (Fig. 4601) displays the mutual relation between the segments and their nerves, and the bodies of the vertebræ, and no further description is needed. But this relation is exceedingly important and should be studied carefully in cases of spinal caries or of fracture of the vertebræ when nervous symptoms develop; also in cases of spinal tumor.

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Spinal Cord, Tumors of the.—Practically all of our knowledge of spinal-cord tumors that is of any import for clinical medicine has come in these last two decades. It is true that, over thirty years ago, von Leyden put medical literature under a great debt by his published studies of one very interesting case, and within a few years after that he succeeded in showing that the diagnosis of the location and of the nature of a spinal-cord tumor is not impossible to the careful clinician. Before this only the pathological anatomists had given any attention to tumors lying within the spinal canal. Of these, two men deserve mention, because of the thorough manner in which they studied the subject and suggested at least the possibility of progress in clinical medicine up to a point where even this obscure condition might be recognized with certainty, its progress foreseen, and possibilities of surgical interference discussed. These two men are Virchow, in Germany, and Cruveilhier, in France.

The most important practical progress in our knowledge of spinal-cord tumors was to come from England. In 1886 Gowers, having demonstrated many times that it was possible to determine exactly the location of tumors of the spinal cord, recommended that when the diagnosis was satisfactory and conclusive, operative interference should be undertaken. Some years before this Erb. at Heidelberg, had made the same suggestion, though it did not for the moment attract much attention. Gower's recommendation was destined to bear fruit very shortly. In 1887 Gowers and Victor Horsley, after thorough discussion of a case of spinal-cord tumor, proceeded to operation, and Horsley removed the tumor successfully, the patient recovering completely and without any serious sequelæ. This classical case is described in a paper by Horsley and Gowers in the *Medico-Chirurgical Transactions*, London, 1888.

This demonstrated that spinal tumors were not as hopeless as had been thought. In the *American Journal of the Medical Sciences* for 1895, page 614, Dr. M. Allen Starr collected the reports of 122 cases of tumor of the spinal cord, with regard to 100 of which fairly satisfactory histories were obtainable. In all of these the diagnosis might have been made before death, and of the 100 cases there were 75, in Starr's opinion, in which the tumor could have been removed. He also reported, apart from the 127, 22 cases in which operations had been performed. In 2 of these the tumor was not found. In 1 it was impossible to remove it when found. In 11 cases death took place soon after the operation. Eleven patients operated upon recovered, and 6 the paraplegia completely disappeared; in the other 5 there was relief of symptoms, especially of pain, and some improvement in the gait.

Dr. Collins, in the *Medical Record* for December 6, 1902, reports 70 cases of spinal tumor from the recent literature, 30 of which were operated upon. He concludes that spinal-cord tumors are twice as operable as brain tumors, and the results of operation are twice as successful. Fifty per cent. of intraspinal tumors are operable and one-third to one-half of these cases are benefited by operation. Of the 30 operations, 12 were completely successful, 8 were partially successful, and 10 failed to give relief, or the patient died shortly after operation. Of the 70 cases reported, 44 were almost surely operable with hope of relief; 26 were wholly beyond hope.

In Clinical Studies (vol. vii., Edinburgh, 1909) Edwin Bramwell reviewed "Spinal Tumors and the Present Position of Operations." His conclusion is "that 50 per cent. of meningeal tumors are capable of actual removal with eventual recovery, and that operation is not only indicated but urgently demanded in all cases in which a localized neoplasm of the spinal meninges is suspected, and in which the level of the lesion can be determined."

A very complete review of "The Surgery of Tumors of the Spine and the Spinal Cord" had been made by Potel and Veaudeau in *Revue de Chirurgie* (May and August, 1913). The literature is very fully gone over and the recent conclusions collated. While the mortality of spinal tumor operations was 45 per cent. only a few years ago the average mortality in our day is scarcely more than 15 per cent. Cures after surgical intervention in spinal tumors have risen to about 60 per cent. and the statistics are constantly improving. The mortality from laminectomy itself which used to be one in three has now fallen to one in twenty. The deaths are very frequently due to postoperative complications, not necessarily connected with the operation, but due to the seriousness of the condition for which the patients are being treated.

Frequency.—Spinal tumors are six times as rare as those of the skull and brain. Schlesinger found only 151 cases of these neoplasms in 35,000 autopsies made in the hospitals of Vienna during nearly twenty years. More than two-thirds of these cases were vertebral. The vertebral tumors because of the frequency of metastatic cancer are commonest in women but tumors of the cord itself are twice as common in men as in women. They are most frequent between twenty-five and forty-five but may occur in children and have been seen after fifty.

Location.—New growths affecting the spinal portion of the central nervous system may spring either from the nervous substance of the cord itself or from some of its coverings. These include not only the spinal membranes (that is, the meninges), but also the periosteum of the spinal canal and the bony column that acts as the support and protection for the cord. It seems better, with the authorities on this subject, to include the bony tumors of the vertebræ. All these tumors give a certain similarity of symptoms, so that we shall consider first tumors of the vertebræ, then tumors which have their origin from the periosteum or from the extradural fat tissue, then intradural tumors which spring from the inner surface of the dura, from the arachnoid membrane, from the ligamentum denticulatum, from the nerve roots, or from the pia mater, and finally true medullary tumors, which spring from the nervous substance of the cord itself.

Tumors of the Vertebræ.—These have been arranged by Bruns, according to their importance, in the following order: Carcinoma, sarcoma, and osteosarcoma, as also sarcomatoid tumors with myxomatous degeneration, or fibrosarcomata, exostoses, or osteomata, especially multiple exostoses, echinococcus cysts, and finally gummata. There is a pseudo-tumor of the vertebra, due to exaggerated callous formation after fracture of a vertebra, which acts exactly like a tumor, and should accordingly be treated among them.

By far the most important and the most frequent form of tumor of the vertebræ is *carcinoma*. In the great majority of the cases the tumor is not primary, but secondary to cancer in some other part of the body. Vertebral cancer follows particularly cancer of the breast. According to the statistics eighty-two per cent. of vertebral carcinoma was metastatic from the breast and on the other hand out of 339 cancers of the breast there were seventy-two metastases. Cancer of the vertebræ in men is extremely rare. Vertebral cancer may occur many years after an apparently successful operation for cancer of the breast. Bruns reported a case in which eight years had intervened. The late Dr. William Pepper showed to his clinic a case in which over six years had elapsed since the removal of the breast. Primary cancer of the vertebræ occurs very rarely.

As might be expected from the original seat of the tumor, secondary cancers of the vertebræ occur especially in the middle and upper dorsal region, occasionally in the lower cervical region. Primary carcinoma of the vertebræ by contrast occurs more particularly in the lumbar region. Secondary cancer does not limit itself to one vertebra, but apparently from the beginning attacks several. There are in the literature a number of cases in which practically every vertebra from the cervical region down to the sacral region had become carcinomatous. The process may spread by continuity, but it would seem that frequently each vertebral body becomes the seat of a new metastatic focus of malignant disease.

Notwithstanding the wide distribution of the carcinomatous process, the area in which there is pain on pressure or in which there are neuralgic pains due to the irritation of the growing tumor may be very small. Even when there is extensive involvement of the vertebral column, deformity may be absent. The usual deformity is a sinking together of the whole spinal column, a change which the French call *entassement*. In a number of cases patients have been distinctly decreased in height by this sinking together

of the vertebræ. Often the bodies of the vertebræ become almost as thin as paper, and it is hard to understand how the patient can hold himself erect. Occasionally there are sudden dislocations of the vertebræ, and these may occur after even very slight trauma. When displacement of the vertebræ occurs, however, there is no true angular deformity as in Pott's disease, but rather a rounded deformity develops. Occasionally thickening and other deformities of the spinous processes can be detected and are pathognomonic. The process extends into the nerve substance very slowly and never goes very far. The spinal nerves may become affected as a consequence of the involvement of the intervertebral openings. The nervous affection may be due only to compression, or it may be a true carcinomatous development. If there is a sudden movement of the vertebræ on one another, the spinal cord may become compressed by the resultant deformity. Slow compression is also possible, because of gradually produced deformity of the vertebral column. The carcinoma may affect the extradural fatty tissue and so compress the cord. In these cases a complete carcinomatous cylinder may surround the dural sac. The tumor is, however, soft in consistence, and so the compression symptoms are unimportant and the real cause of the nervous disturbances is often collateral edema due to interference with the return blood supply of the cord. In cancer of the vertebræ it is very seldom that the nervous substance of the cord itself becomes malignantly diseased.

Primary sarcomata of the vertebræ are not so rare as primary carcinomata. Sarcomata, however, usually occur in the lumbar or the sacral region and the affection develops by continuity from a tumor in the neighborhood. The viscera in the pelvis particularly are likely to be the seat of the primary tumor. Sarcomata are more malignant than carcinomata. They readily involve the dura, and may even penetrate this membrane and infiltrate the cord itself. A long portion of the spinal column may be affected by a sarcoma before serious symptoms begin. Much more frequently than carcinomata of the spinal column, sarcomata involve the transverse processes, the spines, and the vertebral arches, and may, by pressure of the tumor thus formed, cause perforation of the skin. Sarcomata may occur in very early years, though they are more frequent in advanced age.

Exostoses and osteomata may grow from the transverse processes, or from the spinal arches, or from the bodies of the vertebræ. When they grow from the posterior part of the body of the vertebra, or forward from the arch, they cause compression of the cord and of the nerve roots. They seem to be somewhat more frequent in the lumbar and sacral regions. Usually when an exostosis is present in the spinal column, other portions of the skeleton present similar outgrowths. They should be looked for on the ribs, in the supraorbital region, along the spine of the scapula, and on the clavicles. Their discovery usually makes the diagnosis of the variety of tumor in the spinal cord plain without more ado.

Echinococcus cysts are rather rare in the spinal column, but they have been noted in a number of reported cases. Sometimes they cause a sudden dislocation of the bodies of the vertebræ and may lead to acute compression symptoms.

Gummata of the spinal column occur most frequently in the upper part of the cervical region. Not infrequently, as has been pointed out by Gowers, they are associated with ulcers of the pharynx. It is always very difficult to differentiate this condition from tuberculous caries of the vertebræ. The differentiation is, however, extremely important, because of the success of therapeutic measures in the syphilitic process. The Wassermann test should be tried but the therapeutic test still has its value. When a suspicious symptom develops, especially in relation to the upper cervical region, the patient should be carefully questioned as to his history, as to syphilis, and in any case mixed treatment should be used.

Differentiation of Vertebral Tumors.—In differentiating carcinoma of the spinal column from Pott's disease, it may be said in general that Pott's disease is an affection of youth or childhood. It must not be forgotten, however, that tuberculous caries of the vertebræ comes at a later age than any other form of bone tuberculosis. Carcinoma is quite rare, though sarcoma is not infrequent before adult life. It has been said that the intensity of the neuralgia caused by carcinoma is always greater than that due to caries. This must not be accepted as an absolute rule, however, according to the observation of Bruns and Schlesinger. The most important differential diagnostic point between caries and vertebral tumors is the kind of deformity present. Angular deformity is characteristic of Pott's disease. Carcinoma causes a rounded deformity, or else causes, as has been already noted, a shortening of the whole spinal column. If tumor-like masses can be felt alongside the spinal column, or in the pelvis, as is not infrequently the case in sarcoma, the differentiation from Pott's disease is easy. Evidence of the existence of tuberculosis in other organs, or of a cold abscess, makes the decision in favor of Pott's disease. It must not be forgotten, however, that as a consequence of the dyscrasia of cancer, myelitic processes may occur in the spinal cord, and Schlesinger has reported a case in which, notwithstanding the history of carcinoma of the breast, the affection of the spinal cord was a true caries.

If a vertebral tumor is diagnosed, then its nature can sometimes be determined. The most important element is to know the nature of the primary tumor. Sometimes this will be found to be a lymphosarcoma, and in this case there is some hope that the use of arsenic for a long time, either internally as Fowler's solution or, better still, as sodium arseniate subcutaneously, may do some good. When a tumor of the spinal cord is primary, it is more likely to be malignant than benign. The occurrence of vascular murmurs in the affected region speaks for sarcoma. Symptoms of osteomalacia make the diagnosis multiple myeloma. Osteomata run a very slow course, though it cannot always be said, as Bruns does, that they cause less pain than tumors which run a more rapid course. The echinococcus cysts may be recognized by puncture of the tumor and the finding of hooklets in the secretion. In a number of reported cases echinococcus cysts have been considered by very good authorities to be cold abscesses. In almost any case of vertebral tumor, one of the iodides, potassium or sodium, according to the preference of the physician in charge, should be employed. In most cases, unless the history is very clear and the condition absolutely sure, a mercurial inunction course should be given. The condition in malignant tumors is so hopeless that the erysipelas toxins, or the mixed toxins suggested by Coley, should be employed, and it will sometimes be found that they furnish relief, or even an absolute cure, in unexpected circumstances.

The most recent experience in vertebral tumors is that secondary carcinomata should not be operated on. All other tumors are benefited at least by operation and some of them are cured. For the relief of the pain due to vertebral tumors Flatau has found wet compresses applied over the tumor through which an electric current is run of great service. Hot applications often have a distinct anesthetic value.

Intraspinal Tumors.—The tumors that develop within the spinal canal are divided into those of the cord itself and those of the meninges. The most frequent are those of the meninges, the proportion being nearly two to one. Of the meningeal tumors, some are intradural and some extradural.

In contrast to the tumors of the vertebræ, most of

the intraspinal tumors are primary. In the extradural space, the most frequent tumor is the lipoma, which develops in the extradural fatty tissues. Next after this in frequency is the sarcoma which often develops from the periosteum of the vertebræ, though it also sometimes grows on the outer surface of the dura. There may be tuberculous tumors that grow within the spinal canal without any connection with the vertebræ. Such tumors may extend in their vertical diameter and cover a large portion of the cord. Echinococcus cysts may develop in the extradural space, and a very rare form of tumor, the enchondroma, has been encountered here. In one or two reported cases teratomata have also been encountered.

When tumors begin in the extradural space they very seldom find their way through the dura. Practically all of the tumors that occur outside of the dura are single. Lately a few cases of multiple extradural tumors have been reported.

Intradural tumors spring from the inner surface of the dura, from the arachnoid membrane, from the pia mater, or from the ligamentum denticulatum. True neuromata having their origin in the nerve substance, or pseudo-neuromata springing from the sheath of the nerve, are not unusual in the intradural space. Bruns has reported a case in which the nerve root ran directly through the center of such a tumor. The pathological anatomy of intradural tumors is more diverse than that of the tumors which occur in the extradural space. Practically any of the connective-tissue tumors may occur. Fibromata and fibrosarcomata, as well as genuine sarcomata and the subvarieties, angiosarcomata and myxosarcomata, have been reported. In a few cases pure angiomata have been found.

In children particularly there are a certain number of tumors that occur in connection with congenital malformations, associated with patent or latent spina bifida. These tumors are apt to occur, especially in the lumbar region, though they may invade the lower dorsal region. The most frequent variety is the lipoma. Neuromata are especially apt to occur in the cauda equina. Not infrequently malignant degeneration takes place even in tumors which are really not malignant at the outset. Neuromata are apt to be multiple in the cauda equina. At times degeneration of tumors affecting the nerve substance causes the presence of what is known as brain sand. Such tumors are spoken of as psammomata.

Solitary tubercles occur not infrequently in the intradural space, though tuberculosis affecting the membranes is apt to be diffuse. Nearly the same thing is true of syphilitic processes. Perfectly circumscribed gummata are not very frequent, but diffuse gummatous meningitis is not so rare. Echinococcus cysts are very rarely encountered in the intradural space. Some of them have been found free in the arachnoidal space. Aneurysms of the spinal arteries, theoretically, should be encountered occasionally, but as a matter of fact they are very infrequent.

In general it may be said that the pathological anatomy of tumors which occur within the spinal canal is not different from that of the same form of tumors when they occur in other parts of the body. The consistence of these tumors is rather hard, practically always harder than that of the cord itself; hence the compression symptoms that are produced. Only diffuse sarcomatous and carcinomatous new growths are soft in consistence, and such tumors are apt to be very vascular, making any question of their removal futile. As a rule, tumors that grow within the dura are apt to be circumscribed in size, and seldom exceed that of a dove's egg. The limitation in size of spinal tumors is rather favorable for their removal of surgical procedures, and for this reason the prognosis of intradural tumors that are non-malignant is not as serious as it would otherwise be.

Tumors of the upper part of the cervical cord begin usually with pain, and before long areas of anesthesia develop. The pain is felt along the distribution of the cervical plexus in the area supplied by the supraclavicular nerve, the nervi occipitales minores, at times also the nervi occipitales majores, and practically always in the distribution of the great auricular nerve. Atrophic conditions and palsy of the sternocleidomastoid muscles and the musculi circulares usually develop. The deep anterior cervical muscles, as well as the superficial and deep muscles of the neck posteriorly, are likely to be involved in the same process. After the neuralgia, hemiplegia involving the arm and leg on the side of the tumor gradually develops. In contradistinction from cerebral hemiplegia, there is no involvement of the facial or of the hypoglossal nerves. Anesthesia occurs on the opposite side as a Brown-Séquard phenomenon. The paraplegic condition, as a consequence of a tumor in the cervical cord, never lasts long, as the involvement of the phrenic nerve soon causes death from respiratory failure.

Tumors of the cervical enlargement of the cord present first a stage of the Brown-Séquard phenomenon. When the tumor is limited to one-half the cord, atrophy and paralysis with anesthesia and neuralgic pains in the arm on the side of the tumor are soon noted. A spastic paralysis and a disturbance of muscular sensation in the corresponding leg are usual accompaniments; anesthesia occurs in the leg on the other side and in the opposite side of the trunk, and on the ulnar side of the other arm when the tumor in its growth causes a transverse lesion, a spastic paralysis, and anesthesia of both legs with palsy of the trunk muscles and anesthesia of the trunk up to the second rib, are the usual results. In this case there is also paralysis of the arms. If the tumor involves all of the cervical enlargement, there is complete anesthesia of both arms. If there should be direct involvement of the uppermost dorsal nerve root, myosis and immobility of the pupil occur. If the tumor is strictly limited, these symptoms occur only on one side, though usually they develop on both sides a little later.

Tumors of the dorsal cord cause first the Brown-Séquard symptom, and later give spastic paraplegia of the leg and abdominal muscles, and anesthesia of the trunk up to the level corresponding to the height of the tumor. The neuralgia occasioned is at first one-sided, but later it assumes the character of a complete girdle pain. The hyperesthesia does not follow exactly the intercostal spaces, but is more horizontal in its reflexes. Atrophic paralyses of the intercostal muscles can usually not be demonstrated, though they are noted in the abdominal muscles.

When the tumor begins to compress the cord, and before the compression is so severe as to cause an interruption of the flow of nervous impulses, the skin and tendon reflexes are all exaggerated. Patellar clonus and ankle clonus are present. At times even a slight touch upon the lower extremities causes a distinct tremor clonus which was described originally in this country by Brown-Séquard, and designated by him as spinal epilepsy. As the transverse lesion of the cord becomes complete the tendon and skin reflexes decrease. As a rule, however, the skin reflexes remain even after nervous communication through the cord has been completely interrupted. In the so-called Brown-Séquard palsy the paralysis on the side of the tumor is mostly of the spastic variety, and the tendon reflexes are exaggerated. Sometimes when the lesion is very high in the cord an atonic palsy with loss of reflexes is established. Severe trophic disturbances and even a qualitative change of the electric excitability, sufficient to constitute a reaction of degeneration, does not occur as a rule in these cases of paralysis. There are, however, a considerable emaciation and a distinct quantitative reduction of the electrical excitability of the muscle. Sometimes there is, because of a readily produced

edema of the skin, a lowering of the electrical excitability of the paralyzed muscles which simulates the loss of electrical reaction. In these cases, however, while the faradic current may fail to produce any effect, the galvanic current, if strong enough, will always produce quick muscle contraction.

The condition of the bladder and of the rectum, when tumors of the cervical or dorsal cord exist, depends entirely on the extent of the interference with cord functions. At the beginning there is usually only some slight difficulty at the commencement of urination, though the call to urinate is more frequent and more imperative. After a time, voluntary urination becomes impossible and urinary retention sets in. Somewhat later the bladder sphincter loses its power and incontinence results. This takes the intermittent form, so that the bladder empties itself every now and then without the will of the patient, and sometimes the anesthesia is so marked that he does not notice the flow of urine until he becomes wet. If the whole spinal cord becomes affected, all the bladder reflexes disappear, and its muscles become palsied. Nearly always, when paralysis of the bladder occurs, cystitis develops, and this leads to pyelitis and nephritis, and hastens the fatal termination.

The rectum goes through nearly the same functional disturbances as the bladder. At the beginning there is constipation and then later emptying of the rectum becomes impossible by will power. After a time a paralytic condition sets in, though the sphincter maintains enough contractility to retain fecal material for some time. At intervals of several days, the rectum empties itself spontaneously, especially if there has been the slightest increase of peristalsis or any tendency to diarrhea.

With regard to the sexual functions, in tumors of the dorsal and cervical region there are certain characteristic symptoms. They occur, of course, only in men. At the beginning of the affection potency remains, and it may even happen that there is an increase of sexual desire. In tumors of the cervical cord priapism may become an annoying symptom. This may not persist constantly, but the slightest manipulation of the penis, as, for instance, for purposes of catheterization, may cause an erection, and this may interfere with the necessary insertion of the catheter in these cases. When there is a complete transverse lesion of the dorsal cord, impotence is inevitable.

Interference with the vasomotor nervous mechanism and the absence of movement may lead to edema of the affected leg or legs. In these cases there is dry scaliness of the skin that resembles ichthyosis very closely. The joints may suffer from trophic disturbances, and it must not be forgotten that contractures set in and ankylosis may develop. Bedsores are not frequent in tumors of the cord high up, but when the transverse cord lesion is complete, then skin ulcerations occur as easily as in affections of the lower part of the cord.

Tumors of the lumbar enlargement of the cord cause at first pain in the region of the lumbar plexus. This is usually one-sided, and is referred to the anterior and inner side of the thigh, the knee, and the leg. Next in order comes paralysis of the iliopsoas muscle, the quadriceps, the adductors, and the tibialis anticus. The Brown-Séquard phenomenon may occur in one-sided affections of the upper part of the lumbar enlargement. When the whole cord is affected, complete paralysis and anesthesia of the lower extremities develop; at first only in the region of the lumbar plexus, later in the whole leg. Ankle clonus may be present when the knee-jerks are absent; bladder and rectal disturbances and sexual impotence are not so common in lumbar tumors as in those in the sacral region.

Tumors of the sacral cord, if they leave the lumbar enlargement unaffected, cause characteristic symptoms of their own. These are paralysis and wasting of the muscles of the lower leg and of the foot and of the posterior portion of the thigh, especially the gluteal and perineal muscles. At first this may be one-sided, and later, as the tumor develops, it may affect both sides. Anesthesia is noted first in the foot and then at the back of the leg and thigh, and finally in the perineum and the genitals. Total paralysis of the bladder and rectum occurs, and impotence is a marked feature from the beginning. The Achilles reflex is often absent, though the knee-jerk is present. Bedsores and cystitis occur early in the case.

Tumors of the Cauda Equina.—The lumbosacral cord is commonly considered to run from the upper border of the twelfth, or from the lower third of the eleventh dorsal vertebra, to the lower border of the first lumbar vertebra, or at the very most to the middle of it. The lumbar enlargement lies usually beneath the twelfth dorsal vertebra. The sacral portion of it corresponds to the first lumbar vertebra. Below the middle of the second lumbar vertebra, then there is no longer any cord substance, but only a thick bunch of nerves, the so-called cauda equina. As certain of the nerves that come from the lumbar enlargement of the cord run in the spinal canal, it is easy to understand that the same symptoms may occur as a consequence of a tumor in the lumbar enlargement as when the cauda equina is affected by a similar lesion. There are some differential diagnostic peculiarities, however, which make it possible to draw a distinction at times with complete assurance as regards tumors of these two regions. The first and most important distinction is that tumors of the meninges, when they begin to affect the spinal cord itself, usually cause unilateral symptoms. Tumors in the caudal region, however, usually cause from the very beginning bilateral symptoms. It is possible, however, for a tumor of the cauda equina to cause unilateral symptoms at first. Tumors of the lumbar cord usually cause completely symmetrical paralyses and areas of anesthesia. This symmetry is apt to be lacking in tumors of the cauda. Caudal tumors are apt to cause very severe pains that persist in spite of treatment and that are very extensive. The pain is apt to be especially severe and obstinate in the sacral and coccygeal region. Tumors of the lumbar cord exceptionally cause very severe pain, so that this distinction is not very important. Friedrich Schultze claims that very marked and extensive fibrillary tremors are a sign that the cord itself is affected, rather than the nerves of the cauda. Bladder and rectal disturbances and trophic lesions of the skin follow both kinds of tumors.

Multiple Tumors.—The possibility of more than one tumor developing at the same time within the spinal canal must not be forgotten. In a certain number of reported cases the presence of more than one tumor has been recognized by the definite symptoms produced by each of them, and especially by the successive development of symptoms pointing to more than one localized area of irritation or pressure. Gowers calls attention to the fact that the greatest difficulty exists in the cases in which an intracranial tumor precedes the growth within the vertebral canal, and the symptoms of the spinal tumor are overlooked in the presence of the severe manifestations of the intracranial growth.

Symptoms.—The symptoms of extradural and intradural tumors are very similar. There are certain slight differences which with care can be utilized in determining the localization of a tumor. The first symptom in any case is almost sure to be pain. In general, the first mechanical effect of the presence of the tumor is compression of the nerve roots, and then of the spinal cord itself. In this matter, tumors within the spinal canal differ but very little from those which spring from the vertebræ. For a considerable time, at the beginning of the symptomatic course, an

irritative condition is noted, which affects especially the sensory nerve roots, causing neuralgias. The reason for this is not far to seek. Intradural tumors occur more frequently in the posterior part of the cord, or posteriorly and laterally. As a consequence, irritation of the motor roots occurs less frequently and seldom leads to recognizable localizing symptoms.

As a rule the pains are intense and typically neuralgic in character, but lack the tender points of true peripheral neuralgia. The pains are described as lancinating or tearing, and are not infrequently accompanied by causalgia—that is, a burning pain in the skin of the region supplied by the irritated nerve. The first symptom of a spinal tumor is oftenest pain in the hypochondriac region, accounted for by the predilection of tumors for the dorsal region. It often radiates as a girdle pain or toward the lumbar region following the nerves. Very often there is an accompanying hyperesthesia of the skin which makes even the slightest touch unbearable. Bailey insists that no tumor of the spinal cord should be diagnosed if the cutaneous sensibility is intact. He appeals to clinical experience to prove that sensation disturbances are not only an important but essential set of symptoms for the diagnosis. The pains are always increased when the spinal column is moved, or when there is any shaking of the body, as in coughing or sneezing. The pains may last for days and weeks without any intermission, though there may be intervals of comparative painlessness. The complete destruction of a nerve root causes a stoppage of the pain, and it may take some time for the tumor in its growth to reach another nerve root.

As in the case of vertebral tumors, herpes zoster may occur in the painful hyperesthetic part. While in vertebral tumors the pains are from the beginning usually bilateral, in intradural tumors they are much more likely to affect only one side. It is easy to understand, however, that tumors of the meninges may affect both sides of the spinal cord, or both nerve roots at a given level, and so cause bilateral neuralgia. At times there are evidences of irritation of the motor roots, though these are seldom present. Painful cramps or tonic contractions of the abdominal muscles, for instance, or of the cervical muscles causing torticollis, have been noted. In these cases the lesion usually affects the sensory roots and the motor symptoms are reflex.

With regard to paralyses and anesthesia, it must be remembered that the destruction of one nerve root seldom causes the development of such a condition. At least three or more nerve roots must be affected before anesthesia or muscle paralysis will be a prominent feature of the case.

Pain is the most prominent feature of the early history of tumors interfering with the function of the spinal cord. It is prone to occur in attacks that are described as stabbing or tearing in character. It is not unusual, however, for the patient to suffer from dull aches between the severe attacks, or the initial stage of the affection may be characterized by a more or less persistent dull aching discomfort in certain muscles. The result of this is, that not infrequently the diagnosis of chronic rheumatism is made and the patient is treated for that disease. It is not an unusual thing to find that several physicians in attendance upon a given case have spoken of a spinal tumor as muscular rheumatism. As Gowers has pointed out, the pain produced by spinal tumors is intense, and at times so hopelessly obstinate to medical treatment that it has more than once led the unhappy sufferer to attempt suicide. This must be borne in mind by the medical attendant.

Diagnosis.—Hypertrophic pachymeningitis closely simulates a tumor in the symptoms which it produces. It always affects the cervical region, hence the question of its exclusion must always be considered before an absolute diagnosis of the presence of a cervical spinal tumor is made. The differential signs are that the manifestations of hypertrophic pachymeningitis are usually bilateral, while in the case of a tumor the initial symptoms, at least, are unilateral; and that the manifestations produced by pachymeningitis, instead of being very localized, show an involvement of a considerable portion of the cord in vertical extent.

The diagnosis of neuralgia is not infrequent in the primary symptomatic stage of a spinal tumor. In contradistinction to true neuralgia, however, there is, as was pointed out by Dr. Starr, an absence of tenderness, as a rule, in the nerves along the lines in which the pain is felt. When the tumor is within the spinal canal, movement does not usually increase the pain; though this is apt to be the case when the tumor is in the bones. Pain is greatest when the tumor is situated so as to compress the cord directly laterally or posteriorly—that is, when it affects directly the sensory nerve trunks.

It must not be forgotten, in diagnosing tumors of the spinal cord, that the irritation of the sensitive nerve substance may give rise in predisposed individuals to symptoms of functional disorder of the spinal cord. Hysterical manifestations are not an unusual accompaniment of the initial stage of tumors of the cord, and often make the diagnosis more difficult than it would otherwise be. The physician's fear is always lest he should exaggerate the significance of neurotic symptoms. As a matter of fact, however, there is more danger of his minimizing the significance of the symptoms of the organic disease present, and so wasting precious time in the initial stage of the affection, when operation may save the spinal cord from lasting injury due to long-continued pressure.

The most characteristic feature for the diagnosis of a spinal tumor, its character and localization, is undoubtedly the course of the symptoms and the careful observation of the history of the case. The symptoms of tumor begin usually with unilateral pain, associated commonly with hyperesthesia. A little later, one-sided cramps in the muscles are prone to occur, followed before long by paresis and atrophy in the affected muscles. This practically constitutes an index of a lesion involving half the cord. As the growth of the tumor progresses, the other side of the cord also becomes affected and paraplegia develops. A not infrequent accompaniment of this group of symptoms is localized pain, or, in some cases, deformity of the spinal column.

Treatment.—As we have already said, the most favorable form of spinal tumor, as regards therapeutics, is that of syphilitic origin. As Gowers says, syphilis can be excluded only when there has been no possibility of infection. In many cases of late syphilitic lesions there is no history of secondary syphilis, and in others there is no history of a primary sore. Hence it is certain that in some cases of late lesions of syphilis a history of both primary sore and secondary symptoms will be absent, and such cases are actually met with not infrequently in neurological practice. The Wassermann reaction is of great help but a negative Wassermann is not of absolute significance. Salvarsan should be used in all cases where a spinal tumor is seriously suspected and some of the results are most favorable. It should be supplemented by a six weeks mercurial inunction course. The treatment should be prompt and energetic. The pressure must be lessened as soon as possible, otherwise degenerative changes and at times even hopeless destruction of nervous elements will take place. The influence of a few days' loss of time may make a difference of weeks in the duration of symptoms, and may even make the ultimate condition much less satisfactory.

In cases that are non-syphilitic very little can be accomplished by medication. Sedatives must be employed for the pain, and yet with the greatest care,

since habits are so easily formed and anodynes lose their effect. Cocaine may be employed by subarachnoid injection to aid the action of morphine. The coal tar analgesics sometimes relieve for a time at least where morphine fails. The state of the bladder must be watched very carefully, it must not be allowed to become overdistended, yet the catheter must be used with every possible aseptic precaution, including especially the cleansing of the fossa navicularis before the introduction of the instrument; otherwise severe cystitis will be likely to develop in the lowered vitality of the vesical mucous membrane. Because of the diminished nutrition of all tissues, bedsores must be carefully guarded against, and if the patient shows early a tendency to their development, a water-bed must be secured without delay.

Spinal tumors that are not within the substance of the spinal cord itself may not infrequently be removed by surgical procedures. As we noted at the beginning of this article, at least fifty per cent. of all tumors are operable, and of these more than one-half may be practically cured or relieved completely of their annoying symptoms. It must be remembered that Gowers and Horsley insist that the early removal of a small growth in the spinal cord may possibly be followed by the regeneration of conducting fibers that are on the other side of the cord, and by the return of their function, lost only through the effects of pressure. As soon, then, as a definite diagnosis of the presence of a spinal-cord tumor is made, operation should be recommended and the state of the case, with the possibility of a complete cure, set before the patient. Delay in this matter can do no possible good, and a delay of even a few months may cause irremediable damage to the delicate nerve structures. In estimating the chances of a successful issue, it must be remembered that the effect of the operation upon the patient's general condition is distinctly unfavorable.

Laminectomy.—Elsberg and Bailey have recently published a report (*Journal of the American Medical Association*, June 10, 1916) of a series of cases in which laminectomy with simple exposure of the spinal cord has produced great improvement of the symptoms of various obscure conditions related to the spinal cord. Their cases included multiple sclerosis, syphilitic disease of the spinal cord with flaccid paraplegia, and suspected tumors. Their conclusion is that the "free removal of spinous processes and laminæ with opening of the dura in the absence of increased intradural pressure . . . . may have a profound effect in certain pathologic states of the spinal cord and may so modify or check the disease that a return to normal conditions is even possible." This is particularly true as regards the cervical and dorsal regions though exploratory operations upon the conus and cauda equina are apt to be followed by complications so that an exploratory operation here is justified only when strict indications for it exist. More than 150 operations on the spine are in the experience behind this conclusion so that it would seem that operation for suspected tumor should now be freely counseled and at least an exploratory operation done in every case where the symptoms are serious.

James J. Walsh.

Spinal Hemorrhage.—*Synonyms:* Hematomyelia; spinal apoplexy. Hemorrhage in the spinal cord is very rare in comparison with hemorrhage in the brain. When it occurs it is usually of small extent. This is not extraordinary when the size of the organ and the firmness of its connective-tissue sheath, and the low pressure in the spinal arteries, are considered. As a rule, the clot in the spinal cord is long and narrow. It destroys a considerable part of the cord at one segment, and extends into the segments above and below, injuring these to a less extent. The clot is usually found in the gray matter of the cord, most frequently in the anterior horns, then in the posterior horns, and rarely in the white columns. Sometimes the surface of the cord is broken and the blood infiltrates the pia mater. Occasionally a large number of small clots are found at different levels. As the patient rarely dies at once of hemorrhage the clot is usually found in a state of decomposition, and the cord around it is infiltrated with blood cells, pigment granules, and hematin crystals. If the hemorrhage is capillary—as sometimes occurs—it is detected by the presence of pigment and crystals among the degenerated spinal elements. Around the clot the spinal cord is usually found in a state of softening, which is red in recent cases, and white when the process has been a long one. At a postmortem examination the question sometimes arises whether the condition found is a myelitis with secondary hemorrhage, or a hemorrhage with secondary myelitis. In the former case the microscopic examination shows a greater preponderance of granular corpuscles and leucocytes, a greater degree of degeneration in the nerve cells, and a greater extent of connective-tissue growth.

There is a form of acute infectious myelitis in which capillary hemorrhages occur throughout the entire spinal cord, both in the gray and white matter, and in this type both large and small clots are found. Secondary degenerations upward and downward from the segment destroyed, and secondary degenerations in the motor nerves from the segment affected to the muscles, are observed after spinal hemorrhage as after myelitis. The meninges are rarely involved.

Etiology.—Spinal hemorrhage is met with in males more frequently than in females, and in youth and middle age most often. The predisposing causes are chronic changes in the general arterial system, hemorrhagic diathesis, purpura, and acute or chronic myelitis of the spinal cord. The exciting causes are injuries to the vertebral column and cord and extreme muscular effort, also the sudden exposure to a marked change of atmospheric pressure [such as occurs in workers in caissons. A number of cases of hemorrhage in the cervical region of the cord have occurred from sudden bending forward of the neck.

Symptoms.—As a rule, the symptoms begin suddenly, and the patient is seized in a moment with complete paraplegia and intense pain in the back at the level of the hemorrhage, and shooting pains in the body and stiffness of the spine. A spinal apoplexy usually comes without any warning, after a sudden effort. When premonitory symptoms have existed for a few days it is probable that the case is one of acute myelitis. The extent of the paralysis depends upon the level of the lesion. (See article on *Spinal Cord, Diagnosis of Local Lesions in the.*) If it is located in the lumbar or dorsal region, the lower half of the body only is involved; if in the cervical region, the arms are affected as well. The hemorrhage is rarely so very limited as to affect one extremity only, but it is not infrequently the case that the symptoms are more marked on one side, and in some cases the symptoms of a Brown-Séquard type have occurred. The paralysis is total, no voluntary motion is possible, the limbs are relaxed and never rigid. The muscles do not atrophy or present any change in the electric reactions, excepting those which are supplied with nerves from the segment which is destroyed by the hemorrhage. The condition of the reflex action depends upon the seat of the lesion; it is suspended at the level of the hemorrhage, and increased in the segments below it. If the hemorrhage is in the cervical region there is an atrophic flaccid paralysis of the arms and a spastic paralysis of the legs. In such a case there may be pupillary symptoms also.

If the hemorrhage is confined to the central gray matter and the patient survives, the final symptoms may resemble those of syringomyelia. The bladder and rectum are uniformly paralyzed, and various forms

of incontinence of urine and feces result, dependent upon the seat of the lesion. If this is situated high up in the cord, the viscus may empty itself occasionally, as the need arises, unconsciously to the patient and independently of his effort or control. If the lesion is low down (below the eleventh dorsal segment), there is usually retention of urine and feces or complete relaxation of the sphincters. Cases sometimes occur of hemorrhage into the lower sacral region and conus terminalis from injuries; and in such cases there may be paralysis of the bladder and rectum only, with a small heart-shaped area of anesthesia about the anus and buttocks. Vasomotor paralysis accompanies the voluntary paralysis, and results in cyanosis and coldness of the paralyzed limbs, and predisposes the parts to the development of bedsores. The latter appear, very soon after the hemorrhage, on the prominent parts of the body which are subjected to pressure; voluntary movements to relieve such pressure, or reflex movements for the same purpose, being impossible on account of the lack of power and of sensation, for complete anesthesia and analgesia exist in the paralyzed limbs from the outset. Pain in the back, which occurs at the time of hemorrhage, does not usually persist. The danger in these cases is from the occurrence of bedsores, or of cystitis, and consequent infection from these sources, with the development of septic fever. If the hemorrhage involves the respiratory centers in the upper cervical region, sudden death takes place. This is rare.

The symptoms described are those of a severe hemorrhage, sufficient to destroy one or more segments of the cord. As a rule these symptoms gradually subside as the pressure of the clot is removed and the only permanent symptoms are those which are due to the actual destruction of the spinal elements, viz., limited atrophic paralysis and localized anesthesia. Dissociated anesthesia, viz., a loss of the senses of pain and temperature with preservation of the sense of touch, is not an uncommon result in the parts below the segment affected. If the clot is a small one, however, the symptoms may be more limited and less serious, partial anesthesia and localized paralysis with atrophy being the result. This, however, is the exception. Capillary hemorrhages give rise to widespread symptoms, which so closely resemble those of diffuse myelitis that differential diagnosis is impossible.

The PROGNOSIS is very bad in spinal apoplexy, for a destruction of the spinal elements cannot be recovered from. The patients either die suddenly, or die of complications, or linger on for months with all the symptoms of chronic myelitis. In the lighter cases they may recover sufficiently to get about, but some evidences of the hemorrhage in the form of local paralysis or areas of anesthesia always remain.

The DIAGNOSIS is usually easy, the sudden onset of total paraplegia being characteristic. In meningeal hemorrhage the paralysis is less marked than the spasms, and anesthesia is rare. In poliomyelitis anterior there is marked constitutional disturbance, with fever, before the paralysis begins, and anesthesia is not present. In acute central myelitis the onset is more gradual, the symptoms develop successively, they extend gradually to other parts, and fever is usual.

TREATMENT cannot reach the disease, but the patient should be kept absolutely quiet in the prone posture in bed, ice should be applied to the spine, and ergot should be given freely. The subsequent treatment resolves itself into care of the patient, and such measures as are used in the management of a case of chronic myelitis. M. ALLEN STARR.

Spine, Diseases of the.—SYPHILIS.—Syphilis, in either the inherited or the acquired form, may cause deformity of the spine with accompanying symptoms that can hardly be distinguished from those of Pott's disease. As compared with tuberculosis it is a very uncommon disease of the spine. Its manifestations are likely to be general in character, the local deformity being one of many evidences of disease.

Syphilitic disease of the spine, causing destruction of tissue and deformity, demands the same protective treatment as would progressive deformity from other causes. Appropriate medical treatment is of course indicated in addition.

MALIGNANT DISEASE.—Malignant disease of the spine is uncommon, particularly so in childhood. Sarcoma is more common than carcinoma, and it may affect the spine primarily, while carcinoma is almost always secondary to disease elsewhere, as of the breast.

The symptoms of malignant disease are usually more severe than those of tuberculosis. The pain, for example, is often persistent and is not relieved by support or recumbency. The constitutional symptoms are more marked and the steady progress of the disease toward a fatal termination is soon apparent. Not infrequently the tumor may be palpated through the abdominal wall, and the deformity characteristic of destruction of the vertebral bodies is often absent. Paralysis is a frequent and often an early symptom.

Malignant disease of the spine is a fatal affection and the treatment can be but palliative.

ACUTE OSTEOMYELITIS.—Infectious osteomyelitis of the spine is uncommon. The characteristic symptoms are similar to those of acute infectious processes elsewhere, namely, sudden onset with fever and constitutional depression. There are local pain and tenderness about the spine. Abscess quickly forms, and paralysis, from the rapid extension of the disease to the spinal cord, is a frequent complication.

The later symptoms due to pyogenic infection are often pyemic in character. Necrosis of the affected vertebral bodies may result in the formation of large sequestra. The death rate is about fifty per cent.

Treatment.—The immediate evacuation and drainage of the abscess are indicated together with the removal of the necrosed bone if possible. Subsequently the spine should be supported.

A more chronic and more localized form of osteomyelitis may occur, but it is practically impossible to distinguish its symptoms from those of tuberculous disease. In this class of cases an abdominal or pelvic abscess may be the first indication of disease.

ACTINOMYCOSIS.—Actinomycosis of the spine is an extremely rare disease. Its diagnosis may be made by the microscopical examination of the discharge from the sinuses that almost always form early in the course of the disease.

TRAUMATISM.—Severe sprains, rupture of ligaments, or fractures of the spine may simulate disease, particularly when the injury is of the cervical region. Diagnosis is in some instances practically impossible until the effect of local support has been tested, when as a rule, if disease be absent, the symptoms, even though of long standing, quickly subside.

Fracture of the spine in the middle region without displacement may cause angular deformity, and when proper support has been neglected, symptoms of pain and weakness similar to those of Pott's disease may persist indefinitely.

Sudden forcible compression of one or more of the vertebral bodies without displacement and without severe immediate symptoms, other than the slight deformity, may be the result of injury, especially falls from a height. These cases are not uncommon and are usually mistaken for Pott's disease, especially as the deformity may not be evident until several weeks after the injury.

The *diagnosis* should be made clear by the history and by *x*-ray examination.

Treatment.—In all such cases and whenever weakness of the spine persists and when motion causes pain, a support should be applied. Fracture of the spine should be treated as are fractures elsewhere, by reposition if possible or practicable, and by support until the integrity of the parts has been reëstablished. In favorable cases the Albee operation may be of value.

Traumatic Spondylitis.—Kümmell has described a form of rarefying osteitis of the spine induced apparently by injury. It is characterized by symptoms of pain and weakness, referred to the back, and by a rounded kyphosis of the dorsal region. Motor disturbances of the lower extremities are frequent. Such cases may be explained either as direct effects of injury, or as due to subsequent infection—tuberculous or otherwise—of the weakened parts.

The *treatment* is similar to that of Pott's disease.

Rachitic Spine.—The rachitic spine is mentioned in the consideration of the differential diagnosis of Pott's disease, and is described in more detail below. It is a deformity that appears, usually during the first or second year of life, in children who do not walk. The typical rachitic kyphosis is a rounded projection of the middle and lower region of the spine. It is in fact simply an exaggeration of the contour that is normal in the sitting posture. The deformity is more or less rigid according to its duration. If it is extreme, it may be accompanied by a compensatory backward inclination of the head—"posterior torticollis."

Treatment.—Aside from the constitutional treatment of the predisposing disease the indications are to overcome the rigidity and the limitation of motion of the spine, to support it if necessary by a light back brace, and to avoid, as far as possible, the postures that favor the deformity. In severe cases of rickets the recumbent posture on the stretcher frame (see section on *Tuberculosis*) is the treatment of selection.

Typhoid Spine.—During the course of, or during convalescence from, typhoid fever symptoms of pain, weakness, and stiffness of the back may appear, induced in certain instances apparently by sudden movements or strains. Often there may be local sensitiveness to pressure or motion; and a slight posterior projection in the lumbar region of the spine, the part most often involved, is not unusual.

The cause of the symptoms is apparently infection of the fibrous coverings and attachments of the spine similar to the more common and more severe forms of periostitis in other situations that may complicate this disease. It may be stated also that in exceptional instances typhoid infection may be accompanied by abscess, by destruction of bone, and by actual deformity.

Treatment.—The treatment should be symptomatic. During the active stage if the pain is severe the patient should be kept in the recumbent position on a stretcher frame. Locally the application of the Paquelin cautery is of service in relieving pain, and the application of adhesive plaster strapping over the sensitive area may add to the comfort of the patient. As soon as it is practicable a back brace or corset should be applied. Recovery is the rule, although a certain amount of restriction of motion may persist.

The same symptoms may follow other forms of contagious disease, notably scarlet fever, but as a rule they are less persistent and severe.

Gonorrheal Arthritis.—Gonorrheal infection is uncommon. Its symptoms resemble those of the preceding affection; ankylosis is, however, more common as a result; in fact, gonorrheal arthritis is supposed to be one of the causes of spondylitis deformans.

The treatment consists in support for the purpose of preventing deformity and relieving discomfort.

Cervical Arthritis.—The joints of the occipito-axoid region are sometimes involved in what appears to be a form of infectious arthritis, sometimes following diphtheria or other contagious disease. It may be distinguished from tuberculosis by its acute onset, and from acute torticollis by the fact that all the motions of the head are restricted.

Treatment.—The treatment consists in support during the acute stage, as by a collar or jury mast, followed by massage and manipulation to overcome the stiffness.

Spondylitis Deformans.—Spondylitis deformans is a chronic disease of the spine terminating in ankylosis and deformity.

The disease is apparently a chronic inflammation which affects primarily the ligaments and the periosteal coverings of the spine, a form of ossifying periostitis which binds the vertebræ firmly to one another. It may begin on the lateral or on the antero-lateral aspect of the spine. It may be limited to a particular region, but in most instances it progresses until it involves the entire spine, and often the articulations of the ribs as well. The intervertebral discs atrophy, but in some instances the margins of the cartilages proliferate and become ossified in a manner characteristic of osteoarthritis.

Under the general term of spondylitis deformans are included, in all probability, several varieties of disease. For example:

1. The ankylosis of the spine may be simply a part of a general process involving the larger and smaller joints—chronic polyarthritis.

2. The spine may be involved together with one or more of the adjacent joints, which show the characteristic changes of the so-called hypertrophic form of arthritis deformans—osteoarthritis of the spine. This form has been designated by Marie as spondylose rhizomélique (σπόνδυλος spine, ῥίζα root, μέλος extremity), implying a disease of the spine, together with the adjoining "root" joints.

3. The disease may be limited to the spine and even to a particular region; in such cases it may be quite different from the polyarthritic or osteoarthritic types. This form may follow acute rheumatism; it may be induced apparently by gonorrhea or by other forms of infection. It may begin acutely like inflammatory rheumatism, or it may be chronic in character and progress slowly.

In the cases of spondylitis deformans, as distinct from general involvement of the joints, there is often an acute onset, mistaken for lumbago, from which the patient dates the beginning of his trouble. This is followed by a gradually increasing stiffness of the spine and accompanying deformity, with intercurrent attacks of so-called lumbago. In the well-marked cases the patient complains of stiffness, weakness, pain in the loins, pain radiating forward along the ribs; sometimes of weakness in the limbs, of headache, nervousness and the like, symptoms that may be caused directly by the inflammatory process, or by implication of the nerve roots, or by an accompanying neurasthenia. The direct symptoms are increased by jars which are exaggerated by the inelasticity of the spine. The disease is usually progressive and terminates finally in complete rigidity of the spine, which is bent into a long kyphosis most marked in the upper dorsal region, the lumbar lordosis being obliterated in many instances.

When the disease is limited to the spine or to the spine and larger joints, the occipito-axoid articulations are not usually involved; but in the cases of general polyarthritis, stiffness of the neck may be an early symptom.

Treatment.—Possible sources of infection from the teeth, intestines, or urinary tract should be investigated

and general medical supervision is of course essential.

The local treatment is symptomatic. The application of the cautery adds to the patient's comfort, and self-suspension at intervals may relieve the dragging sensation in the muscles. Rubber heels are of service in lessening the jar. A brace or plaster corset may be applied if the pain is aggravated by motion. It should serve also, together with the avoidance of predisposing attitudes, to prevent extreme deformity of the spine. Such protection is of great service if it is applied early in the course of the disease, especially in those cases in which it is localized, as it sometimes is, in the lumbar region.

Fig. 4602.—Complete Ankylosis of the Entire Spine. The patient, about one year before coming under observation, fell down a flight of stairs, rupturing the bony adhesions between the vertebral bodies at the points of greatest deformity (as seen in the picture). The accident was followed by great pain and marked sensitiveness at and near the points of injury, and these symptoms persisted for many months.

Adolescent Kyphosis.—A form of extreme kyphosis, accompanied by stiffness and discomfort, is not infrequently seen in adolescence. It appears to be a static deformity induced by overwork. It can hardly be classified with spondylitis deformans, although there may be some difficulty in distinguishing between the two. The treatment is, if possible, prevention in avoiding predisposing postures and in strengthening the muscles. In more advanced cases, forcible correction after the Calot method, followed by support, massage, and exercise, may be of service.

The kyphosis of old age is a familiar deformity that does not require special mention.

Osteitis Deformans.—Osteitis deformans is described elsewhere. It is a general disease characterized by hypertrophy and softening of the bones. The deformity of the spine is similar to that of spondylitis deformans, but the local discomfort is far less marked.

Neurotic Spine.—This affection is far more common in adolescence and adult life than it is in childhood, and in females than in males. The subjects are usually of a nervous or neurasthenic type, often overworked and physically depressed. In certain instances, however, the exciting cause appears to be direct injury. The patient usually complains of a dull pain in the back of the neck, or in the lumbar or sacral region, of a constant tired feeling, and not infrequently of sharp neuralgic pain localized about a certain point in the spine, often the vertebra prominens. The contour of the spine may be normal, but there is usually a well-marked tendency toward a forward droop, the curve of weakness. A common symptom of the neurotic spine is the extreme local tenderness, or hyperesthesia of the skin over certain spinous processes. Thus, if one passes the finger gently along the spine the patient will often shrink or cry out when the sensitive point is reached. The pain is usually localized about the spine, and there is no limitation of movement or especial discomfort on motion. The symptoms are distinctly subjective, thus differing from those of actual disease.

Treatment.—The treatment of the neurotic spine must include, of course, the general condition of the patient. Locally, a light back brace or a long corset, reinforced with steel bands, adds to the comfort of the patient. The application of the cautery lessens the local sensitiveness. Massage and exercises may be employed with advantage. Complete recovery is usually long delayed.

Hysterical Spine.—The hysterical spine is usually classed with the neurotic spine. The local subjective symptoms may not differ particularly from those of the neurotic spine, but in certain instances actual deformity may be present. This is usually exaggerated lateral distortion of the lumbar region. This deformity may appear after injury, but, except as a possible cause of a particular manifestation of the mental condition, it is usually apparent that injury cannot explain the symptoms or the deformity.

Treatment.—The local treatment is similar to that of the neurotic spine.

Pain in the Lower Part of the Back.—Pain, discomfort, and weakness are sometimes caused by disease or displacement of the pelvic or abdominal organs. Similar discomfort is a common symptom among overworked women. It is usually present also whenever the lumbar lordosis is exaggerated, as a compensatory deformity for dorsal Pott's disease, or because of flexion of the thigh after hip disease.

The *treatment* must be directed to the conditions of which it is a symptom.

Pain and weakness in the lumbar region may be induced by strain or other injury. In such instances it is usually increased by sudden motion or overexertion, and it may be persistent and disabling. Such cases are often classed as chronic lumbago. The cause is apparently strain of the joints, the deep ligaments or muscles of the spine, but the symptoms may be exaggerated, doubtless in certain instances by gout, rheumatism, or other disease of this character.

When motion causes pain and when the symptoms are persistent, support in the form of a back brace or firm corset is indicated, so made as to hold the pelvis firmly and check movement within the painless range. During the more acute stage the cautery, followed by the application of intersecting straps of adhesive plaster covering a wide area, will often relieve the pain. Later, massage, electricity, and the like, may be of service.

Spondylolisthesis.—Spondylolisthesis, or exaggerated lordosis, is a deformity in which the body of one of the lower lumbar vertebræ, most often the fifth, is displaced forward and downward. The displacement is usually accompanied by distortion of the affected vertebra. The spinous process remains in its normal position, while the laminæ become elongated or separated from the displaced vertebral body. Spondylolisthesis was first described by Killian in 1854 and more recently by Neugebauer in 1890.

The ordinary causes are congenital malformation, injury, and possibly disease of the lumbosacral

articulation. Lane states that slighter degrees of the deformity are often observed among laborers. The effect of the displacement is to exaggerate the lumbar lordosis or the backward inclination of the body and to increase the prominence of the sacrum and of the iliac crests. The deformity is most frequently seen in women, it often causes no particular symptoms, but if extreme it induces an awkward gait, discomfort in the back, and pain in the limbs. The deformity in males is usually the direct result of injury with forward displacement of the fifth lumbar vertebra upon the sacrum.

Treatment.—Support may be required if the symptoms indicate it. In the slighter grades of deformity a strong corset reinforced by steel bands is efficient.

Fig. 4603.—Sciatic Scoliosis.

If the deformity is progressive the Albee operation of bone transplantation may prevent further development.

Deformity of the Spine Secondary to Sciatica.—Persistent sciatica often induces a change in the attitude and contour of the spine. As a rule the patient habitually inclines the body away from the painful part, in order to relieve the limb from weight, and bends the body slightly forward to relax the tension on the sensitive nerve or plexus of nerves. Thus the pelvis on the affected side projects, there is a lateral lumbar convexity toward the opposite side, and often the normal lumbar lordosis is lessened or lost, so that the final result may be a permanent lateral curvature together with a flattening of the lumbar region. If the sciatica is a symptom of a more widespread neuritis of the lumbar plexus, muscular weakness and muscular spasm may cause variations in the typical attitude, but this is unusual.

Aside from the direct treatment of sciatica support may be required if movements of the spine aggravate the pain. This is always indicated in cases of persistent distortion. If the deformity is resistant the patient should be suspended and corrective jackets applied at frequent intervals. As the attitudes and symptoms described may be caused by disease or injury of the sacroiliac articulation, this region should in all instances be carefully examined.

Neuritis of spinal nerves in other regions of the spine may cause symptoms of reflected pain and local sensitiveness. These are increased by motion, and a certain amount of deformity, similar in character to that due to sciatica, may be present.

The *treatment* is similar to that indicated for the former affection.

Tuberculosis.—Tuberculous disease of the spine, or Pott's disease, is a chronic destructive process of the bodies of the vertebræ, the weight-supporting portion of the spinal column. As the disease progresses the part of the spine above the weakened point sinks downward and forward, throwing into relief the spinous processes at the seat of disease. Thus an angular posterior projection is the characteristic deformity of Pott's disease, or rather of any process attended by local destruction of one or more of the vertebral bodies. If one vertebral body is destroyed, the projection is sharp and well defined; if several are involved, it will be less angular; and if one side of a vertebral body breaks down, there may be a slight lateral distortion as well.

The size of the deformity and its effect upon the individual depend in great degree upon its situation. If it is at either extremity of the spine the deformity is small, because so little of the spine is affected compared with that which remains free from disease. Thus, angular deformity in the upper cervical region simply shortens the neck, and disturbs the pose of the head. In the lowermost region it shortens the trunk and induces a peculiar attitude, but in either case the posterior projection or "hump" is slight; but when the middle of the spine is involved the opportunity for deformity is great since the entire spine may enter into the formation of the kyphosis.

Pathology.—The first indication of disease is usually found in the anterior part of a vertebral body beneath the longitudinal ligament. From this point the infected granulation tissue, following the course of the blood-vessels, invades and destroys the adjacent spongy tissue. In other instances the disease may begin in several minute foci in the interior of a vertebral body near the upper or lower epiphysis. These, coalescing, gradually enlarge, forming a cavity; collapse follows and the deformity appears. Less often the disease advances beneath the anterior ligament as a form of tuberculous periostitis, without implicating deeply the substance of the vertebral bodies. The posterior part of the spinal column usually remains free from disease, unless it comes into direct contact with it.

The course and outcome of the disease depend upon its character. If the area of primary infection is limited, the local resistance may check its further progress and cure without deformity may follow. In other instances, although the area of active disease is small, it continues to progress and the deformity slowly increases, although unaccompanied by pain or by constitutional symptoms. In the majority of cases, however, the tuberculous granulations advance rapidly, destroying the bone or other tissues with which they come into contact. The usual retrograde metamorphosis to cheesy degeneration follows, with subsequent liquefaction or abscess formation.

In characteristic cases that come to autopsy during the progressive stage of the disease, one finds, on

dividing the thickened tissues in front of the spine, a cavity the walls of which are lined with tuberculous granulations in various stages of degeneration and containing puriform fluid. The adjoining vertebral bodies present a worm-eaten appearance, and one or more of them is partially destroyed. Small fragments of necrosed bone and "bone sand" may be present, together with larger masses of degenerated tissue; less commonly sequestra of considerable size may be found, loose or embedded in the diseased area.

As the disease progresses it may force its way into the vertebral canal and press upon the spinal cord, involve its coverings, and cause paralysis of the parts below. Such a complication is more frequent when the disease begins in the center or posterior portion of a vertebral body. In such instances the paralysis may precede the deformity. Pressure on the cord may be caused also by an abscess or a projecting fragment of bone. The caliber of the spinal canal may be lessened also by the pressure of the superincumbent weight upon the softened and thickened tissues at the seat of disease, but as a rule its capacity is not directly lessened by the characteristic angular distortion. In fact, pressure paralysis more often complicates cases in which the deformity is moderate or slight in degree than those in which it is extreme.

In rare instances tuberculous disease may appear in two regions of the spine simultaneously, but it usually begins in one or two adjacent vertebral bodies, one or both of which are partially destroyed. From this point the disease extends in either direction, and in ordinary cases the final area of deformity and rigidity shows that from three to six bodies are more or less involved before a cure is established.

At all stages of the disease resistance to its progress and local efforts at repair are evident in the affected parts. This is accomplished occasionally by contact and solid union of the adjoining surfaces of softened bone, but this is possible only when the area of the disease is small. If several bodies are destroyed there is usually backward displacement of the upper segment of the spine as it sinks downward. Thus the anterior surface of one or more of the bodies of the upper segment may be apposed to the upper surface of the lower body. In such instances the ankylosis is in part fibrous, in part cartilaginous, and in part bony. This may include the articular processes, the pedicles and laminæ; in fact, ankylosis may be established here before repair has advanced appreciably in the anterior portion of the column.

Cure may be complete, no vestige of the disease remaining; or the diseased products may undergo calcareous degeneration and may be enclosed in newly formed tissue. In other instances the disease is simply quiescent, and may show its presence from time to time by recurrent symptoms of discomfort, by abscess formation, or even by paralysis many years after apparent cure.

Etiology.—The etiology of tuberculosis of the spine does not differ from that of other bones; the subject is considered elsewhere.

Relative Frequency.—Tuberculosis affects the spinal column more frequently than it does any other single bone or joint. This point is illustrated by the statistics of tuberculous disease treated in the out-patient department of the Hospital for Ruptured and Crippled during a period of twenty years: Tuberculosis of the spine, 4,299 cases; hip-joint, 3,329 cases; other joints inclusive, 3,222 cases.

Age.—Pott's disease, although far more frequent in the middle period of childhood (from the third to the tenth year), may occur at any time from earliest infancy to extreme old age. The following statistics are from Whitman's Orthopedic Surgery.*

* The youngest patient was two months old, the oldest seventy-one years.

	Cases.	Per cent.
Less than one year.	38	3.1
Between one and two years.....	176	14.2
Between three and five years.....	627	50.2
Between six and ten years.....	234	18.3
Between eleven and twenty years....	89	7.2
Between twenty-one and thirty years	43	3.5
Between thirty-one and fifty years...	31	2.6
Over fifty years.....	11	0.8

Sex exercises comparatively little influence upon the liability to disease of this region. In 3,822 cases 53.2 per cent. were in males and 46.8 per cent. in females.

Situation.—The dorsolumbar section of the spine is most often affected. Cervical disease is comparatively infrequent.

In a series of 1,355 cases the attempt was made to locate the origin of the disease by the most prominent spinous process in the tracing. The following are the conclusions:

Cervical.		Dorsal.		Lumbar.		Lumbosacral.	
First,	3	First,	26	First,	94	13	
Second,	3	Second,	43	Second,	96		
Third,	15	Third,	42	Third,	64		
Fourth,	20	Fourth,	46	Fourth,	57	No deformity.	
Fifth,	13	Fifth,	49	Fifth,	6	Cervical,	2
Sixth,	22	Sixth,	76		—	Dorsal,	31
Seventh,	24	Seventh,	82		317	Lumbar,	22
	—	Eighth,	97				—
	100	Ninth,	92				55
		Tenth,	110				
		Eleventh,	71				
		Twelfth,	120	Disease in two regions of the spine, 16.			
			—				
			854				

From these statistics, which do not differ essentially from those reported by others, it appears that the disease is much less common in the cervical than in the dorsal region. This may be explained by the greater strain to which the middle and lower part of the spine is subjected, as well as by the relatively larger proportion of cancellous tissue which offers the opportunity for infection.

Prognosis.—Pott's disease is the most serious of all the tuberculous affections of the bones and joints, because of the relative importance of the structures directly and indirectly implicated. Prognosis must include also the indirect influence of the deformity. In the typical "humpback" deformity the contents of the thorax and abdomen are necessarily compressed, the blood-vessels are distorted and the caliber of the aorta is thereby often much diminished, respiration is made difficult, and the circulation is impeded. As a consequence the heart is usually hypertrophied or dilated, and valvular insufficiency is not infrequent. Thus the vital functions which are carried on at a disadvantage even under favorable conditions become impossible under the added strain of unfavorable surroundings, overwork, or disease. It is a matter of common observation that few of those who are markedly deformed reach old age. On the other hand, it may be assumed that slight deformities, or those which do not as directly interfere with the vital functions, exercise but little influence upon the future well-being of the patient. This emphasizes the importance of early diagnosis and efficient treatment.

The direct mortality of Pott's disease cannot be accurately estimated, but at least twenty per cent. of all patients die during the progress of the disease and within a few years after its onset, from causes directly or indirectly dependent upon the local lesion. Some of these die from general dissemination of the

tuberculous infection and tuberculous meningitis; some from exhaustion following septic infection or from amyloid degeneration dependent on long-continued suppuration; some from tuberculosis of the lungs, and many from intercurrent affections that are fatal because of the devitalizing influences of the disease and its complications.

Symptoms.—The most positive sign of Pott's disease is deformity. At an early stage of the process there may be but a slight irregularity in the contour of the spine, and if several adjacent vertebral bodies are affected the projection may be somewhat rounded in outline. But as compared with other deformities of the spine, that of Pott's disease is characteristically angular, because its cause is loss of substance.

This angular deformity was once thought to be essential for diagnosis, but it is simply the result of disease that may have existed for months, a disease whose presence may be detected long before it reaches the destructive stage.

The spine is the most important support of the body, an elastic column that accommodates itself to every movement of the trunk and limbs. The early symptoms of a destructive disease must be therefore pain and functional disability. The spine also contains the spinal cord, from which branch the nerves that supply the organs and members of the body, and in certain instances the sudden onset of paralysis due to extension of the disease backward might occur early in the process. Or, again, abscess, one of the common accompaniments of tuberculous disease, might, because of its size or situation, become the most noticeable symptom.

These are symptoms that may be misleading, and it is well, therefore, to consider them apart from those that indicate the primary effect of the disease upon the spine considered as an elastic support. These direct symptoms usually precede and always accompany the secondary or complicating symptoms, and upon them the diagnosis depends.

The primary and diagnostic symptoms of Pott's disease may be classified as follows: (*a*) Pain. (*b*) Stiffness. (*c*) Weakness. (*d*) Awkwardness. (*e*) Deformity.

The *pain* of Pott's disease is not usually localized at the affected vertebræ nor is it accompanied by sensitiveness to pressure or by infiltration and swelling of the overlying tissues, as is usually the case when other bones are involved; for the vertebral bodies are within the trunk, almost as far from the spinous processes as from the anterior surface of the body. Thus sensitiveness to direct pressure is unusual, and palpation, except in the cervical region, is of little diagnostic value. The pain is not localized, because the nerve filaments that supply the bodies of the vertebræ are insignificant parts of nerves that are distributed to distant points—to the head, to the limbs, to the front and sides of the body, and to these parts the pain is referred. Thus "earache" or "stomachache" or "sciatica" may be symptomatic of Pott's disease of the different regions of the spine. This pain is by no means constant; it is rather occasional, induced by jars or by unguarded movements. Often at night when muscular protection is relaxed, sudden movements during sleep cause discomfort or pain and the child moans, or is restless, and sometimes wakens with a cry—"night cry."

Stiffness of the spine is in some degree voluntary, in that the patient adapts himself to the disease and avoids, if possible, strain and jar, but the essential stiffness of Pott's disease is caused by the involuntary muscular tension and contraction of the muscles about the seat of disease. The degree of muscular spasm varies with the sensitiveness of the diseased tissues; thus it may fix the spine, or it may limit only the extremes of motion. Reflex muscular spasm precedes deformity and continues until a cure is established; it is therefore the most important of the diagnostic symptoms of Pott's disease.

A destructive disease of the most important support of the body it is a direct as well as an indirect cause of *weakness;* the younger the patient, the more apparent is this symptom which is shown by the "loss of walk," the refusal to stand, or the instinctive desire for support at an early stage of the disease.

Pain and weakness and rigidity of the spine induce changes in the habitual attitudes and movements of the patient that are often almost diagnostic of the disease and of the part of the spine involved.

The *deformities* of Pott's disease may be classified as—Bone deformity, muscular deformity, compensatory deformity. The characteristic angular projection due to destruction of bone has been described already. Muscular deformity is the distortion due to muscular spasm or contraction. Wry-neck, symptomatic of cervical disease, and psoas contraction, a common accompaniment of disease of the lower region, are the familiar examples. Compensatory deformity signifies the general effect of the local disease and local distortion upon the spine as a whole. Thus an angular projection must be balanced by a compensatory incurvation, and lateral distortion in one direction by lateral distortion in another. These secondary changes in contour often attract attention before the primary local deformity is detected.

Although angular deformity is characteristic of the disease, lateral deviation of the spine is not infrequent. It may be direct distortion at the seat of disease, caused by the destruction of the side of a vertebral body; more often, it is a secondary effect of such irregular erosion at one or the other extremity of the spine. It may be caused by muscular contraction, or it may be due to simple bodily weakness. In such instances it is a transitory distortion.

Aside from direct deformity, there is usually at the earliest stage of the disease a slight change in the outline of the spine; it no longer forms a long regular curve when the body is bent forward, but an irregularity of contour, of limitation of normal flexion, is almost always apparent.

Secondary Symptoms.—In the retropharyngeal space the tumor of an abscess may interfere with respiration and deglutition. In the thoracic region it may be mistaken for pleurisy or empyema, and in the iliac fossa, when accompanied by psoas contraction, it may interfere with locomotion.

Paralysis is usually one of the latter symptoms, but if the disease begins in the center or posterior part of a vertebral body it may implicate the cord before deformity appears.

Abscess and paralysis are classed as complications because they must be explained by a proper diagnosis. Their appearance is always preceded and accompanied by the essential symptoms of Pott's disease.

General Symptoms.—If the disease is active or if an abscess is approaching the surface there is usually a slight but constant elevation of the temperature, but the positive value of the symptom in early or quiescent cases is doubtful. A patient suffering from tuberculous disease of the spine usually presents the evidences of a painful and depressing affection and in many instances the appearances of inherited or acquired weakness; but these general symptoms are of comparatively little value in diagnosis.

Of the early symptoms of Pott's disease two have been noted as of especial importance—the impairment of normal mobility and the change in the contour of the spine. The contour of the spine varies considerably in the adult It is affected by the occupation and by many other circumstances; of this the round shoulders of the cobbler or the weaver, the stoop of weakness and of old age, are familiar examples, but in childhood distinct variations from the normal contour almost always have a pathological

cause. As the normal contour is the effect of the balancing of the body in the upright posture, it is evident that if the outline of one part is permanently changed, compensation for this change must be made in another part. Thus, when deformity is well marked the normal curves of the spine are often completely reversed, and even at an early stage of the disease the abnormal contour will often attract attention long before the characteristic angular projection has become apparent.

Although the spine is a flexible column that is constantly changing in outline with every movement and posture, yet the range and character of this motion vary greatly in its different parts. In the cervical and lumbar regions motion is extensive, but it is comparatively limited in the thoracic region because the intervertebral discs are thin, because of the overlapping spinous processes, and because it forms a part of the rigid thorax. It is evident that the symptoms of a destructive disease will show themselves far more quickly in those regions of the spine where motion is free than where it is slight, and that these symptoms will differ somewhat in character with the function of the part involved. Thus, in considering early diagnosis, and in fact treatment and prognosis, one should divide the spine into sections:

1. The neck part, that permits free motion of the head, ending at the third dorsal vertebra.

2. The rigid thoracic part, which includes the third and tenth dorsal segments.

3. The lower portion, made up of the two lower dorsal and the lumbar vertebræ, in which the principal movements of the trunk are carried out. One must bear in mind the distribution of the nerves because the characteristic pain is referred to their terminations, also the parts in relation to the spine at different levels that may be implicated in the disease. Thus, remembering that the symptoms of Pott's disease are in general, stiffness, weakness, pain, and deformity, one will always apply these symptoms to a particular region of the spine and will picture to himself the effect of such stiffness, weakness, and deformity at this or that vertebra; the effect of an abscess in this or that situation, and the area of paralysis that might be caused by pressure on the cord at one or another level.

The Rational Signs.—The symptoms of Pott's disease vary not only with the region of the spine involved, but also with the age and surroundings of the patient.

Tuberculous disease of the spine is usually an insidious chronic affection which does not often attract attention in its incipiency. The child may cry after overexertion or injury, but at other times it may appear to the unobservant eye, to be in its usual health. When the diagnosis is finally made, however, the parents always remember that something was "wrong" with the child, that it was fretful and disinclined to play, that it liked to lie on the floor, that it was awkward in its movements, that it was troubled by a cough or indigestion or by oppression of breathing. These symptoms, which are readily explained by the disease, do not as a rule attract attention until deformity appears.

An exact history of the case is often of importance both as to prognosis and as to treatment. For example, one should inquire if the immediate relatives of the child have suffered from phthisis or other form of tuberculosis; also if the child has always been strong, and if recovery from the ordinary ailments of childhood was prompt or tedious, in order that one may judge of the quality of the patient. One next asks, not "How long has the child been ill?" for this is usually understood to refer to the duration of the more decided symptom, but, "When was the child last perfectly well?" Then as to the onset of the first symptoms, whether it was sharp and decided, or gradual and ill defined; and whether the symptoms were preceded by contagious disease or by injury. If there is a history of injury it should be made clear whether the injury was the direct cause of the symptoms, or if it may have simply aggravated or brought to light the dormant disease. To establish injury as the sole and direct cause of symptoms, the patient must have been well at the time of the accident, the symptoms must have followed immediately and have continued since; and, finally, the symptoms must be of such a nature as to be explained by a definite injury.

Physical Examination.—Although histories are usually indefinite and misleading, it is commonly made clear that the affection is chronic, although its course has been varied by acute exacerbations. This is the characteristic of tuberculous disease.

The diagnosis is, however, almost entirely dependent upon the physical examination. This begins on the first sight of the patient, when one notes the general condition and the actions and postures. These show the adaptation of the body to the disease, the conscious and unconscious efforts of the patient to guard the weak part from strain that induces pain and discomfort.

The object of the physical examination is to compare the part suspected of disease with the normal, and the examination must be purposeful.

When one asks the patient to pick up a coin from the floor—the popular test for Pott's disease—one employs it to test the mobility of the lower region of the spine, the region in which the motions of stooping and turning the body are carried out; remembering that such movements are often not restrained in the slightest degree by disease in the upper portion of the spine.

Such tests must not only be purposeful, but they must be adapted to the age and intelligence of the patient. The child that refuses to pick up a coin will often gather up its clothing, because it wishes to be dressed again. If it will not stoop it will usually rise if placed in the recumbent or sitting posture, which is an equally useful test. A child will walk toward its mother if placed at a distance from her. It will always turn its head toward her, and therefore voluntary motion of the cervical region may be tested by changing the mother's position, while the child is held by the examiner.

Young children who struggle and resist passive motion, if placed on the table, submit quietly when held in the mother's arms.

The most important of the early signs of Pott's disease is the peculiar stiffness due to the reflex action of the muscles. This spasm limits movement in all directions. It is always present from the beginning of the disease until consolidation is finally completed.

The muscular rigidity is most marked in the neighborhood of the disease, but it extends to a greater or lesser distance, according to the acuteness of the local process and the susceptibility of the patient. Even at an early stage the situation of the disease is usually shown by a slight irregularity of the spine in the center of the area made rigid by muscular spasm, as well as by the change of contour. This change in outline and flexibility may be demonstrated by bending the patient forward. If the spine forms a long, even, regular curve, and if there be no evidence of pain or stiffness when such an attitude is assumed, Pott's disease is extremely improbable. If, on the other hand, the outline of the curve is broken, if the motion of one section of the spine is restrained by muscular rigidity, disease may be suspected, and, if other evidence of tuberculous ostitis is present, the diagnosis may be made with certainty.

By a careful physical examination one may expect to detect Pott's disease at any stage and to fix upon its location, or at least upon the point suspected of disease. One will then ask one's self if tuberculous disease of the bodies of the vertebræ of this par-

ticular region will satisfactorily explain all the symptoms of which the patient complains; if, for example, the pain corresponds to the distribution of the nerves, if restraint of function will explain the attitudes of the patient, if the change of contour is significant of a destructive process, and the like.

The Lower Region.—As has been stated, the spine should be divided into regions according to varying function. Of these regions the lower is the most important from the standpoint of relative liability to disease, and, as it is the movable region of the spine, the symptoms of disease here are usually evident long before the destructive stage.

The characteristic attitude of the patient is one in which the body is swayed backward. Often there is an increased hollowness (lordosis) of the back: thus, the prominent abdomen may first attract attention. The walk is careful, and often there is a peculiar tiptoeing step, which lessens the jar on the sensitive spine. This gait, although most common as an

Fig. 4604.—Pott's Disease in the Lower Dorsal Region, showing Compensatory Lordosis.

accompaniment of disease of this region, is simply an evidence that the spine is sensitive to slight jars. More characteristic of lumbar disease is a peculiar waddle, explained in part by the exaggerated lordosis, and in part by the loss of the accommodative balancing motion of the lumbar spine, as the weight falls alternately on the legs in walking.

The increased lumbar lordosis so characteristic of the early stage of the disease is capable of several explanations. It is partly voluntary, the backward inclination relieving the pressure upon the diseased vertebræ. It is partly involuntary, caused by the contraction of the large muscular masses on the posterior aspect of the spine. It is in part compensatory, as the slight psoas contraction which is often present has a tendency to tilt the pelvis forward, necessitating a greater compensatory backward inclination of the body.

As the disease progresses, the lumbar section becomes straighter, and finally it may project backward in the characteristic angular deformity. Yet even after the lordosis has been changed to a kyphosis the backward inclination of the body still continues as a compensation for the reversal of the lumbar curve.

Slight psoas contraction simply increases the lordosis, but when the contraction is more extreme and persistent, the erect attitude is no longer possible. The limbs are drawn toward the body and the body is inclined forward to relax the tension. This greater contraction, which is usually symptomatic of abscess formation, is most often limited to one side. Thus the patient inclines the body somewhat forward and toward the flexed leg, "favors it," and the resulting limp is usually mistaken for a sign of hip disease. Unilateral psoas contraction of this character is, in fact, so often present when the patient is first brought for treatment, that a limp and the accompanying inclination of the body may be considered as characteristic of more advanced disease of the lumbar region.

The location of the pain depends upon the distribution of the nerves that supply the diseased vertebræ, or that pass in its vicinity. It may radiate over the inguinal region or backward to the loins or buttocks, or down the front or back of the legs to the knees. Painful cramp is not infrequently a symptom, the thigh is spasmodically drawn toward the body, and the patient seizing it with both hands shrieks with pain.

Lateral inclination of the body is often present. Commonly it indicates unilateral psoas contraction, or at a later stage it may be caused by collapse or destruction of one side of a vertebral body. In other instances it was simply adaptation to weakness or pain, an attitude similar to that caused by persistent sciatica.

The effects of the stiffness, weakness, and pain are usually sufficiently apparent. For example, the child may be unable to turn in bed. If the disease is at all active, the standing is more comfortable than the sitting posture, in which more weight is thrown upon the sensitive vertebral bodies. When seated, particularly when riding in a carriage or street car, the patient often sits upon the edge of the seat, the shoulders only touching the back, while the hands rest instinctively on the seat, partially supporting the weight and steadying the spine.

Stooping, a posture that increases the pressure in the diseased vertebral bodies and which necessitates muscular tension and strain in regaining the erect position, is particularly difficult, and it is always avoided by the patient if the disease is at all acute. For example, when the child is asked to pick up an object from the floor, it either refuses or it squats on the heels or drops upon the knees instead of flexing the spine as in health. Young children having seized the object upon the floor, regain the erect attitude by pushing the body up by the pressure of the hands upon the thighs. If the child is placed upon the floor it will, if possible, seize the mother's dress, or will crawl to a chair or other object, upon which the body may be drawn up by the arms, so that the discomfort caused by muscular contraction of the back muscles may be avoided.

After this preliminary observation and examination the patient should be placed at full length, face downward, on a table, and the range of extension and of lateral motion is then to be tested by lifting the legs and swaying the body gently from side to side. One should always test for psoas contraction by holding the pelvis firmly against the table with one hand while the leg in the line of the body is gently lifted by the other. As tested in this manner the normal range of extension should allow the knees to be lifted two or three inches from the table. Slight restriction of extension of both thighs, indicating a slight degree of psoas contraction, is very common in

Pott's disease, but when the restriction is marked, and especially if it be unilateral, a deep abscess may be expected. Such unilateral psoas contraction may be more clearly demonstrated by placing the child on the back, allowing the limbs to hang over the table, when the unaffected thigh will drop below its fellow.

Fig. 4605.—Pott's Disease of the Lower Region before the Appearance of Deformity, illustrating the Manner of Picking up an Object from the Floor.

As has been stated, in many instances the lordosis is increased, and in all cases flexion of the lumbar spine is much more restricted in the early stages of the disease than is extension. This rigidity and fixation may be demonstrated by placing the child on its hands and knees and lifting it from the floor, the trunk, instead of bending over the supporting hands, retaining almost its original contour.

Although in many instances no noticeable deformity is present, still one can almost always detect a slight fulness about the spinous processes or a slight irregularity in their line, indicating the exact seat of the disease. Strong pressure upon the spinous processes at this point may induce discomfort, and sometimes greater elasticity at the diseased area is apparent. This is, however, a test of comparatively little value.

Abscess is very commonly a complication of disease in this region of the spine, and it may be suspected when persistent unilateral psoas contraction is present in marked degree. In such cases the patient may be turned upon the side, and by deep pressure one may often detect an elastic tumor in the loin or pelvic fossa.

Disease of the Middle Region.—As motion in the thoracic region of the spine is limited, the early symptoms of disease are far less marked than in the region below. On the other hand, a slight exaggeration of the normal dorsal kyphosis causes noticeable deformity. Thus it is that deformity may be the first symptom that attracts attention.

The effect of the disease upon the attitudes varies. If the disease involves the lower part of the thoracic segment, and if it be at all acute, they are similar to those of disease of the lumbar region, namely, erectness, the peculiar cautious intoeing step, and the disinclination to bend the body forward.

In disease of the upper dorsal region there is usually a slight forward inclination of the body while the head is tilted backward or inclines toward one side. A peculiar shrugging squareness and elevation of the shoulders is often noticed, due in great part to the lowering of the head and forward inclination of the neck resulting from the deformity. Another effect is pigeon-chest. As the deformity progresses the sternum is thrust forward and the anteroposterior diameter of the chest is increased at the expense of its height. This deformity of the chest may be the first symptom to attract the attention of the parents.

Of the early symptoms of dorsal disease pain and labored or "grunting" respiration are the most characteristic.

Pain referred to the abdomen and to the front and sides of the chest is usually an early and often a constant symptom. Thus, persistent "stomachache" in a child should always lead the physician to make an examination of the spine. A "spasm of pain" is sometimes excited by lateral compression of its chest, as when the child is lifted suddenly by the parent.

Of still greater importance is the labored respiration, which, indeed, is almost pathognomonic of Pott's disease. The "grunting" is caused by the interference with respiration, more particularly with the normal rhythmical movements of the ribs. The restraint is in part due to muscular spasm and in part to the voluntary efforts of the patient. The inspiration is quick and shallow, in great degree diaphragmatic, and expiration is accompanied by a

Fig. 4606.—Pott's Disease at the Cervicodorsal Junction, showing the Effect of the Deformity in Thrusting the Neck Forward.

sigh or grunt. This is apparently caused by a momentary closure of the larynx to resist the escape of air and thus sudden motion of the chest wall. Grunting respiration is of course an evidence of the more acute type of disease, but even in mild cases it is usually present when the patient is fatigued or dur-

ing play. An irritating aimless cough is often a symptom of disease of the upper dorsal region, and spasmodic attacks resembling asthma are not uncommon.

When symptoms have existed for any length of time the characteristic angular kyphosis is usually apparent on physical examination, or at least the significant break in the contour of the spine when the patient is inclined forward.

In tracing the neuralgic pain to its origin, the sharp downward inclination of the ribs must be borne in mind: thus the cause of pain in the "stomach" must be looked for between the shoulder blades.

As in the lumbar region, slight lateral deviation of the spine is not uncommon, and it may be accompanied by a slight twist or rotation, so that the ribs on one side are more prominent.

Fig. 4607.—Illustrating the Change from the Normal Contour, made Evident when the Patient Bends Forward.

Involvement of the cord from extension of the disease backward is far more commonly a complication of disease of the upper and middle dorsal region than of disease elsewhere, and an awkward stumbling gait or even complete paralysis may be the first important symptom of the disease. Abscess is less common here than in the lower region. Its presence may be suspected if an area of dulness is found by the side of the kyphosis. In rare instances an abscess in the posterior mediastinum may press directly upon the trachea or bronchi and cause spasmodic attacks of dyspnea resembling asthma.

It is hardly necessary to mention the list of affections that may cause pain in the chest or abdomen, or induce a labored respiration or cough. As regards deformity the round stiff back, a postural deformity of adolescence, and the rachitic kyphosis may be excluded without much difficulty. Spondylitis deformans, the typhoid spine, and the like differ essentially in history and symptoms. Acute or chronic affections within the chest may cause pain and even deformity of the spine. Such disease, however, could hardly be mistaken for Pott's disease. The abscess of Pott's disease in this region, as has been mentioned, causes dulness or flatness on percussion of the chest, and within this area friction sounds and râles may be heard. If the diagnosis of Pott's disease had not been made, or if the presence of the abscess had not been determined by the previous physical examination, it might be mistaken, during an acute exacerbation of the disease or constitutional disturbance from other cause, for pleurisy or empyema, and at other times for phthisis. The tuberculous fluid may remain indefinitely in the posterior mediastinum, and the area of flatness may extend beyond the axillary line, yet it may give rise to no symptoms.

In all cases a careful examination of the chest should be made from time to time in order that the presence or absence of abscess may be recorded.

The Upper Region.—The upper region of the spine, which includes the cervical and two of the dorsal vertebræ, is a region of free movement. This movement is in part true joint motion; thus it is necessary to consider disease of this portion apart from that of the remainder of the upper section. Occipito-axoid disease is comparatively rare, and relatively more frequent in adult life than in childhood. It is especially dangerous because the displacement or fracture at this point may cause sudden death by pressure on the vital centers. In a typical case the symptoms are neuralgic pain radiating over the back and sides of the head, following the distribution of the auricular and occipital nerves. The head is usually inclined forward and rotated slightly to one or the other side of the median line. There is usually thickening of the tissues on the posterior and lateral aspects of the neck, and there is in most instances sensitiveness to deep pressure. As a rule motion in these joints is absolutely restricted, as is shown when one attempts to move the head up or down or from side to side.

In disease of this region if an abscess appears it usually presents itself on the posterior or lateral aspect of the neck, but in some instances it forces its way forward as a retropharyngeal abscess. In such cases the symptoms may be characteristic of obstruction, such as snoring, change in the quality of the voice, difficulty in swallowing, and sometimes spasmodic attacks of so-called croup.

When an abscess is present, or when the disease is at all acute, the reclining posture often increases the discomfort.

The symptoms of disease of the middle cervical region are similar to those of the upper dorsal section. There is usually a backward inclination of the head if deformity is present. In other instances the head may be turned to one or the other side, so-called false torticollis. Deformity at the upper extremity of the spine straightens the natural anterior curvature in the cervical region, and as a result there is compensatory flattening of the back; thus a short neck and a flat back are often the most prominent physical signs of disease of this region.

The distortion of the head symptomatic of Pott's disease is sometimes mistaken for torticollis. From chronic torticollis it may be easily distinguished, because in this distortion there is limitation of motion only in the direction opposed to the contraction and there are no accompanying symptoms. From so-called acute torticollis caused by enlarged or suppurating glands, or following irritation of the nose or pharynx, the diagnosis may be more difficult; but in this affection, if the head be inclined toward the contracted muscles, motion in other directions will be unrestricted, whereas in Pott's disease all movements are checked by muscular spasm. It may be stated also that the distortion of Pott's disease is often irregular, and there is no evident contraction of certain muscular groups, such as is usually present in simple torticollis.

Injury of the upper segment of the spine may cause pain and stiffness and deformity, symptoms that could not be distinguished from those of Pott's disease but for the history of the case.

Weakness of the posterior muscles following diphtheria may cause a forward droop of the head. Spasm of the posterior muscles is sometimes seen incidental to meningitis and even as a less serious symp-

tom in weakly children, but such deformities can hardly be mistaken for Pott's disease.

Abscess may cause symptoms of obstruction in the throat which might be mistaken for that due to adenoid growths or enlarged tonsils. It may be mentioned also that the seventh cervical vertebra often forms a noticeable projection at the base of the neck. In hysterical or hyperesthetic individuals these symptoms are sometimes mistaken for those due to disease.

Forms of organic diseases of the spine other than tuberculous are described elsewhere.

The diagnosis having been established, an accurate record of the case should be made. This should include the general condition of the patient, the character of the disease, whether acute or quiescent, and the presence or absence of complications. The position and character of the deformity should be recorded by means of a tracing of the entire length

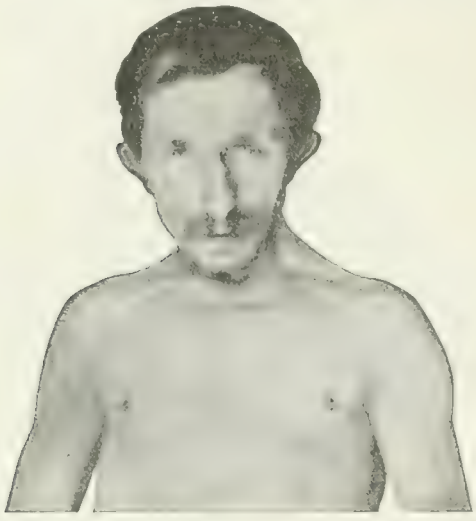


FIG. 4608.—Atlo-axoid Disease, showing the Characteristic Attitude.

of the spine, such a tracing being made by means of a strip of lead or tin while the patient is lying extended in the prone position.

X-ray examination has not been mentioned because in many instances it is not available for diagnosis. It is especially valuable as showing the situation and extent of the disease and its progress, favorable or otherwise.

Diagnosis.—The diagnosis of Pott's disease, even in the early stage, is comparatively easy on careful and systematic physical examination. It is most often mistaken for some one of the following affections:

Lumbago is usually of sudden onset, characterized by local pain and by sensitiveness of the muscles themselves. It is very uncommon in childhood.

Strain of the back has as a rule a well-defined cause. Like lumbago, its onset is sudden. The pain is usually localized at the point of injury and it is relieved by rest. In Pott's disease the pain is neuralgic, it is often worse at night, and the stiffness due to reflex muscular spasm is quite different from that caused by strain.

The pain of sciatica is most often unilateral; it is usually confined to the distributions of this nerve. The pain of Pott's disease, if it is referred to the legs, is usually bilateral. In sciatica movements of the limb often aggravate the pain, while motion of the spine is free or but slightly restricted. The reverse is true of Pott's disease. In persistent sciatica of long standing, lateral deviation and even rigidity of the lumbar spine are sometimes observed, but the history of the case is very different from that of Pott's disease.

Sacroiliac disease is far more likely to be mistaken for disease of the hip-joint than of the spine. The pain and sensitiveness are usually localized about the seat of disease, the motions of the spine are but slightly restricted and the posture is usually a lateral derivative similar to that of sciatica.

The attitude characteristic of Pott's disease of this region—viz., the hollow back, the prominent abdomen, combined with the waddling gait—may be simulated by bilateral congenital dislocation of the hip and by certain forms of nervous disease in which the muscles of the back are weak, as, for example, progressive muscular atrophy, or pseudo-hypertrophic muscular paralysis. In these affections the characteristic symptoms of bone disease are of course lacking.

Hip Disease.—Unilateral psoas contraction induces a limp, and not infrequently the patient complains of pain in the affected limb. These symptoms are usually mistaken for those of hip disease. The limp of Pott's disease is caused simply by flexion of the leg; when, therefore, in the physical examination the tension of the contracted iliopsoas muscle is believed by flexing the thigh still further, the other movements of the hip—flexion, rotation, and the like—may be shown to be free. In hip disease all motions are restrained in equal degree by muscular spasm.

In infancy sympathetic spasm of the lumbar muscles is often present in hip disease, and a similar spasm of the muscles about the hip may accompany disease of the lower part of the spine. In doubtful cases of this character the application of a temporary support to the back and limbs, as, for example, a plaster spica bandage which will relieve the secondary spasm, is an aid in diagnosis.

An infected abscess in the neighborhood of the hip-joint may finally set up secondary disease of its structure, and in the presence of discharging sinuses that involve the tissues about the hip it is not always possible to decide whether or not the joint is actually diseased.

Pelvic Abscess.—As abscess is a common complication of Pott's disease it will be necessary to consider abscesses of other origin within the pelvis or in the neighborhood of the spine that may induce symptoms resembling somewhat those of Pott's disease. The most common abscesses other than those resulting from disease of bone are the perinephritic and appendicular. As a rule these are of sudden onset, and are attended by local pain and by constitutional symptoms. There is of course no deformity of the spine.

Chronic abscess in the pelvis, of other than spinal origin, may be the result of disease of the pelvic bones, or of the sacroiliac articulations, or of the hip-joint. It may be caused by the breaking down of lymphatic glands, or it may have its origin in inflammation about the uterine appendages, and cases of so-called idiopathic inflammation and suppuration of the iliopsoas muscle have been described. In childhood chronic abscesses in this locality are almost always tuberculous in character, and are caused by disease of bone, either of the spine or of the pelvis. Disease of the spine can be determined usually by the methods already indicated, but, if the abscess is of other origin, its exact cause can be decided in many instances only by an operative exploration.

Abscesses of this character, of slow and apparently painless formation, may finally cause a swelling in the inguinal region or about the saphenous opening, that in the adult is not infrequently mistaken for hernia. In practically all cases, however, the tumor of the abscess may be made out on palpation within the pelvis, while the swelling, although its contents may be in part forced into the abdominal cavity, feels very differently from that of an ordinary hernia,

which may usually be completely reduced. In addition, some sign of the disease of the spine or pelvis, of which the abscess is a result, is almost always present.

Pott's Disease in Infancy.—Attention has been called to the great importance of carefully observing the movements and postures of the patient, and of noting the contour of the spine when the patient is in the erect attitude. In Pott's disease of infancy such observations are of course not possible. As a rule, at this age the muscular spasm is more intense and its extent is greater. The child screams when it is moved or lifted. There is usually no difficulty in determining the presence of disease from the evidence of rigidity and pain, but, as has been stated, it is sometimes difficult to decide whether the lumbar spine or one of the hip-joints is involved. Slight irregularity of the spinous processes, indicating the position of the destructive process, is often evident at an early stage and early abscess is not unusual.

Fig. 4609.—Pott's Disease in Infancy, showing the Early Indication of Deformity.

Pott's disease of infancy and early childhood is most often mistaken for *rachitic deformity*, or rather, this deformity is often mistaken for that of Pott's disease. The diagnosis from Pott's disease should be made without difficulty. The characteristic deformity of rachitis is a rounded projection of the middle and lower part of the spine. It is simply an exaggeration of the contour of the sitting posture which the rachitic child habitually assumes, a posture that would be painful if actual disease were present in this situation.

If the patient be placed in the prone posture the projection may be reduced in great part by raising the thighs while gentle pressure is exerted upon the kyphosis; and although the spine is somewhat rigid, and although such extension and pressure may be resisted by the patient, yet there is complete absence of the muscular spasm characteristic of Pott's disease.

Treatment.—Pott's disease is the most important of the tuberculous affections of bone, and the importance of proper surroundings, nourishing food, open air, and sunlight can hardly be exaggerated.

Special orthopedic treatment is essentially mechanical; its object is to resist the natural tendency of the disease toward deformity.

Under normal conditions the weight of the head and of the thoracic and abdominal organs tends to bend the spine forward. If the support is weakened by the direct destruction of the weight-bearing portion of the spine this tendency is greatly increased. It is evident, therefore, that the force of gravity is a very important factor in the production of deformity. Flexion of the spine compresses the vertebral bodies; extension of the spine relieves this pressure and transfers it in part to the articular processes.

The object of a brace or other support in the treatment of Pott's disease is to hold the spine in the extended position and to prevent motion at the seat of disease. The effectiveness of any splint depends upon the accuracy of its adjustment, and it is apparent that such adjustment is more difficult in certain regions of the spine than in others. For example, if the disease involves the lower thoracic region the splint is likely to be effective because its two extremities attached to the pelvis and to the shoulders are equally distant from the point to be supported; but if the upper thoracic region is affected, it is difficult to fix the spine because of the insufficient leverage of the supporting appliance. Even if the brace is accurately adjusted it cannot remove entirely the jar and strain incidental to the upright posture. It is evident, therefore, that complete rest can be assured only in the attitude of recumbency.

Horizontal Fixation.—A number of appliances to assure horizontal fixation are in use, but the most effective and convenient support is of the type of the Bradford frame or stretcher. This is a rectangular frame of ordinary gas pipe, a few inches longer and a little wider than the patient's body, covered with canvas or cotton cloth, except for an interval in the center, as shown in the illustration from Bradford and Lovett[2] (Fig. 4610).

This appliance may be modified with advantage in the following particulars: it should be made slightly narrower than the patient's body, its width corresponding to the distance between the articulating surfaces of the shoulder-joints. The cover should be made of strong canvas in one piece so that it may be drawn tight by means of straps and corset lacings. The center should be covered by rubber cloth. Upon the canvas cover opposite the seat of disease should be sewed two pads of felt about six inches long, one inch wide, and half an inch thick. These should be parallel to one another and about one inch apart. They protect the spinous processes from pressure, and aid in fixing the spine. The patient, in most instances a young child, wearing simply a shirt and diapers, is then placed upon the frame, and is fixed to it by means of a front piece of canvas, as shown in the illustration. If the disease is of the upper region, the frame should be bent so that the head may lie on a lower plane than the body and if desirable the head should be fixed by an appliance similar to the ordinary jury-mast; if it is in the lower region the movement of the limbs should be restrained by means of a swath or by traction straps. When the frame has been adjusted the child's clothing is put on, to include it and the frame. This illustrates the advantage of making the appliance as narrow as possible. When the patient has become accustomed to the restraint the frame is gradually bent backward until at the end of a few weeks the spine is forced, if possible, into an attitude of overextension (Fig. 4611).

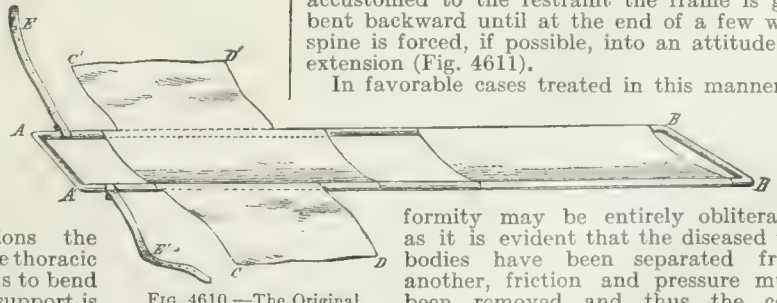


Fig. 4610.—The Original Bradford Frame.

In favorable cases treated in this manner the deformity may be entirely obliterated, and as it is evident that the diseased vertebral bodies have been separated from one another, friction and pressure must have been removed and thus the conditions most favorable for repair have been established. The patient is kept constantly fixed upon the frame, except that once a day he is carefully removed and placed face downward on a pillow. The back is then rubbed with alcohol and powdered, the frame cover is cleansed, and the child is then replaced upon it. As has been stated, the child wears diapers, and a dust-pan serves as a convenient form of bedpan. As much of the time

as possible is passed in the open air in the ordinary baby carriage.

The time during which the patient should be treated by this method varies with the severity of the disease; as a rule it is from six to eighteen months. The indications for its discontinuance are the subsidence of the symptoms and the behavior of the patient. A child suffering from active disease almost instantly recognizes the benefit of treatment and dislikes to be removed from the frame; but when repair is advanced he becomes impatient at the restraint, and when he begins to crawl about with the frame on his back and to attempt to stand, it is evident that the necessity for this mode of treatment is passed.

Although there is a strong prejudice against this form of treatment, I have never noticed ill effects from it, even when it has been long continued. The

Fig. 4611.—The Stretcher Frame, showing the Attitude of Overextension in Disease of the Upper Dorsal Region.

patient usually gains in weight and often grows rapidly, more rapidly in fact than those who are allowed to go about.

It is apparent that this form of recumbent treatment, although by far the most efficacious, is limited practically, as a routine practice at least, to early childhood, that is, to patients of four years or less, who can be carried about in arms. As a treatment for special cases, or to meet special indications, it has, however, no limit of age. For older patients the cover should be made in two parts, as in the original Bradford frame, to allow for the use of the bedpan.

Horizontal fixation must be supplemented of course by a support for the weakened spine when the erect posture is again assumed, and ambulatory treatment by such means is in the majority of cases the only one that is employed. These supports are either in the form of metallic braces applied along the spine or as circular supports, of which the plaster jacket is the common form. The object of every form of appliance is to remove as far as possible the weight from the weakened vertebral bodies by holding the trunk in the extended position, and to prevent motion at the seat of disease.

The Back Brace.—The most efficient spinal brace consists essentially of two steel bars that are applied on either side of the spinous processes from the top to the bottom of the spine. The attachment at the lower end is made by means of a pelvic band of sheet steel (gauge 18) from one and a half to two inches in width, long enough to reach from one iliac spine to the other. It is placed as low as possible on the pelvis—in other words, just above the upper extremities of the trochanters. To this the uprights are firmly attached at an interval of from one and a quarter to one and three-quarter inches from one another, so that the spinous processes may pass between them while pressure is made on the lateral masses of the vertebræ. The uprights are made of varying strength according to the age of the patient, usually about one-half an inch in width (of gauges 8 to 12), and of such quality of steel that although unyielding to the strain of use it may be readily bent by wrenches and thus accurately adjusted to the back. The uprights reach to the root of the neck, or to about the level of the second dorsal vertebra. From this point two short arms of metal project forward and outward on either side of the neck, reaching to about the middle of the clavicles. To these are attached padded shoulder straps, which pass under the arms to a crossbar on the back brace; thus downward pressure on the shoulders is avoided and increased leverage is assured.

Opposite the point of disease two strips of this steel, about three-quarters of an inch in length are fixed. These are slightly wider than the uprights, and are perforated for the attachment of the pressure pads, made of layers of Canton flannel or felt, or of unyielding material, such as leather or hard rubber if this is preferred.

The pads should project from a quarter to a half inch in front of the uprights in order that firm and constant pressure, to the extent that the skin will tolerate, may be made at the seat of disease.

Fig. 4612.—Whitman's Shoulder Brace; side view.

In measuring for this brace the patient is placed in the prone posture and a tracing of the outline of the back, beside the spinous processes, is made by means of the lead tape. This outline may be cut in card-board and fitted to the back; in fact, if the mechanic is unfamiliar with the work, each part of the brace, uprights, pelvic band, etc., may be cut in card-board and attached to one another to serve as a model. Before the brace is finished it should be applied to the back, and should be carefully adjusted by means of wrenches. The pelvic band is then padded and the parts that come in direct contact with the skin are usually covered with leather, or, in the treatment of young children, with rubber plaster and Canton flannel, to prevent rusting.

If the brace is applied before the stage of deformity, it should follow the exact shape of the normal spine; but if deformity is already present, particularly in disease of the thoracic region, it should be made somewhat straighter than the compensatory curves above and below the projection, in order to permit a gradual straightening of the compensatory lordosis in the lumbar region, and for increased leverage above the deformity. As has been stated, a certain amount of recession of deformity can be obtained by rest in the horizontal position; and if practicable this improved contour should be attained before the brace is applied. The apparatus is held in

place by an "apron," which covers the chest and abdomen, and to which straps are attached. Ordinarily this is made of strong linen or cotton cloth, but a canvas front, shaped accurately to the body and strengthened with whalebone as is a corset, is a much more comfortable and efficient support. In applying the brace with the patient in the recumbent posture the pelvic band is first attached to the apron, then the straps in order from below upward, and finally the shoulder straps. Each strap is then tightened until the brace is firmly fixed in proper position. When a brace is properly applied and properly fitted, it holds its place by friction; but in certain cases when the disease is low in the back, it is sometimes of advantage to apply perineal straps to hold the pelvic band firmly in its place.

At first the brace is removed once a day in order to wash and powder the back, the same care being observed in moving the child as in the treatment by

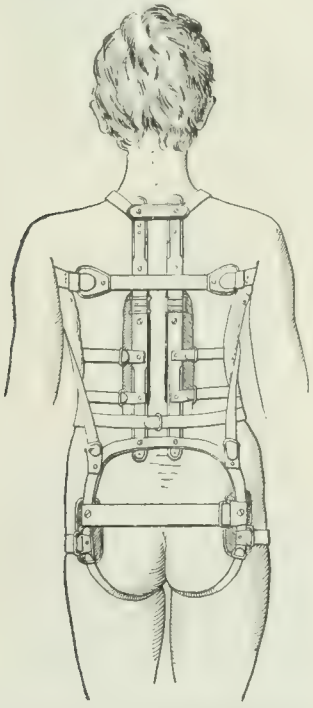


Fig. 4613.—The Taylor Back Brace.

the frame; but when the back has become accustomed to the pressure, the brace should be removed only at infrequent intervals, and thus, if need be, only under the supervision of the surgeon.

This description indicates the essential qualities of the back brace. It has been modified in various ways. For example, Dr. Taylor, its inventor, finally discarded the straight pelvic band in favor of one of a U-shape, as shown in the illustration (Fig. 4613). This makes the brace somewhat lighter and relieves the sacrum from the pressure of the pelvic band, but it does not add to its effectiveness. The efficiency may be increased, however, by improving the attachment at its upper extremity. Taylor has accomplished this by placing two triangular pads against the chest. If, however, the disease is of the upper and middle segment of the thoracic region, more efficient support is of advantage; for in such cases the upper part of the chest is flattened, the inclination of the ribs is increased and the shoulders incline forward, carrying with them the scapulæ. Thus the weight and the strain of the motion and use of the arms tend to increase the deformity.

In health direct forward or reaching movements of the arms are always accompanied by an increase in the posterior curvature of the dorsal spine. On the other hand, if the shoulders are drawn backward and held in this attitude the curvature of the spine is lessened and the chest is elevated and expanded.

In the treatment of disease of the upper dorsal region it should be the aim, in the application of a brace, to follow this indication and to apply pressure directly upon the extremity of the shoulders, to assure the greatest possible fixation of the spine and to restrain the movements of the arms that tend to increase the deformity.

The accompanying diagrams show how such support should be applied (Figs. 4614 and 4615). Two

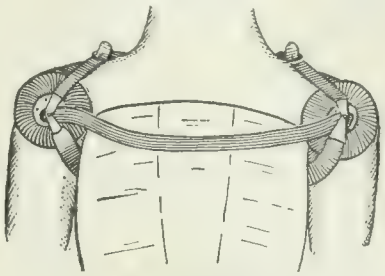


Fig. 4614.—Whitman's Brace; front view.

saucer-shaped plates of hard rubber or padded metal cover the heads of the humeri and are joined by a rigid bar of steel which passes across, but does not touch, the chest. On the back brace are placed two triangular pads of similar construction, which cover and press upon the scapulæ. These pads are, however, not essential, and are often omitted. The back brace is applied, the shoulders are then drawn backward, and the shoulder cups are firmly attached by straps to the neck bars of the brace above and below by axillary bands in the usual manner. By this means the thorax is elevated and the spine more effectively fixed, while direct movement of the arms forward is made impossible. It would seem that such restraint would be irksome to the patient, but in an extended use of the apparatus I have never heard this complained of. In many instances, even when

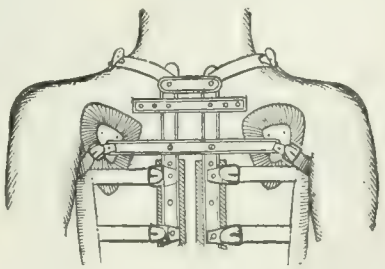


Fig. 4615.—Whitman's Brace; rear view.

the disease is as low as the tenth dorsal vertebra, this form of brace may be used with advantage, but it is especially indicated when the disease is in the neighborhood of the seventh dorsal vertebra. In connection with the shoulder brace it is usually advisable to apply a support beneath the chin to prevent the forward inclination of the neck and to tilt the head somewhat backward. A very simple and inoffensive support of this character is a loop of steel surrounding the neck and attached by screws to a back bar on the brace (Fig. 4616). If a more efficient brace is required, as when the disease is of the upper dorsal or cervical regions, the Taylor head support should be used (Fig. 4617). This is an oval ring of steel, which may be clasped about the neck by means

of a lateral hinge. On the front a cup of hard rubber supports the chin, and behind the ring fits upon an upright pivot, that may be raised or lowered upon a crossbar on the upper part of the brace. Free lateral motion is allowed, or it may be checked by means of a screw.

If absolute fixation of the head is indicated, as in disease at or near the occipitoaxoid region, two steel uprights are attached to the back of the ring, and are bent to fit the posterior and lateral aspect of the head closely. If necessary, a band of webbing is passed from one upright to the other and about the forehead.

In applying the support the chin should always be slightly tilted upward in order to throw the weight of the head backward.

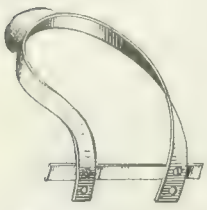


Fig. 4616.—Chin-piece to Whitman's Brace.

The adjustment of the head support is made easier if the pivot is attached to the upright by means of a ball-and-socket joint (Shaffer) that may be regulated by a screw and key. This arrangement is of service when the head is distorted, but it is by no means necessary.

When the Taylor head support and similar appliances are used, the greater part of the pressure is sustained by the chin, which may after a time undergo an unsightly recession. It may be of advantage therefore in certain cases, particularly when restraint of the motion of the neck is desirable, to transfer this pressure to the forehead by means of a strap attached behind to light bars of metal shaped to the occiput and attached to the upper extremity of the brace (Fig. 4618).

A jury-mast may be used to support the head also. Its adjustment will be described in connection with the plaster jacket, with which it is usually associated.

The Plaster Jacket.—It was at one time claimed that a plaster jacket applied while the body was partially suspended would actually relieve the weakened area of superincumbent weight by holding the diseased surfaces apart; but it is now generally conceded that the jacket supports the spine, as does the brace, by holding it in the erect or extended position. One is a circular and the other a posterior splint. There is this difference, however: the brace fits the spine accurately and holds its place by pressure and friction. The jacket is held in place by the support of the projecting pelvic bones. It lacks the accuracy of adjustment of the brace at the seat of disease; but, on the other hand, it provides a solid support on the front and sides of the body that may be even more effective.

Fig. 4617.—Whitman's Anterior Shoulder Brace Applied with the Taylor Brace and Head Support.

Each appliance has advantages and disadvantages that become apparent in the treatment of certain phases of the disease or conditions of the patient.

The plaster jacket is a simple support whose efficiency depends upon the accuracy of its adjustment to the irregularities of the body, and upon the leverage that it exerts above and below the point of disease. It should be applied while the body is held in the best possible position. Its inner surface should be smooth, and the bony prominences that are susceptible to friction and pressure should be protected. A seamless shirt should be worn. These are made in several sizes and are sold by the yard at a low price. The shirt should fit the body closely and should be long enough to reach to the knees. The patient is then placed upon a stool and the halter of the suspension apparatus is carefully adjusted. The arms are extended over the head and the hands clasp the straps or rings; thus the chest is expanded to its full limit. Sufficient tension is made upon the rope partially to suspend the body and to draw the spine into the best possible attitude. In most instances the heels should be slightly lifted from the stool.

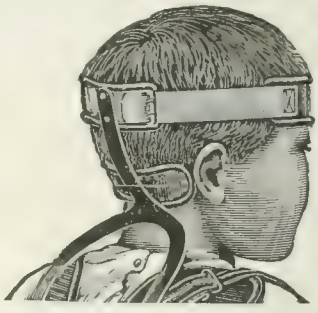


Fig. 4618.—Head Rest by a Forehead Band.

Dr. Sayre, to whom we are indebted for the exposition of this valuable means of treatment, insisted that the sensations of the patient should be the guide, and that traction should be made only to the point of comfort. This is a valuable indication in the treatment of the adult, but it is not often of service in childhood.

Before the plaster bandage is applied pieces of piano felting or Canton flannel of sufficient size should be placed about the anterior pelvic spines and over the upper part of the sternum. A thin strip of the same material may also be used to cover the spinous processes. Finally, long strips of saddler's felt, or other material of sufficient thickness, are applied on either side of the prominent spines to protect them from friction, and to provide greater pressure and fixation at the seat of disease. The "dinner pad" is now very rarely used, except in the treatment of adults and in certain cases of deformity in which the abdomen is retracted. In childhood the abdomen is usually prominent, and as the jacket expands some-

Fig. 4619.—The Plaster Jacket from Behind. (From Whitman's "Orthopedic Surgery.")

what no extra space is required. The pad, which is supposed to represent the space required after a full meal, is made by folding a napkin in the shape of a sandwich. To this a bandage is attached, and it is placed beneath the shirt just below the ensiform cartilage. When the jacket is hard it is drawn out. Another long bandage is placed beneath the shirt, to remain permanently for the purpose of cleaning the skin beneath the jacket. The bandages should be freshly prepared of dental plaster, which should be rubbed into strips of crinoline from three to five inches in width and about six yards in length. From three to six of these are required according to the size of the child. As ordinarily applied by means of the swing the surgeon sits behind the patient, grasping the child's legs between his knees to prevent swaying of the body; and during the application of the bandages the layers of plaster should be constantly rubbed in order that the support should fit the body accurately. At the same time gentle pressure may be exerted with the aim of straightening or overextending the spine. It is well to make the first turn about the waist and use the first bandage about the pelvis, as this is the base of support. The bandages should also be applied with especial care across the upper portion of the chest, as this is the most important point for counter-pressure. When the jacket is nearly firm it should be trimmed, if practicable, while the patient is in the swing. As a rule, the front of the

Fig. 4620.—The Anterior Shoulder Brace Applied with the Plaster Jacket and Jury-mast.

jacket should extend from the top of the sternum to the pubes; behind, from the spines of the scapulæ to the gluteal fold. Laterally, it should be cut away sufficiently to prevent chafing of the arms, and below, too, in order to allow flexion of the thighs in the sitting posture. When properly applied, the jacket need not exceed a thickness of from one-eighth to one-quarter of an inch. The shirt is then drawn up over the jacket and sewed to the upper border, and the two ends of the bandage or skin rubber are tied together.

In the treatment of children by this means a protective bib should be worn to prevent crumbs from falling under the jacket, and at morning and night the skin should be vigorously rubbed by means of the bandage. In many instances the anterior shoulder brace, already described, may be used with advantage. This may be attached to buckles incorporated in the back of the jacket, or the shoulders may be included in the plaster support. Such restraint should always be applied when the forward inclination causes pressure on the chest.

If the disease is of the upper or middle region of the spine a head support is required. For this purpose a jury-mast is most often employed. (Fig. 4620.) This should be of tempered steel, and its base should be incorporated firmly in the jacket below the seat of disease. When it is properly applied the head should be tilted and drawn somewhat backward with so much tension as can be tolerated.

In place of the jury-mast a fixed support may be used. Fixed supports of this character have an advantage over the jury-mast in the matter of security, for although the latter appliance is effective when properly adjusted, it is of no value when the straps are allowed to hang loosely about the head, as is the case in so many instances.

Application of the Jacket in the Recumbent Posture.—For young children who have been treated on the frame a very satisfactory method is the following: The patient is suspended face downward by two assistants, one holding the arms and the other the thighs. Thus a certain amount of traction is exerted while the trunk is in the overextended position. The jacket is applied, and before it has hardened the patient is replaced upon the frame, and the spine

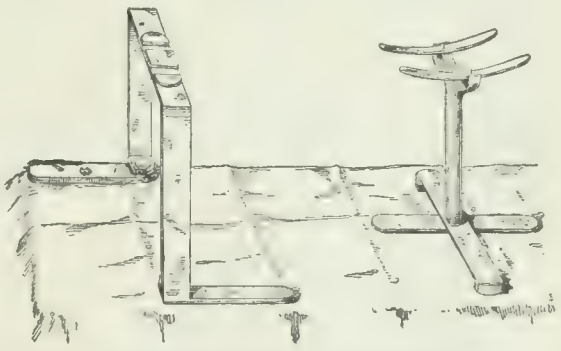


Fig. 4621.—The Goldthwait Frame as used with the Short Uprights in Applying the Plaster Jacket.

becomes fixed in the habitual attitude. The jacket may be applied in the supine posture by means of the appliance devised by Goldthwait. The body is supported at the seat of disease by means of an upright, on which are placed two pads like those used in the Taylor back brace. The two extremities of the spine are then allowed to sink downward with the aim of extending the spine at the point of disease. The jacket is then applied about the central support, and when it is firm the patient is lifted from it, the two adjustable pads remaining within the jacket or the patient may be suspended in a sling passed over the deformity as suggested by Roberts.

As a rule a jacket may be worn for three months, although in hospital practice six months is not unusual.

In the stage of recovery the jacket may be replaced by a corset. This is constructed as follows: A jacket applied in the manner described is cut through the center and removed from the body. It is then thoroughly dried and trimmed, and strips of leather with hooks having been sewed in front, it may be laced like an ordinary corset. The corset should always be removed and reapplied with the patient in the suspended or recumbent posture. It should not be used during the active stage of disease.

In contrasting the two ambulatory supports that are in common use, the jacket and the metallic

brace, it may be stated that the jacket has the great advantage in that the treatment is in the hands of the surgeon. It is inferior to the brace when the disease is in the lower lumbar region. The brace is to be preferred also when the disease is in the upper region, as in such a case the jacket serves only as a base for the head appliance.

In certain instances when the disease is in this situation, the jacket is carried over the shoulders and is made to include the head. This is an effective treatment, but rather cumbersome.

If the disease is seated in the lower region of the spine, and if it is accompanied by contractions of the

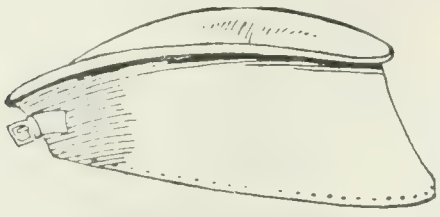


Fig. 4622.—The Thomas Collar.

thighs, the limbs may be encased by means of the spica jacket. As a rule, however, cases of this character are best treated by recumbency.

In certain instances the Thomas collar may be used. This is of especial service in atlo-axoid disease, where it may be used with or without the jury-mast. The shape is shown in Fig. 4622. It is made of a piece of thin sheet metal, wide enough to reach from the sternum to the chin and from the back of the neck to the base of the occiput. The edges are turned out and the whole properly covered with pieces of felt and fitted. One may improvise a support of this character by making a thick muff-like appliance of absorbent cotton, which may be stiffened by layers of adhesive plaster on the exterior. The original form of collar is shown in the illustration.

Fig. 4623.—The Thomas Collar Applied.

The Calot Jacket.—Calot, it may be recalled, was the original advocate of forcible correction of the deformity of Pott's disease—a procedure long since abandoned. He has, however, never lost sight of the importance of preventing, and as far as might be correcting deformity, and the Calot jacket is applied for this purpose.

It differs from the ordinary plaster appliance in that the shoulders are supported in all cases, and the head and neck in a large proportion. Furthermore that direct pressure is exerted on the spine by the insertion of pads of cotton from time to time over the kyphosis and the front of the jacket being cut away to permit protrusion of the chest.

As applied by Calot the patient is suspended in the usual manner, a thick pad of cotton being placed over the chest. The jacket is then applied, to include the neck if the disease is below the sixth dorsal vertebra, and to support the head if it is above that point.

When the plaster is solid the kyphosis is exposed, and the front of the jacket is cut away, as shown in the illustration, and thick pads of cotton are pushed in on and about the kyphosis, with the aim of straightening the spine, and forcing the chest forward. These are fixed in place by bands of adhesive plaster, which, when firmly adherent, are cut away from the opening at the chest.

This pressure is renewed from time to time, according to the limit of comfort.

The Calot jackets are far more effective than the ordinary type, and, in a modified form at least, should be employed except in disease of the lower region.

Fig. 4624.—The Calot Jacket, showing the Anterior Fenestra.

Prognosis and Treatment as Influenced by the Situation of the Disease.—The prognosis as regards deformity is favorable. The part may be easily supported. The cases are often seen before the deformity is extreme; and, as a rule, one may predict recovery without marked local or general distortion. In most cases the trunk is somewhat shortened and a peculiar erect attitude persists. The most troublesome complications of disease in this region are psoas contraction and the abscess with which it is often combined. Slight psoas contraction usually disappears after the application of effective support. If it persists it is well to provide the patient with crutches. If it is a symptom of progressive disease and is accompanied by pain, the patient should be placed in bed, where, if necessary, the deformity may be reduced by traction. In confirmed cases in which the distortion has become fixed by secondary

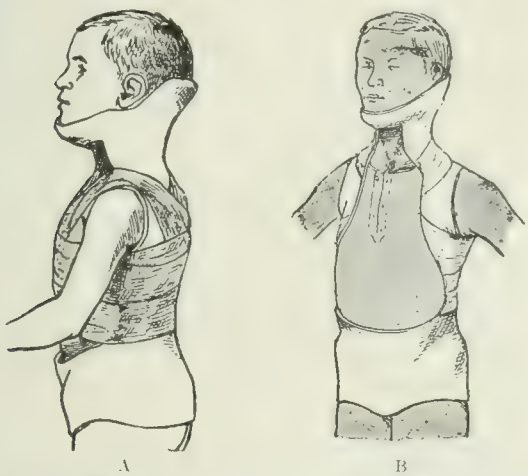
Fig. 4625.—The Method of Inserting Pressure Pads over the Kyphosis in the Calot Jacket.

contraction of the muscles and fascia, operative treatment is occasionally required to overcome the deformity. In this region of the spine the plaster jacket or the spinal brace may be used, the former means being perhaps preferable. The most troublesome complication is abscess, which is present in about fifty per cent. of the cases.

Disease of the Middle and Upper Dorsal Region.—Disease of this region of the spine is not often acute

in its onset, and in most instances deformity is advanced before treatment is begun. It is the region most unfavorable for treatment from the standpoint of prevention of deformity, for the reasons that have been stated.

Whenever possible the patient should be treated by recumbency in the overextended position until the progress of the disease has been checked. Support must be employed for many years because there is a tendency toward increase of the deformity even after the cure of the disease. The Taylor brace assures better fixation than does the jacket. In most instances the anterior shoulder brace should be employed for better support, and to prevent the forward movement of the arms; and whenever the disease is above the eighth dorsal vertebra a head support should be applied. In this region of the spine paralysis is the most important complication. This occurs in about ten per cent. of the cases.



A B

Fig. 4626.—The Calot Jacket. *A* shows the fixation of the pressure pads by bands of adhesive plaster; in *B* these are cut away in front leaving the chest and abdomen free. The illustration also shows the head support.

Disease of the Cervical Region.—In disease of the cervical region the prognosis is good, the most noticeable deformity being the shortened neck and the forward thrust of the head.

Disease of the occipito-axoid region is uncommon. The tendency is toward fixation of the head in the attitude of flexion. This may be prevented by the use of apparatus. The jury-mast when properly applied is a thoroughly efficient support, but fixation of the head by means of the Taylor support or posterior splint insures better control of the patient when he is not under observation.

Complications.—Abscess.—It may be assumed that a limited collection of tuberculous fluid accompanies practically every case of Pott's disease; but unless it can be demonstrated by palpation or unless it appears upon the surface of the body it is not as a rule detected. Abscess as a complication in this sense is present in about twenty-five per cent. of the cases. It is far less common in the upper than in the lower region of the spine. This is accounted for in part by the fact that abscesses find their way downward, and in part because the large size of the vertebral bodies in the lumbar region offers better opportunity for their formation.

An abscess may appear without noticeable symptoms, but in many instances it is preceded by pain or discomfort, which indicates apparently tension at the seat of disease.

Abscesses are not as a rule accompanied by increase of bodily temperature, but when they are of large size and are approaching the surface, and especially when the skin covering them is reddened, there is usually a rise in temperature that implies apparently secondary infection of a mild type.

Abscess accompanying disease of the occipito-axoid region may force its way forward and appear in the throat as retropharyngeal abscess. More often it finds its way backward, distends the suboccipital triangle, and then passes forward to the region of the mastoid process. Abscesses from the middle cervical region pass outward and appear usually in the interval between the trapezius and the sternomastoid muscles.

In the thoracic region the abscess in the posterior mediastinum usually passes outward to perforate the intercostal muscles and appear on the posterior or lateral aspect of the chest. Or it may pass downward through the openings in the diaphragm and become an iliac abscess. Abscesses that originate in the lumbar region, or that have come from above, may follow various paths. Some perforate the sheath of the quadratus lumborum muscle and become a lumbar abscess, distending the skin between the twelfth rib and the crest of the ilium. Others pass downward on the surface of the iliac fascia and form a tumor at the outer extremity of Poupart's ligament or escape into the thigh. Psoas abscess burrows in the sheath of the psoas muscle and appears on the inner aspect of the thigh. Occasionally the fluid may escape from the greater sacrosciatic foramen and appear as a gluteal abscess. In rare instances abscesses may take other courses. They may find their way into the spinal canal or break into the lung or into the intestines.

In most instances abscesses cause no direct symptoms, but occasionally from their size or situation they may cause dangerous complications. The retropharyngeal abscess may interfere with breathing or swallowing. An abscess in the posterior mediastinum may press upon the trachea and cause attacks of inspiratory dyspnea resembling asthma. Psoas contraction, which so often accompanies lumbar abscess, has been described already.

Treatment of Abscesses.—Abscesses that cause direct symptoms may require immediate treatment. The retropharyngeal abscess in case of emergency may be opened by direct incision in the throat. As a rule, however, a lateral opening in front of or behind the sternomastoid muscle is preferable. Obstruction due to mediastinal abscess is uncommon, and in such cases the abscess should be evacuated. An incision is made at the point of deformity over the articulation between the transverse process and rib. A portion of the latter is removed and the abscess is exposed, lying as a rule directly in front of the spine. Care should be taken to follow the spine as closely as possible in order not to wound the pleura.

All infected abscesses should be opened and drained, but quiescent abscesses that cause no discomfort must not be disturbed, as a collection of tuberculous fluid is simply an incident of the original disease of the bone.

If an abscess is of large size, as, for example, when it distends the lumbar region or iliac fossa, the fluid may be evacuated by simple incision. The contents having been removed, the cavity is thoroughly flushed with hot salt solution in order to remove the shreds of necrotic tissue, and the wound may be then closed by layers of sutures or drained for a day or two and then closed. Drainage should be employed if the abscess is infected, or if the surroundings are such that subsequent infection may be avoided. It must be borne in mind that the danger of a tuberculous abscess is an indirect one, and this danger is from secondary infection, which does not often occur until a communication with the exterior has been established either by operation or by spontaneous evacuation.

It is on this account that one hesitates to open abscesses when their source cannot be removed.

Aspiration serves a useful purpose in removing the thinner fluid and thus preventing the extension of the abscess. The injection of iodoform emulsion is sometimes employed after aspiration, although it is less in favor than in past time. The action of the iodoform is that of a local irritant, and it may be supposed to lesssen the infectious quality of the tuberculous fluid. The ordinary form is a ten-per-cent. emulsion of iodoform in sterilized oil. A quantity varying from four to thirty grams, according to the size of the abscess, is injected at intervals of from two to four weeks. Beck's mixture of bismuth and vaseline in proportion of 1–10 injected with the purpose of distending the cavity of the abscess after the evacuation of the abscess, at one time in favor, is no longer in general use.

In many instances abscesses disappear spontaneously by absorption, and after natural evacuation there is apparently no more danger from infection than after operative intervention, if cleanliness is assured.

It is apparent that the treatment of abscesses must be governed by the conditions in the individual case.

Paralysis.—The tuberculous process in the vertebral bodies may find its way backward into the epidural space, press upon the spinal cord, and thus cause paresis or paralysis of the parts below. In most instances the pressure is due to the inflammatory thickening of the coverings of the cord. Thus, in addition to direct pressure, there is often an interference with the blood supply and with the lymphatic circulation. As a result there are, after a time, an increase of the interstitial connective tissue and atrophy of the nervous elements, which may go on to partial or complete sclerosis. As a rule, however, but little permanent damage results, even from long-continued pressure and paralysis.

Occasionally paralysis is due to the pressure of an abscess; and when it is of sudden onset it may be caused by a breaking down of a vertebral body, which allows pressure of the thickened tissues upon the cord. In cases of this character the paralysis is at once relieved by straightening the spine.

The caliber of the spinal canal is not lessened by the characteristic angular deformity; in fact, paralysis more often accompanies slight than extreme distortion.

Paralysis not infrequently complicates disease in the upper and middle dorsal regions of the spine, occurring in about ten per cent. of the cases. It is an unusual complication of disease of other regions of the spine.

The early symptoms, as noted by the patient or his friends, are weakness and an awkward shambling gait. The symptoms usually increase rapidly until paralysis of motion is complete. The extent of paralysis depends upon the situation of the pressure; thus the paralysis is most evident in the legs. There is an increase of the reflexes; and although when the patient is quiet the limbs appear limp, when he is moved, or when the reflexes are stimulated, the peculiar spastic stiffness appears. As a rule, this increases with the duration of the disease, and in cases of long-standing flexion contraction becomes permanent. This indicates irretrievable damage to the cord. Sensation is retained in the ordinary cases, but in those of the more severe type it may be impaired or lost.

When the paralysis is incomplete, control of the bladder is retained; but usually there is incontinence. As the bladder fills, the reflex center is excited and it empties itself. The control of the sphincter ani is less noticeably impaired.

If the pressure on the cord is in the cervical region the arms are involved in the paralysis. If it is in the lower portion of the spine the symptoms are weakness and impaired sensation. The reflexes are not exaggerated.

Occasionally paralysis may precede deformity, but as a rule it is a late symptom, appearing more often from one to two years after the beginning of the disease.

In exceptional cases in which the paralysis is caused by temporary pressure or disturbance of the circulation, it may be relieved at once by straightening and supporting the spinal column. If, however, the paralysis is complete, as it is in most instances, it persists usually for at least six months, and not infrequently for a year or longer, recovery being dependent upon the organization of the tuberculous granulations or disappearance of the abscess that causes pressure.

In properly treated cases the prognosis is very favorable. In about seventy-five per cent. of the cases practically complete recovery occurs; absolute and permanent paralysis is unusual. Recurrence of the paralysis after an apparent cure is not uncommon, being dependent of course upon the persistence of the local disease.

The treatment of the paralysis is in great degree included in the treatment of the disease of which it is a symptom. If possible, rest on the stretcher frame in the position of overextension should be employed. If the disease is in the upper region of the spine traction upon the head is of value. In many instances the additional fixation secured by a plaster jacket should be used also.

If there is persistent contraction of the lower limbs restraint and traction should be applied. Counter-irritation, such as the local application of the actual cautery, is thought by some to exert a favorable influence upon the disease. Iodide of potassium in large doses may aid in bringing about the absorption of the granulation tissue.

The first indication of improvement is a lessening of the muscular rigidity; then there is a gradual return of voluntary motion.

The exaggerated reflexes persist long after the disappearance of the paralysis.

Operative treatment may be required in exceptional cases. If the presence of an abscess in the posterior mediastinum can be demonstrated it is well to evacuate it before opening the spinal canal, because the pressure may be due to the collection of fluid. If after persistent mechanical treatment there is no improvement in the paralysis, the operation of laminectomy may be undertaken. Eighteen months has been suggested as the limit of time which should have tested the efficacy of mechanical treatment.

The usual method of operating is as follows. A long incision is made parallel to and close by the side of the spinous processes. The muscles are drawn to one side, the spinous processes of several of the vertebræ at the seat of disease are cut through at their bases, and with the attached tissues are drawn to the opposite side. The laminæ are then removed with cutting forceps, exposing the dura mater. The thickened tuberculous tissue is usually found by the sides and in front of the cord. As much of this should be removed as is practicable. The wound is then closed and the spine is supported by a plaster jacket or other appliance.

Operative Treatment.—It has long been known that the cure of Pott's disease is accomplished by consolidation and ankylosis in which the laminæ and spinous processes are often included. The object of operative treatment is to induce early fixation of the posterior part of the spine in order to relieve the diseased vertebral bodies from pressure and friction.

One of the earliest attempts in this direction was made by Hadra[3] of Texas, by wiring the spinous processes to one another, a type of operation afterward repeated by others, but apparently with but little success.

In 1910 F. Lange[4] reported a case in which the symptoms had been relieved by implanting metallic

rods on either side of the spinous processes beneath the dorsal muscles. He also suggested bone transplantation for the same purpose.

In 1911 R. A. Hibbs[5] presented a report of cases successfully treated by an elaboration of the older methods, and shortly afterward F. H. Albee[6] described an operation of bone transplantation for the same purpose.

These operations have now become recognized surgical procedures. Hibb's operation is described by him as follows: "A longitudinal incision is made directly over the spinous processes, through skin, supraspinous ligament, and periosteum, to the tips of the spinous processes. The periosteum is split over both the upper and lower borders of the spinous processes and the laminæ, and stripped back from them to the base of the transverse processes. The spinous processes are then transposed after partial fracture, so that they make contact with fresh bone, the base of each with its own base, and the tips with the base of the next below (broken and forced downward). The adjacent edges of the laminæ being absolutely free from periosteum, a small piece of bone is elevated from the edge of the laminæ and placed across the space between them, its free end in contact with the bare bone of the laminæ next below it. The lateral walls of periosteum and the split supraspinous ligament are brought together over these processes by interrupted chromic catgut sutures. The skin wound is closed by silk, and a steel brace applied. The only addition to this technique has been as follows: The lateral articulations are exposed and the cartilage removed by a very small curette. This adds to the extent of the fusion."

The spine is protected by a brace for several months or longer, until the symptoms indicated that the operation has been successful. Farrell,[7] in a recent paper reports 150 operations by this method without mortality and with but five failures.

The Albee operation consists essentially in splitting the spinous processes and inserting a section of bone cut from the tibia between them, thus assuring an immediate and permanent splint at the point of greatest mechanical advantage.

The details of the operation are as follows: The patient is placed in the prone position. An incision is made parallel to the spinous processes about one and one-half inches distant, approaching the middle line above and below the site of operation. The flap of skin is turned back, exposing the spinous processes. The supra- and interspinous ligaments are then split in the middle line, and separated slightly to either side. With a wide chisel then the spinous processes are split into equal parts, one side being pried away laterally in order to make a sufficient opening for the insertion of the graft. It is then packed in gauze soaked in hot salt solution. The area of the operation is dependent upon the extent of the disease. If of the dorsal region the graft should cover two healthy vertebræ at either end. If of the lumbar region, where the preservation of some movement is of importance one may be sufficient.

A leg is then flexed acutely at the knee so that its dorsal surface lies uppermost, and a long incision exposes the crest of the tibia, from which a graft is cut of proper length and size, varying therefore according to Albee from ten to nineteen centimeters in length, and six to twelve millimeters in breadth, and six to nine millimeters in thickness. If the deformity is slight a straight graft may be used. If it is more pronounced the graft may be bent by making multiple incisions on its under side with the saw, as a carpenter saws a board in order to fit it to a curved surface. If, however, the deformity is more extreme, the contour is taken with a probe, and the bone is cut with the electric saw from the side of the tibia, the periosteum being preserved. The graft is then placed in the groove with the marrow side in apposition to the upright halves of the spinous processes, and is fixed in place by strong sutures passed between the split interspinous ligaments. The other tissues and the skin are sutured with catgut, and the patient is placed preferably upon a stretcher frame. Other forms of restraint may be used, and in older subjects, or if the disease is quiescent support may be dispensed with.

Albee thinks that the graft becomes firmly fixed in four weeks, and that it preserves, as it were, its individuality, and becomes hypertrophied even under strain. Consequently in favorable cases he permits limited activity without support in from six to eight weeks after the operation. In his latest articles Albee[8] advocates operating in cases in which pain and muscular spasm are present—practically, therefore, in all cases, and at any age.

In comparing the two procedures, that of Albee has the advantage of simplicity, and at least of more immediate effectiveness. It has the disadvantage of a secondary operation, on the tibia.

Both are ankylosing operations, that restrict the motility of the spine. This is of but slight importance in the dorsal as compared with the cervical and lumbar regions, in the former of which the operation is hardly practicable.

The operation, therefore, is primarily indicated in disease of the dorsal region in adolescence or adult life, but under favorable conditions the final result in early cases in childhood treated conservatively is often better, in the sense that the deformity is slight, and almost normal motion is preserved.

It is assumed by those who favor operative treatment as a routine that a successful operation will permanently restrain direct or indirect deformity, and cure the disease, so that support or even supervision may be dispensed with; a conclusion that is more than doubtful. A more extended experience will probably indicate that operations for the relief of tuberculous disease of the spine, as for other joints, will supplement, rather than supplant conservative treatment.

Duration of the Treatment.—The duration of treatment must depend upon the extent and the severity of the disease. It may be divided into two stages, one in which the disease is active, when absolute fixation is indicated, and a stage of recovery in which supervision is required. Tuberculosis of the spine is slow in progress and recovery is insecure. The course of the disease is shortest in the cervical region, but even here brace treatment will be required for at least two years. In the lumbar region twice this time may be assigned to this period, and in the upper and middle dorsal regions, where the deformity may increase long after the cure of the disease, support may be required indefinitely.

Indications of Recovery.—As pain is almost always relieved by efficient treatment, its absence is no indication of cure. Muscular spasm usually persists as long as the disease is active; it is therefore a valuable indication in prognosis. The appearance of the kyphosis has some significance. In the early stage of disease the area of the destructive process is not defined; but when consolidation has taken place, its extent is shown by the rigid vertebræ that stand out from the remainder of the spine separated from it by a well-marked depression, deeper below than above. In all cases removal of support must be gradual and its effect must be watched. When the disease is cured massage of the muscles, breathing exercises, and mild gymnastics may be employed with advantage. It may be noted that abscess or even paralysis may appear many years after the apparent cure of disease.

If recovery from Pott's disease has been complete, and if the deformity is slight, the individual may be to all intents normal; but if the deformity is great,

his condition is abnormal, and he is unfitted for ordinary occupations. Such individuals usually suffer from neuralgic pain about the weakened spine, and in most instances some form of light support must be worn. ROYAL WHITMAN.

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Spine, Surgery of the.—The surgery of the spinal cord is directed to the relief of pressure on the cord causing a partial or complete interruption of its conduction. Such paralysis may be due to pressure from neoplasms of the cord, its membranes, or the vertebræ; to inflammatory diseases; and traumatic conditions as fractures, dislocations, hemorrhage, excessive callous formation, and scar contraction. The operation of laminectomy is performed to remove the offending pressure when it is located in the posterior spinal arches, or to afford access to lesions of the cord and membranes requiring further interference. The mortality from the operation itself has been greatly reduced, so as to compare favorably with the rank and file of major procedures, due to the refinements in technique and improved methods of anesthesia.

POSITION OF THE PATIENT.—The patient may be placed in the lateral, prone, or semi-prone positions. When the lateral position is selected, the vertebral column should be well flexed ventrally, so as to increase the space between the spinous processes. Pillows and sandbags placed under the abdomen will flex the vertebral column ventrally, in the prone position. The shoulders should likewise be elevated so as not to embarrass the thoracic respiration.

ANESTHESIA.—General anesthesia, preferably ether, following primary nitrous-oxide anesthetization, is the method of choice. When general anesthesia is contraindicated, or considered extrahazardous, as in the complication of crushed thorax, local anesthesia may be employed. The writer has performed three laminectomies under local anesthesia successfully, absolutely painlessly, and free from shock or by-effects. Due to the angiospastic effect of the adrenalin in the local anesthetic solution, the operations were practically bloodless, which in this class of surgery is of the greatest advantage. Shock and hemorrhage are the principal causes of death in laminectomies, and both factors are reduced to a minimum when local anesthesia is employed.

Technique of Local Anesthesia for Laminectomy; Anatomical Considerations.—The anterior and posterior roots of the spinal nerves join within the intervertebral foramina, and shortly after the so-formed spinal nerves emerge from the foramina, they send off connecting branches (the rami communicantes) to the sympathetic system, and then divide into anterior and posterior primary branches. The anterior branches supply the longitudinal muscles and fascia of the back and the periosteum of the vertebræ, and innervate the skin to the right and left of the median line. It is the posterior branch which is blocked to obtain local anesthesia for laminectomy. By injecting an anesthetic fluid directly into the trunk or immediate neighborhood of this posterior branch, its line is temporarily put out of commission; and painful sensations or stimuli cannot be sent to headquarters, and so sensed as pain. In other words, local anesthesia obtains.

Injection.—Outline an ample field of operation by the formation of endermic wheals at convenient points, as ABCXYZ, forming a hexagon. (See Fig. 4627.) The endermic wheal is formed by the injection of 0.5 per cent. novocain, through a very fine hypodermic needle, directly into the skin, forming a blanched, button-like elevation, which is rendered immediately anesthetic, thus making painless all further injections and manipulations through the skin. Introduce a long hypodermic needle through these wheals and connect the points ABCXYZ by subcutaneous injection of 0.5 per cent. novocain, so forming a fence of the anesthetic fluid around the operative field. Palpate the interval between the transverse processes. Through this intertransverse space, and at a point about one and a quarter inches laterally from the tip of the spinous process, introduce the needle directly inward to the depth of one and a quarter or one and a half inches until the bony obstruction of the transverse process is felt. The needle is now carried past the upper border of the transverse process, and 5 c.c. of a one per cent. solution of novocain deposited. The posterior branch of the spinal nerve is thus blocked by endoneural or perineural injection. This paravertebral blocking is carried out bilaterally for all of the posterior branches of the spinal nerves in the field. Wait ten minutes for complete, perfect anesthesia to obtain before beginning the laminectomy.

TECHNIQUE OF LAMINECTOMY.—Make a median incision directly over and down to the spinous processes of the vertebral column. Clamp towels to the incised skin margins. Usually three to six laminæ require removal. Free the muscles and fascia, on one side of the spine, from the spinous processes and well out over the laminæ with scalpel and blunt dissection. Clamp bleeding vessels and pack the trough-like cavity with gauze wrung out of water at 101°F. to control oozing; repeat the procedure on the opposite side. By this time the packing may be removed from the first side and the hemostatic forceps replaced by ligatures. The second side is likewise prepared. Spread the margins of the wound by broad and deep retractors, for operative field exposure. A self-retaining retractor serves admirably and by pressure controls oozing. Divide the interspinous ligaments with the scalpel. Remove the spinous processes with bone cutting forceps. Bite the laminæ away with small rongeurs, beginning at the lower margin of the laminæ, or a start may be obtained by perforating a lamina with a Hudson burr or trephine. The laminæ should be removed well out to their articulating facets in order to obtain a broad exposure of the dura. All leverage in biting bone must be out and away from the cord so as to avoid injury to the dura and underlying cord. This can be done rapidly and still with the utmost care and delicacy. Bleeding from the divided laminæ is controlled by Horsley's bone wax. The dura must not be opened until perfect hemostasis is effected. Carefully palpate the dura for cord tumor, when suspected, and inspect for cardiac and respiratory pulsation. To incise the dura, divide between delicate elevating forceps, and enlarge by following a grooved director. If the dura is carefully and skilfully divided, the arachnoid sac need not be opened. Upon the escape of cerebrospinal fluid it is well to lower the head of the table slightly so as to retard the rate of its flow. Traction sutures of fine silk may be placed through the dural margins. Inspect and examine the spinal canal and its contents. The lateral and anterior surfaces of the cord deserve just as careful attention as the posterior. The examination of the posterior surface may be effected by dividing one or more dentate ligaments at the dural attachment, after which they may be used as retractors. The cord may be gently pulled or pushed from side to side and rotated so as to expose the anterior surface. The indications of the pathological condition

uncovered are met, after which the dura should be closed with fine interrupted catgut sutures. After washing out the wound with warm saline and paying scrupulous attention to hemostasis, close the muscles and fascia in layers, plain catgut being placed in the muscles and tannicized gut in the fascia. Broad, flat dressings are strapped to the back and the patient is returned to bed. No special spinal support or apparatus is necessary. The patient should be kept on his back for several days, after which he may be carefully moved on the side. Subsequent treatment is carried out along general surgical principles.

The bone work may all be performed with the chisel or saw, by which methods the Continental surgeons do marvelously beautiful and rapid work. However, except in the hands of the highly and specially trained, the method as given is infinitely more safe. Various osteoplastic operations have been devised, but are, firstly, unnecessary, as the function and stability of the spine is not appreciably affected even in the extensive laminectomies by the classical type of operation; and secondly, they are more time-consuming and hemorrhagic.

Surgery of the Cord and Membranes.—This is conducted on general surgical and anatomical principles. Extreme gentleness in all manipulations is essential to success. The tumors met with, unfortunately, are mostly malignant and are subject to the general law of recurrence. Extradural tumors are usually easily separated from their attachment and removed. Tumors too adherent to be peeled off, and particularly if malignancy be suspected, should be removed with a piece of attached dura. If necessary to removal, one or more posterior roots may be divided or resected. If the neoplasm is subdural, its attachment to the pia should be most carefully divided so as to avoid injury to the cord. All blood-vessels are ligated with very fine silk and divided. Oozing is controlled by the application of pledgets of cotton taken out of hot saline, or by gentle irrigation with the saline solution. The solution used for the cotton compresses or for irrigation should be between 100° to 103° F., a bath thermometer being kept in the solution all of the time. The writer knows of a case of laminectomy in which the "hot saline" irrigation ordered by the surgeon was so hot that the cord was practically cooked, with a disastrous result.

Intramedullary tumors should be treated according to the ingenious extrusion method of Elsberg. A short incision is made in the posterior median column, a few millimeters outside of the posterior median fissure where the neoplasm is nearest the surface, down to the growth, which will begin to bulge through the wound. If the incision requires enlarging, a blunt instrument, as a small strabismus hook, should be employed. Under no circumstances is the growth removed at the first operation. The dura is left open and the muscles, fascia and skin closed. After the interval of a week the wound is opened, and the tumor will usually be found outside the cord and may be safely removed. If thorough extrusion has not taken place the growth should not be disturbed and is to be considered irremovable.

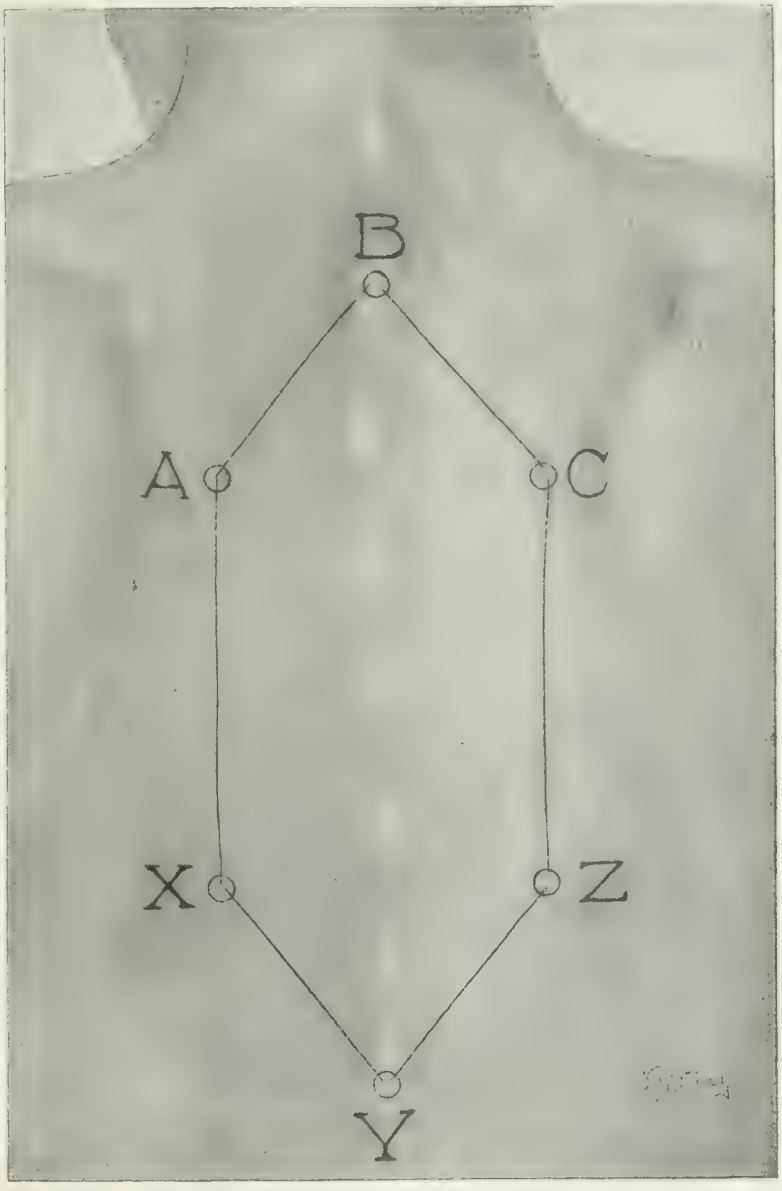

Fig. 4627.—Diagram Showing the Lines of Injection for Inducing Local Anesthesia Prior to Laminectomy.

Foerster Operation.—Laminectomy is performed to afford access to the posterior roots of the spinal nerves, that they may be resected for the relief of spasticity; for the gastric crises of tabes, and the relief of pain, as in the neuritis and plexus neuralgias. The nerve root is resected between its origin from the posterior column of the cord and its entrance through the dura.

Traumatic Spines.—The spinal column is formed by articulating vertebræ, composed of their bodies, laminæ, processes, and spines, lashed together by ligaments and further bound together by a complicated system of muscles and fascia. When subjected to trauma any or all of these various structures may be affected, giving dislocated vertebræ, fractures of the bodies, laminæ, or spines, and ruptured and contused ligaments and muscles. The term "sprained back" is not significant, including lacerated muscles, ligaments, fractured spinous processes, and even fracture dislocations of the vertebræ. The Roentgen examination of some of these old sprained backs and stiff necks has yielded surprising information of unsuspected bone injury and fracture displacements in some of the writer's cases. Every patient giving the slightest suspicion of a major injury should be given the benefit of the *x*-ray. Much information may be obtained by physical examination, but the *x*-ray is final. Plates should be taken to give both an anteroposterior and a lateral view. All patients with grave or suspicious spinal injuries should be placed in bed, with the spinal column slightly dorsiflexed. Patients requiring transportation should have the vertebral column immobilized upon a long, broad posterior splint, well padded and strapped and bandaged in position. All cord injuries, even simple contusions, usually require regular catheterization of the urinary bladder, and the patients should be given full doses of urotropin. Decubitus must be combated immediately by scrupulous attention to cleanliness, alcohol massage, and protection of all bony prominences by suitable pads and rings. Extension apparatus, particularly in the cervical injuries, frequently gives relief from pain and muscle spasm.

Operative Indications.—Positive *x*-ray evidence of cord compression by bone, calls for laminectomy, unless the symptoms of complete transverse lesion of the cord are present; such are immediate and complete flaccid motor paralysis, complete sensory paralysis below the lesion, and a hyperesthetic girdle above. Operation then only hastens the exitus and brings spinal surgery into disrepute. Persons with fracture of the upper cervical region usually die in a short time with medullary symptoms, and also should not be operated upon. Operation is contraindicated in the presence of very high or subnormal temperature, rapid pulse and respiration, or symptoms of shock. Operation under local anesthesia should be considered when the operative conditions are imperative and the general condition such as to make the risk extrahazardous. The cases of partial paralysis due to compression by blood clot and fragments of bone, and the old cases in which some improvement has obtained by conservative treatment yield the best operative results.

The laminectomy should be performed as described. Extreme care must be exercised so as not to cause further injury to the cord by pressure on, or further displacement of fractured fragments. Fracture dislocations should not be reduced until the laminæ are completely removed, when the manipulations may be intelligently practised. The dura should be opened and any clots present removed.

Arthur C. Strachauer.

Spinose Ear-tick.—The spiny nymph stage of *Otiobius* (= *Ornithodoros*) *megnini* which ranges through Mexico and the southern United States. It usually is found in the ears of horses and cattle, but often attacks man, causing severe pain. A bland oil poured into the ear is recommended for treatment. A. S. P.

Spiritus.—Spirits.—In the case of drugs containing active principles at once *volatile* and *soluble in alcohol*, the pharmacy of former days obtained alcoholic solutions of such principles by distilling the crude drug with alcohol. Such distillates were called *spirits* of the respective drugs from which they were obtained, and the principal drugs so treated for the obtaining of "spirits" were those whose activities resided in a *volatile* or so-called *essential oil*. Alcoholic solutions of volatile oils are still official under the title of *spirits*—constituting, indeed, the great majority of official so-called "spirits;" but such spirits are now obtained by direct solution of the previously extracted volatile oil in alcohol instead of by distillation of the crude drug. Such "spirits" of the present United States Pharmacopœia are solutions of the volatile oils of the more fragrant so-called "aromatics," and constitute a fairly distinct class of medicinal preparations. The same are often called *essences*, as, for instance, so-called *essence of peppermint*, and are, as a class strong preparations of their kind, whose dose ranges from a few drops only to not more than a teaspoonful. Besides such spirits of the aromatic herbs, the United States Pharmacopœia entitles as "spirits" the alcoholic solutions, respectively, of *camphor*, of certain volatile *ethereal* bodies, such as ether, chloroform, nitrous ether, etc.; of *ammonia*, of *phosphorus*, of *nitroglycerin*, and also the two distilled liquors *brandy* and *whiskey*. All so-called "spirits," being solutions in alcohol of sufficient concentration, are self-preservative against decomposition.

The United States Pharmacopœia (1910) contains fifteen spirits, and the National Formulary nine.

Name.		Composition.	Dose.
Spiritus Acidi Formici (Spirit of Formic Acid).	N.F.	Formic Acid 40, Distilled water 225, Alcohol to make 1,000.	
Spiritus Ætheris (Spirit of Ether).	U.S.P.	Ether 325, Alcohol 675.	1 fluidram
Spiritus Ætheris Compositus (Compound Spirit of Ether, Hoffman's Anodyne).	N.F.	Ether 325, Alcohol 650. Ethereal Oil 25.	1 fluidram
Spiritus Ætheris Nitrosi (Spirit of Nitrous Ether)	U.S.P.	Sodium Nitrite, 100.0, Sulphuric Acid, 4.00, Monohydrated Sodium Carbonate 0.6, Potassium Carbonate 3.0, Alcohol and Water, *q.s.*	
Spiritus Ammoniæ Anisatus (Anisated Spirit of Ammonia).	N.F.	Anethol 30, Ammonia Water 200, Alcohol, *q.s.*	15 minims
Spiritus Ammoniæ Aromaticus (Aromatic Spirit of Ammonia).	U.S.P.	Ammonium Carbonate 34, Ammonia Water 90, Oil of Lemon 10, Oil of Lavender Flowers 1, Oil of Myristica 1, Alcohol 700, Distilled Water to make 1,000.	30 minims
Spiritus Amygdalæ Amaræ (Spirit of Bitter Almond).	U.S.P.	Oil of Bitter Almond 10, Alcohol 800, Distilled Water to make 1,000.	8 minims
Spiritus Anisi (Spirit of Anise).	U.S.P.	Oil of Anise 100, Alcohol 900.	1 fluidram
Spiritus Aromaticus (Aromatic Spirit).	N.F. (1906)	Compound Spirit of Orange (U.S.P.) 65, Alcohol 935.	
Spiritus Aurantii (Spirit of Orange).	N.F. (1906)	Oil of Orange Peel, 50, Deodorized Alcohol, 950.	
Spiritus Aurantii Compositus (Compound Spirit of Orange).	U.S.P.	Oil of Orange Peel 200, Oil of Lemon 50, Oil of Coriander 20, Oil of Anise 5, Alcohol to make 1,000.	
Spiritus Camphoræ (Spirit of Camphor).	U.S.P.	Camphor 100, Alcohol to make 1,000.	15 minims
Spiritus Cardamomi Compositus (Compound Spirit of Cardamom).	N.F.	Oil of Cardamom 2, Oil of Caraway 0.75, Oil of Cinnamon (Cassia) 0.50, Alcohol 500, Glycerin 65, Water to make 1,000.	

		Composition.	Dose.
Spiritus Chloroformi (Spirit of Chloroform)	U.S.P.	Chloroform 60, Alcohol 940.	30 minims
Spiritus Cinnamomi (Spirit of Cinnamon).	U.S.P	Oil of Cinnamon 100, Alcohol 900.	30 minims
Spiritus Curassao (Spirit of Curaçao	N.F. (1906)	Oil of Curaçao Orange 165, Oil of Fennel 3, Oil of Bitter Almond 0.75, Deodorized Alcohol 832.	
Spiritus Frumenti (Whiskey).	U.S.P. (1900)		
Spiritus Gaultheriæ (Spirit of Gaultheria).	U.S.P. (1900	Oil of Gaultheria 50, Alcohol 950.	30 minims
Spiritus Glycerylis Nitratis (Spirit of Glyceryl Trinitrate; Spirit of Nitroglycerin).	U.S.P.	One per cent. of glyceryl trinitrate.	1 minim
Spiritus Juniperi (Spirit of Juniper).	U.S.P.	Oil of Juniper 50, Alcohol 950.	30 minims
Spiritus Juniperi Compositus (Compound Spirit of Juniper).	U.S.P.	Oil of Juniper 8, Oil of Caraway 1, Oil of Fennel 1, Alcohol 1,400, water to make 2,000.	2 fluidrams
Spiritus Lavandulæ (Spirit of Lavender).	U.S.P.	Oil of Lavender Flowers, 50, Alcohol 950.	30 minims
Spiritus Limonis (Spirit of Lemon).	N.F. (1906)	Oil of Lemon 50, Lemon Peel, freshly grated 50, Deodorized Alcohol to make 1,000.	
Spiritus Menthæ Piperitæ (Spirit of Peppermint).	U.S.P.	Oil of Peppermint 100, Peppermint 10, Alcohol to make 1,000.	30 minims
Spiritus Menthæ Viridis (Spirit of Spearmint).	U.S.P.	Oil of Spearmint 100, Spearmint 10, Alcohol to make 1,000.	30 minims
Spiritus Myrciæ Compositus (Compound Spirit of Myrcia).	N.F.	Oil of Myrcia 8, Oil of Orange Peel 0.5, Oil of Pimenta 0.5, Alcohol 610, Water to make 1,000.	
Spiritus Myristicæ (Spirit of Nutmeg)	N.F. (1906)	Oil of Nutmeg 50, Alcohol 950, to make 1,000.	
Spiritus Odoratus (Perfumed Spirit).	N.F.	Oil of Bergamot 15, Oil of Lemon 8, Oil of Rosemary 7, Oil of Lavender Flowers 4, Oil of Orange Flowers 4, Acetic Ether 2, Water 120, Alcohol 840.	
Spiritus Oleorum Volatilium (Spirit of Volatile Oils)	N.F.	Any Volatile Oil 65, Deodorized Alcohol, 935.	
Spiritus Ophthalmicus (Ophthalmic Spirit).	N.F. (1906)	Oil of Lavender 2, Oil of Rosemary 6, Alcohol 92.	
Spiritus Saponatus (Spirit of Soap).	N.F. (1906)	Castile Soap 175, Alcohol 600, Water to make 1,000.	
Spiritus Sinapis (Spirit of Mustard).	N.F.	Volatile Oil of Mustard 2, Alcohol 100.	
Spiritus Vanillini Compositus (Compound Spirit of Vanillin).	N.F.	Oil of Vanillin 40, Oil of Orange 10, Oil of Cardamom 2, Oil of Cinnamon 1, Alcohol *q.s.*	
Spiritus Vini Gallici (Brandy).	U.S.P. (1900		

R. J. E. Scott.

Spirochæta.—A large genus which includes the parasites causing many important diseases. *S. recurrentis* causes relapsing fever; *S. duttoni*, African tick-fever; *S. novyi*, relapsing fever. These protistans differ from other spirochetes in having an undulating membrane. *S. pallida*, the microorganism of syphilis and other allied species are now known under the designation *Treponema* (*q.v.*). See *Protozoa*. A. S. P.

Spirochætacea.—A group of minute organisms which are probably more closely related to plants than to animals. They are usually parasitic; the body is narrow, thread-like, and wavy, with or without an undulating membrane. The cytoplasm is divided into endoplasm and ectoplasm, and is bounded by a flexible chitinous periblast. The nucleus consists of a spiral achromatic filament on which are arranged transverse bars of deeply staining chromatin. See *Protozoa*. A. S. P.

Spirochætidæ.—The family of spirochetes in which an undulating membrane is present, or the body is ribbon-shaped in transverse section. See *Protozoa*. A. S. P.

Spitzka, Edward Charles.—Born in New York City, November 10, 1852. He studied medicine at the University of the City of New York, and received the degree of Doctor of Medicine from that institution in 1873. After spending two years abroad, a large part of the time in laboratory work at the University of Vienna, he returned to New York and began the practice of his profession. In August, 1877, he was awarded the Tuke Prize of 100 guineas, by the Medico-Psychological Association of Great Britain, for the best essay on "The Somatic Etiology of Insanity." From 1881 to 1884 he was Professor of Medical Jurisprudence and Nervous Diseases in the New York Post-Graduate Medical School and Hospital. His original investigations in the anatomy and physiology of the nervous system, and his success in the treatment of all diseases relating to this branch of medicine, gained for him a national reputation. He died January 13, 1914.

Of his published writings the following deserve to receive special mention: "A Second Origin of the Abducens," and "On the Connection between the Symptoms of Insanity and the Lesions on which they Depend," in the *Transactions of the International Medical Congress;* "The Psychological Pathology of Progressive Paresis," and "Contributions to Encephalic Anatomy." Dr. Spitzka contributed to Pepper's *System of Medicine* (1887) the sections on diseases of the spinal cord, and on inflammation, anemia, and hyperemia of the brain, and he wrote an elaborate article on the anatomy of the spinal cord for the first edition of this Handbook. He also published in 1883 a "Treatise on Insanity."

The following are among Dr. Spitzka's original discoveries in neuroanatomy: "The Interoptic Lobes of the Iguana;" "The Identification of the Hitherto Unrecognized Postoptic Lobes in Birds and Mammals;" "The Spinal Course of the Cortex-Lemniscus in Man;" "The Marginal Tract (described one year later by Lissauer and known as the Spitzka tract and as the Spitzka-Lissauer tract);" "The Auditory Tract in the Cetacea;" "The Superficial Decussation of the Pyramids in Pteropus." A. H. B.

Splanchnoptosis.—*Synonyms:* Enteroptosis, Visceroptosis, Glénard's disease.

Introductory and Historical.—Anomalous downward displacements of the abdominal viscera were described by Virchow, Leube, and others, several years before Glénard's monograph appeared. In 1885, Glénard set forth his views upon enteroptosis and connected therewith certain nervous phenomena which have since borne the name of "Glénard's disease." Prominent among the features of this symptom-complex, which Treves is pleased to call "that medley of symptoms," are downward displacement of the stomach, a movable right kidney, various digestive disturbances, and often very typical neurasthenic symptoms.

The interest awakened in postural anomalies of abdominal organs by Glénard's article is still kept up, and many physicians have verified the statement of that author which was made with such enthusiastic earnestness at the close of his early monograph. "I can affirm," wrote Glénard, "that the physician who will follow my directions and strive to verify my statements in such cases will find in his practice the satisfaction which a positive diagnosis gives to both physician and patient, from which alone a proper prognosis can be made, and that satisfaction, the greatest of all, which directs the treatment and avoids for the patient the trial upon him of so many remedies, while at the same time it secures him relief and prevents the physician himself from falling into therapeutic scepticism."

The investigations made by the French were rapidly followed by similar work by German clinicians, with the result that another view of the cause of the displacements was advanced. Then the English and American writers contributed articles and case reports upon the subject, dealing with the nature and anatomy as well as with the etiology and treatment of the disease.

The Application of the Term Enteroptosis.—It would appear that Glénard's original article included a description of a displacement of the intestine alone. The Germans broadened the application of the term and made it to include, in most instances at least, ptosis of all the abdominal viscera. Schwerdt, however, pleaded that the term was applicable when at least two of these organs suffered downward dislocation. If, however, one wished to specify the organ dislocated such terms as gastroptosis, hepatoptosis, and nephroptosis are available.

Etiology.—The study of visceral ptosis, from the etiological standpoint, has provoked a variety of theories differing so widely that it is manifestly impossible to find one theory broad enough to explain all cases. It has been urged that enteroptosis is a congenital anomaly—*asthenia universalis congenita*—(Stiller); that it is a constitutional ailment (Schwerdt), a general atony of nervous system and muscles; that it is the result of wearing corsets, or tight waistbands with heavy skirts (Meinert); that it is a result of a neurasthenia basis (Charcot); that rapid emaciation or a severe illness may account for it; that to overlifting or frequent pregnancies many cases may be traced; that adhesions, the result of peritoneal inflammation, may pull down one organ after another (Treves); that it is a reversion to a fetal or an embryonic type (Rosengart); and with the name of Arthur Keith by whom this subject has been illuminated from many viewpoints is associated that theory which regards enteroptosis as "a result of a vitiated method of respiration," and assigns to it a place among respiratory diseases.

It is admitted, that there are several factors which maintain the abdominal organs in position, and of these the most important are: (1) The intra-abdominal pressure, and (2) the ligamentous attachments of the viscera to the body walls. These two are so important that when either fails ptosis may result. Hence it may be said that these factors are those by which the normal postural relations of the viscera are maintained. It is not difficult then to believe that any cause, or combination of causes, which lowers the intraabdominal pressure by exhausting the muscular tone, or which weakens or stretches the supporting ligaments, would readily alter the relation of the organs—especially that of the heaviest organs or of those with weakest supports—and result in ptosis.

Thus, as one reviews the various causes of enteroptosis suggested, one finds that each involves a change in either one or other of the factors regarded above as combining to maintain the organs of the abdomen in position. This applies also to Keith's theory that "enteroptosis is a result of a vitiated method of respiration," which may be better understood after an explanation. When Keith remarks that enteroptosis is a result of a vitiated method of respiration, he means, doubtless, that faulty movements of the diaphragm, resulting from a variety of causes, determine visceral ptosis, and that under normal relations of the muscles of inspiration—the diaphragm, the external intercostals, and the interchondrals—to the muscles of expiration, and chiefly to those of the abdominal walls, there is but slight downward displacement of the viscera. The organs swing and move upon each other, often as much forward as downward, maintaining their normal positions and postural relations. As a result of various conditions the inspiratory muscles may "gain the upper hand and the muscles of expiration yield," and ptosis is induced. This writer strongly emphasizes the importance of the diaphragm in bringing about the changes incident to enteroptosis. He remarks that the inspiratory downward displacement, if once the diaphragmatic supports commence to yield, is one of the factors in the causation of visceral ptosis; and while minimizing the function of visceral bonds to the causation or prevention of enteroptosis, he maintains that the active contraction of the crura is the most important factor in the production of visceral ptosis, acknowledging in the same article that while the support of the diaphragm is threefold—abdominal, costal, and thoracic—doubtless that derived from the abdominal muscles, the muscles of expiration, is of the most importance.

At all events, one is justified in ascribing highest importance to the action of these muscles, since it appears that the normal respiratory swing of the organs, the stomach, liver, and spleen, gives place to downward displacement in the presence of relaxation of the abdominal support, or what is even worse, perhaps, when the body cavity is constricted by corsets or distorted by disease, the action of the diaphragm pushes the organs down. Corsets when applied prevent an inspiratory downward displacement of the liver, but when removed the relaxed condition of the muscles—being too weak to oppose the dropping—favors ptosis.

"The condition essential to the displacement of either kidney is a diminution of the subdiaphragmatic space which may be accounted for, (1) by compression of the thorax with clothing, (2) by a partial collapse of the thoracic walls, following chest or spinal disease, and (3) by the permanent contraction of the diaphragm, which follows a relaxed or paretic condition of the abdominal walls." The left kidney is not displaced so frequently as the right, from the fact that "the left hypochondrium is provided with a safety valve in the shape of the splenic flexure of the colon." So that when the subdiaphragmatic space is lessened, the "colon is extruded and the other organs are left undisturbed." Again, the close attachments of kidney to spleen, and of spleen to diaphragm, prevent dislocation. From the domain of comparative anatomy one may gather some clew also to this condition. It is affirmed that with the evolution of the orthograde posture and the orthograde type of respiration, mesenteric adhesions, which appeared one after the other in five different areas, spread out and bound the alimentary tract more and more to the abdominal wall as the animal became more and more orthograde in posture. Hence, various degrees of extent and strength of mesenteric adhesions due to arrest of development or otherwise, may help to account for visceral ptosis, in some instances at least.

The etiology of enteroptosis lies doubtless in a great variety of causes which in one way or another bring about lowered intraabdominal pressure. There is a type of thorax and of pelvis, a defective neuromuscular mechanism of intestines or of body wall or of both, a mode of dress, recurring and chronic

infections lessening the tone, deep lying congenital defects escaping definition, multiple pregnancies, and so on, all tending with more or less facility to lower intraabdominal pressure and to stretch ligamentous attachments. The fact that enteroptosis is largely a feminine condition supports the view that corsets, skirts, and pregnancies lie near at hand as causes of these displacements. Apparently with this in mind Rovsing classifies the types as virginal and maternal. On the other hand disregarding sex Keith makes three classes: (1) Complete enteroptosis, when there is a prolapse of both supra- and infra-umbilical viscera. (2) Partial enteroptosis due to visceral enlargement when only the supra-umbilical viscera may be affected. (3) Partial enteroptosis caused by compression—both supra- and infra-umbilical viscera are always affected.

Symptoms.—Enteroptosis does not invariably give rise to symptoms, or, in other words, a considerable degree of downward displacement of one or more of the abdominal organs may exist without calling forth any complaints. On the other hand, however, one finds a variety of symptoms referable to the digestive tract, the nervous system, the circulatory system, the condition of the blood, and so on; in a word, all manner of subjective symptoms may exist, from the severest abdominal pain, usually spasmodic, to the mildest paresthesia.

It must be admitted, however, that, prominent and more frequent among the complaints urged by the subjects of enteroptosis, are those of digestive and nervous disturbances, distressful weight after food, referred to the right upper quadrant; sometimes spasmodic pain; sometimes vomiting, flatulence, constipation, and throbbing in the abdomen, headache, sleeplessness, and fatigue. The distress, which in pronounced cases is for the most part constant and referred to the upper quadrants, is promptly relieved on assuming the horizontal position, only to return again on getting up and walking about. Hence some persons make this complaint prominent while speaking of their symptoms. It is interesting, in this connection, to note that constipation, which in one case under the writer's observation was very obstinate, always disappeared when the patient lay in bed for a few days.

Those in whom the condition is marked are usually tall and thin, with no compactness of form, while the facial expression in many instances bespeaks a "neurasthenia basis," and, according to Keith and Williams, in cases of visceral ptosis, there is commonly a marked forward curvature of the cervical region of the spine—"ewe-neck." The chest is small, the waist is long and narrow, and the pelvis is broad.

The examination of the abdomen should be made in both the upright and dorsal positions. In the former attitude one finds, in typical cases, the lower part of the abdomen flaccid and prominent, overhanging the symphysis pubis—the "Hängebauch" of the Germans, contrasting strongly with the upper quadrants which are usually flat or hollowed out. Meinert holds that such a pendulous abdomen holds a dilated stomach and not a dislocated one. It is in the dorsal position, however, that one gets positive evidence of the postural anomalies of enteroptosis. The epigastrium is usually flat and somewhat scaphoid, with widespread pulsations, while the periumbilical region is prominent. Peristaltic waves may be seen crossing the abdomen from side to side; the recti abdominales are frequently widely separated, as may be shown either by palpation or by directing the patient to lift the head and shoulders unaided by the hands or elbows, when a prominent central ridge appears running from the ensiform cartilage downward. The usual methods for determining the positions of the different organs should be resorted to: palpation and percussion for the solid organs, while inflation and illumination, as well as auscultatory percussion, may determine the situation of the stomach, etc. Of these methods there seems but little doubt that inflation and an x-ray examination aided by barium or bismuth are the most accurate. It is important of course to distinguish between a displaced stomach and a dilated stomach. Indeed, when that organ is displaced it is usually dilated to some extent.

The organs usually found prolapsed, in cases of enteroptosis, are the stomach, the right kidney (movable or floating), and the colon. There is, however, increasing evidence to show that the liver is much more frequently dislocated than was at one time supposed. The left kidney and the spleen are rarely implicated in this condition as compared with the right kidney. The pancreas may be displaced also, chiefly at its head. Not infrequently the pelvic organs suffer the same displacement. The diaphragm and heart participate in complete enteroptosis—downward displacements of one inch and one-half to two inches having been observed.

With reference to the determination of the position of the stomach, it is important to remember that normally the lesser curvature does not come into view when the organ is inflated, and that the whole of the organ lies above the umbilicus. Hence, when the lesser curvature is seen, and its normal relation to the greater curvature (four to four and one-half inches) is not greatly altered, gastroptosis is present, and in proportion as the lesser curvature approaches the umbilicus, or goes even below it, an increasing degree of gastric dislocation obtains. The stomach is sometimes seen in the oblique or almost vertical position, and not infrequently the pyloric end is dilated, forming a three-quarter circle with the umbilicus as center when outlined upon the abdomen. Again, the stomach may be somewhat V-shaped.

What is the small band which is palpable running across the abdomen about two inches or so above the umbilicus? Glénard termed it "la corde colique transverse," and regarded it as the "colon transversum." There is good reason to doubt the correctness of this view. If the stomach is low the colon is generally lower, and in a case in which the band was most typically found by the writer, operation proved it to be the pancreas. In palpation of the abdomen Glénard laid special stress upon a test of considerable diagnostic value. The examiner, standing behind the patient, who is also in the erect position, places both hands flatly over the lower zone of the abdomen and applies firm and gentle pressure upward and backward. In the great majority of cases of enteroptosis this act affords considerable relief to the distressing dragging sensation felt in the epigastrium and abdomen. At the same time the result when this test ("l'épreuve de sangle") is applied, is an index to the treatment.

Stiller's Sign. (Costa fluctuans decima.)—Stiller, regarding enteroptosis as of a neurasthenic or congenital origin, looks upon the presence of a floating tenth rib as indicative of the presence of a neurasthenic tendency. Observations upon this point reported by Meinert, Zweig, Arneill, and others, go to show that this sign in the diagnosis of enteroptosis, or neurasthenia, is scarcely so important as Stiller would have it.

With respect to the relation of enteroptosis, more especially gastroptosis, to chlorosis, it must be said that it is not that of cause and effect—no characteristic blood condition is found in cases of enteroptosis, and many cases of chlorosis occur in which there is no evidence of visceral displacements.

Jaundice, which has been seen in several cases, may result from a variety of causes. "Gallstones are commonly, if not always present, in cases of enteroptosis." This statement, made by Dr. A. Keith, seems rather too broad, although it must be admitted "that the condition of visceral ptosis favors their formation." However, there can be no doubt that the altered relation of the bile ducts and organs,

especially the right kidney, the liver, and the duodenum, may cause in a variety of ways obstruction to the outflow of bile and thus induce jaundice.

Pathology.—The symptoms of enteroptosis may be accounted for by various theories, which for convenience fall under three headings: (1) The mechanical theory of Glénard. (2) The neuromechanical theory of Meinert. (3) The neurointoxication theory of Schwerdt.

The first theory, though not a purely mechanical one, does not ask for any antecedent nervous cause, but implies a weakness of the suspensory ligaments of the transverse colon, especially the colohepatic ligament. The descent, Glénard claims, begins at the hepatic flexure and the other events incident to the disease follow—enterostenosis, due to a kinking of the colon at the point of prolapse, gastroptosis, constipation, autointoxication, the neurotic manifestations, etc.

Under the second theory Meinert attributes the symptoms associated with dropping of the viscera to the constant stimulation and irritation of the sympathetic nerves, as a result of pulling and stretching of these nerve fibers. The blood-forming organs and the general nervous system participate in this abnormal irritation and stimulation, and chlorosis, neuroses, and a variety of vasomotor disturbances are thus induced ranging in their subjective features with the degree of sensitiveness found in patients.

Schwerdt believes that the nervous system is primarily at fault; the fiber of the individual in toneless, the functions of the abdominal muscles, both parietal and visceral, are not normal; intraabdominal pressure is lessened, ptosis follows. There is a stasis in the blood and lymph vessels, the bowel contents stagnate and decompose, excretions accumulate; absorption of poisonous products goes on, and intoxication is the result—dyspepsia, headache, anemia, palpitation, neurasthenia, etc.

Diagnosis.—In the great majority of cases one may suspect the condition from the complaints made by the patient—digestive disturbances, distress, not necessarily pain, in the stomach on getting up in the morning, or after being in the recumbent posture for some time, dragging under the right costal margin, a feeling as if something falls over to the left side when the patient turns on that side, constipation, lack of energy, and other neurasthenic symptoms. Rovsing makes a strong diagnostic point of the disappearance of pain when the patient lies down. The absence of constipation while in bed is also equally significant in the writer's experience. The patient is generally slender and of lean habit.

An examination of the abdomen, however, is necessary to correct or justify the suspicion derived from the complaints. The contour of the abdomen may further suggest a condition of splanchnoptosis and inflation of the stomach by means of tartaric acid and bicarbonate of soda, or air cautiously pumped in, readily and accurately serves to locate that organ. The solid organs may be palpated, and it is recommended to examine the liver while the patient is in the upright position. Displacements of this organ are doubtless much more frequent than might be supposed, judging from the results of examination in the dorsal position. The right lobe of the liver in some cases projects in a tongue-like process below the costal margin. It has been described as Riedel's lobe, and may occasionally be somewhat misleading. The test known as "l'épreuve de sangle," already described, should be applied in all suspected cases. It is scarcely possible, after a careful examination, to mistake enteroptosis for any other ondition. Doubtless many cases of gastric neurasthenia, of nervous dyspepsia, and of gastric ulcer would be cleared up by a careful search for visceral ptosis. Of untold value in many doubtful cases is a careful radiographic examination of the stomach and bowels.

Among others at least two instances of mistaken diagnosis coming under the writer's notice may be recorded. In one, a diagnosis of malignant disease of the stomach led to a laparotomy revealing the pancreas as the palpable misleading mass, while in the other, recurrent jaundice was thought to be due to gallstones or a "sluggish liver," and horse-back riding, rowing, walking, canoeing, recommended for its relief, aggravated all the symptoms. On the other hand, one must avoid the danger of attempting to explain too many symptoms by visceral ptosis.

Prognosis.—Many patients recover entirely, losing all symptoms and signs of the disease. The majority may recover from the evil train of symptoms, the ptosis existing in part at least. It may be fatal as the result of the exhaustion and intoxication in extreme cases

Treatment.—The recognition of the characteristic shape of the body in a child, attention to general nutrition in children; careful direction of these and of patients during recovery from exhausting diseases, and after parturition may accomplish much by preventing the development of visceroptosis. The indications for the treatment of enteroptosis as originally recommended by Glénard can scarcely be improved upon. They are as follows:

1. The intestines must be elevated and kept in their new position.
2. The abdominal pressure must be increased.
3. The bowels must be regulated.
4. The secretions of the intestinal glands must be increased.
5. The digestion and nutrition must be regulated and stimulated.
6. The whole organism must be strengthened.

If a cause can be fixed upon as inducing or aggravating the displacement, let it be removed. Those measures will best meet all these requirements which increase the strength and raise the tone of the whole musculature. It seems in most cases to be a question of nutrition, rest, good food, mild yet efficient purgatives, or better still enemata, occasionally gastric lavage, with drugs directed against fermentative processes in the early stages of the treatment, as indicated. Many patients are restored only when they have gained many pounds in weight, and to this end rest in bed and forced feeding are essential. While this is being secured massage and exercises combined with hydrotherapy to increase the tone of the muscles in general, and the abdominal muscles in particular may be carried on. It is of the highest importance to increase the strength of the abdominal muscles by regulated exercise. Belts, or abdominal supporters, so highly recommended and in such variety, are of doubtful utility. Only those belts which increase the intraabdominal pressure and which are carefully applied, exerting pressure upward and backward, should be used. It is not only futile, but often harmful, to attempt to hold a kidney or a stomach in place by any special device externally applied.

The surgical treatment of this condition, should be undertaken only after other methods have failed, and then only with the greatest care, especially in those cases in which the neurasthenic element is strongly manifest, for such patients are often worse rather than better after surgical interference. If one would choose for operative treatment those with whom other measures had failed might be taken first. Then those where digestive symptoms are prominent, with prolapse of stomach or stomach and transverse colon, would form a second group for such measures. Rovsing reports recoveries by gastropexy "to the extent of being relieved of their sufferings, of regaining their health and strength, and from being incapable,

depressed, miserable wrecks, have become able-bodied, healthy, and happy people" in from seventy-one to seventy-five per cent. (256 operations). Duret first operated in 1894, lifting the stomach and fixing the serosa of the lesser curvature of the stomach to the parietal peritoneum and muscle of the anterior wall of the abdomen. Byron D. Davis (1897), Beyea (1898), Hartmann (1899), Treves, Bier, and Webster, have operated with varied success on similar cases. Beyea and Stengel shortened the gastric hepatic omentum and gastrophrenic ligament by plicating with multiple sutures, thus bringing the stomach up to its normal position. Webster, selecting those cases in which there was separation of the recti muscles, sought to increase intraabdominal pressure by resecting the fascia of these muscles and then suturing the muscles together.

William Fawcett Hamilton.

Spleen, Anatomy and Physiology of.—The spleen is the most deeply placed of the intraperitoneal organs. It is located in the dorsal part of the upper left portion of the abdominal cavity, extending from the epigastrium into the left hypochondrium. It lies under cover of the ninth, tenth, and eleventh ribs. The superior portion of the spleen is under cover of the base of the left lung in addition to the pleura, diaphragm, and thoracic wall. Therefore, if this portion of the spleen be punctured from behind the wound would involve injury of the lung as well as the opening of the pleural and peritoneal cavities. It is a highly vascular organ, of a purplish color, soft and very elastic; it is constantly changing in volume as will be considered under its *Physiology*.

Anatomy.—The *shape* of the spleen depends upon the condition of the surrounding organs—the diaphragm, stomach, left kidney, and colon. It is usually given as tetrahedral, but it resembles more an irregular, three-sided pyramid with its base pushed into the visceral surface and forming part thereof. This shape is exhibited when the organ is fixed *in situ* with the stomach contracted and the colon distended. Its measurements average about 5 inches (12.5 centimeters) in length, 3 inches (7.5 centimeters) in breadth, and $1\frac{1}{4}$ inches (3 centimeters) in thickness. Its weight is variable averaging $5\frac{1}{2}$ to $6\frac{1}{2}$ ounces (165 to 195 grams).

The spleen usually exhibits an *apex*, a *base*, *two surfaces*, *three borders*, and *four angles*. The *apex* (*superior angle*) is somewhat pointed and $1\frac{1}{2}$ inches (3.75 centimeters) from the midvertebral line. The *base* is triangular in shape and corresponds to the colic area of the visceral surface; it usually extends to the midaxillary line.

The *parietal* or *diaphragmatic surface* (*facies diaphragmatica*) is smooth and convex, being moulded into the concavity of the diaphragm. The *visceral surface* is irregular and divided into three areas by three ridges. The largest ridge starts below the apex and extends nearly to the base ending at the intermediate angle. It separates the larger concave *gastric area* (*facies gastrica*) above, from the smaller and flatter *renal area* (*facies renalis*) below. Upon the gastric area is seen the hilus where the vessels enter and leave. The triangular *base* in *colic area* (*facies colica*) is the smallest and is bounded by the intermediate ventral and dorsal angles. It is flattened or slightly concave.

The *ventral border* (*margo ventralis*) is thin and notched (one to six or seven notches) and separates the diaphragmatic surface from the gastric area. The *dorsal border* (*margo dorsalis*) is thin and separates the diaphragmatic surface from the renal area. This border corresponds approximately to the left, eleventh intercostal space. The *inferior margin* (*margo inferior*) separates the diaphragmatic surface from the colic area. The ridges upon the visceral surface extending from the intermediate angle to the ventral and dorsal angles are the *ventral* and *dorsal intermediate borders* (*margines intermedii ventralis et dorsalis*).

The *angles* are the *superior* (apex) *intermediate* (internal), *ventral* and *dorsal*. The last three are upon the visceral surface and bound the base or colic area.

The spleen is completely invested by peritoneum and is connected to certain organs by folds of perito-

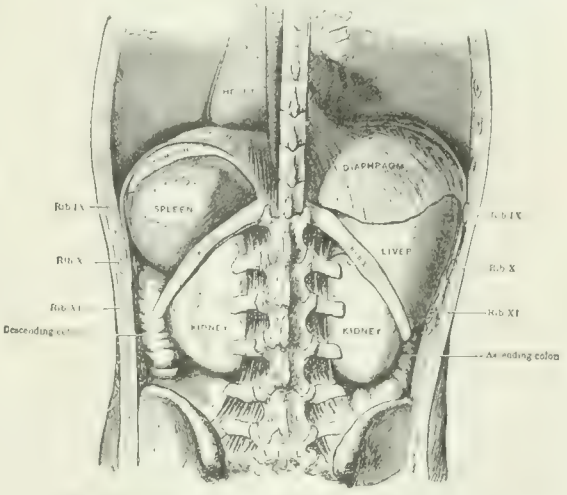

Fig. 4628.—Dissection showing the Spleen, Liver, and Kidneys from behind in a Subject Hardened by Formalin-injection.

neum called *ligaments*. The *gastrosplenic ligament* extends from the hilus of the spleen to the fundus of the stomach and serves as a passageway for the *aa. gastricæ breves* which are branches of the splenic artery that supply the fundus of the stomach. The *lienorenal ligament* is a fold of peritoneum that extends from the region of the left kidney to the spleen where it spreads and forms part of the peritoneal investment of that organ. Between its two layers the

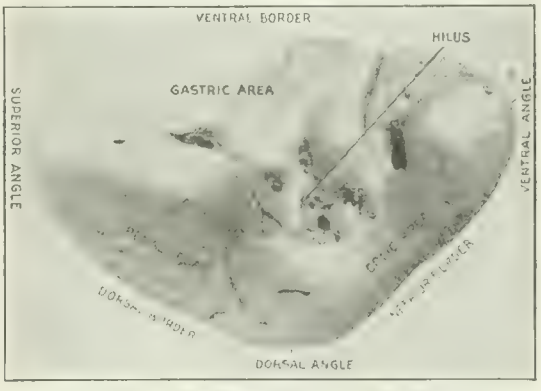

Fig. 4629.—The Visceral Surface of the Spleen.

splenic artery gains access to the hilus of the spleen and the splenic vein leaves. The lower part of the spleen rests upon the *phrenicocolic ligament* that extends from the splenic flexure of the colon to the diaphragm. When the spleen is displaced (floating) the gastrosplenic and lienorenal ligaments are lengthened forming a pedicle.

The *blood-vessels* are the splenic artery and the splenic vein. The splenic artery (a branch of the celiac axis) reaches the spleen between the layers of the lienorenal ligament. Near the hilus it divides into numerous branches that enter the organ, represent-

ing terminal vessels. Numerous venous channels emerge from the hilus and unite to form the large splenic vein, which passes into the lienorenal ligament and ultimately assists in forming the portal vein.

The *lymphatics* are small and drain the capsule and framework only; they emerge at the hilus.

The *nerves* are sympathetic and are derived from the splenic plexus of the celiac plexus. The nerves follow the splenic artery and its branches.

The *position* of the spleen depends upon the position of the body. In the erect position the long axis of the spleen is frequently vertical, especially in females. In the recumbent posture the long axis corresponds to the axis of the tenth rib.

To outline the position of the spleen upon the body three points are first determined: 1. one and one-half inches to the left of the tenth thoracic spine; 2. in the eleventh, left intercostal space on a level with the first lumbar spine and one inch medial to the level of the center of the crest of the ilium; 3. in the ninth left intercostal space in the midaxillary line. Join 1 and 2 by a slightly curved line with the convexity downward following the eleventh intercostal space (*renal line*); then join 2 and 3 by a curved line with the convexity outward (*colic line*); then continue the curved line from 3 to the upper border of the ninth rib and follow this to the scapular line; then pass horizontally across to the upper border of the tenth rib and thence in a sharp curve proceed to point 1. It must be remembered that this gives the *anatomical outline*, but this entire area does not give dulness upon percussion, as approximately the apical one-fifth of the spleen is too deeply placed.

Structure.—The spleen is called a ductless gland, although it is not of epithelial structure or origin, and gives rise to certain cells, leucocytes, and erythrocytes. It is closely associated with the lymphatic and blood-vascular systems and is lymphoid in structure. According to Mall the spleen consists of a large number of splenic lobules each of which measures about one millimeter in diameter. Each lobule is divided into about ten compartments by smaller trabeculæ. The pulp is arranged in the form of anastomosing cords called *pulp cords* and each cord receives a branch of the main arterial channel (intralobular artery) that traverses the lobule.

The spleen is surrounded by a *capsule* of white fibrous connective tissue which is further invested by a serous covering, the peritoneum. The *serous* coat consists of a single layer of flattened endothelial cells that rest upon a thin layer of fibroelastic tissue called the subendothelial tissue; the latter is firmly adherent to the capsule proper. The capsule, or fibrous coat consists of a rather thick, strong layer of tough white fibrous tissue. Much smooth muscle tissue is present and to this are due the rhythmic contractions of the organs. From the under-surface of the capsule, especially at the hilus, thick trabeculæ of fibromuscular tissue pass into the organ forming a coarse meshwork. From these trabeculæ smaller ones arise and all serve to support the blood-vessels, nerves, and lymphatics. From the smaller trabeculæ delicate bundles of fibers pass across the large meshes forming a series of finer and more delicate spaces in which the splenic pulp is found. This delicate reticulum is said to be retiform connective tissue, or *reticulum* and is not noticed except under special stain methods. The reticulum consists of delicate fibers covered by the reticulum cells which are branched connective-tissue cells. They contain a variable number of yellowish pigment granules. The reticulum and trabeculæ constitute the *interstitial tissue*.

Within the capsule is the *splenic substance* (parenchyma), consisting of the splenic pulp and the splenic corpuscles. The *splenic pulp* is of a reddish-brown color and of a cellular structure. Leucocytes are the chief constituent and the cellular elements are as follows:

1. *Large Lymphocytes* or *Hyaline Cells.*—These predominate. These cells are large and possess a large nucleus. Both cytoplasm and nucleus do not stain deeply. The average 11 to 15μ in diameter and are actively ameboid and phagocytic.

2. *Lymphocytes*, or *small mononuclear, leucocytes* are next in number. These are 5 to 8μ in diameter and each consists of a large nucleus surrounded by a narrow rim of cytoplasm. Both nucleus and cytoplasm stain readily and these cells are ameboid and phagocytic.

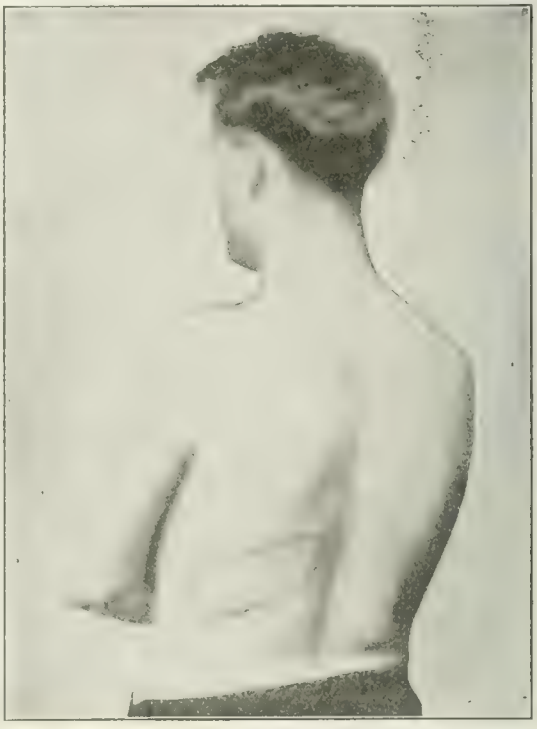

Fig. 4630.—Topographic Outline of the Spleen.

3. *Polymorphonuclear leucocytes*, or *finely granular eosinophils* are present in small numbers. These are 7.5 to 11μ in diameter and are actively ameboid and phagocytic. The nucleus varies in shape and may even be segmented. The cytoplasm contains many fine granules that respond readily to the plasmatic stains, eosin especially.

4. *Eosinophils* are not numerous but more so than in any other lymphoid structure except red bone marrow. These cells are 7 to 10μ in diameter and are actively ameboid but not phagocytic. The nucleus may be lobulated and the cytoplasm contains a few coarse granules that respond to the eosin.

5. *Basophilic leucocytes* are few in number. The cytoplasm contains some fine granules that respond to the nuclear stains.

6. *Splenic phagocytes* are large cells resembling leucocytes but larger; these cells are actively ameboid and phagocytic. They often contain disintegrating red blood cells and pigment granules and fat droplets; in diseased conditions they may contain bacteria.

7. *Giant cells* are large masses of nucleated protoplasm resembling the giant cells of the bone marrow. The nucleus may be lobulated, or several nuclei may be present. These cells are most numerous in young animals.

8. *Erythrocytes* are very abundant. They pass out of the ampullæ into the pulp where many remain and disintegrate while others return to the venous channels. These cells scattered in with the leucocytes give a mottled appearance to the splenic pulp.

9. *Erythroblasts* are occasionally seen in the adult pulp, though some authors deny their presence. These are nucleated, or young red blood cells that are very numerous in the spleen in fetal life and early childhood, indicating an important function of the spleen during that time, namely, the manufacture of red blood cells.

10. *Thrombocytes*, or *blood platelets* are frequently found. They are small, 2 to 3μ in diameter, and non-nucleated. They probably pass into the pulp with the blood and are not formed here.

FIG. 4631.—Portion of Section of the Spleen. × circa 12. *a*, Arteries, some with lymphoid sheaths; *cf*, capsule; *Mk*, Malpighian capsule; *pl*, splenic pulp; *tr*, trabeculæ; *v*, vein in one of the trabeculæ.

The *splenic*, or *Malpighian corpuscles* are practically solitary nodules closely associated with the arterioles. They are spherical or ovoidal in shape and measure, on the average, 0.36 millimeter in diameter though both smaller and larger ones are found. They are located in the adventitial of the arteriole and each consists of a delicate network of reticulum which is continuous with the reticulum of the pulp. The meshes of the reticulum are filled with leucocytes. Each corpuscle consists of a central, lighter area, the *germinal center*, where the cells are fewer in number and where they multiply. The newly formed cells are crowded to the edge of the corpuscle and are there closely packed giving a denser appearance to that part of the corpuscle; from here they pass, ultimately, into the pulp and blood-vessels. Throughout the corpuscles are capillaries that are derived from the contained arteriole which is usually eccentrically located. These splenic corpuscles are usually not as abundant in man as in certain lower animals.

The *blood-vessels* are the splenic artery and vein, both of which are much larger than would be necessary for mere nourishment of an organ the size of the spleen. At the hilus the artery divides into numerous branches that follow the longer trabeculæ; from these vessels smaller branches are given off that enter the pulp, became associated with the splenic corpuscles and ultimately end in a series of fine, pencil-like branches in the pulp. The splenic corpuscles are really located in the adventitial or lymphoid sheath of the arteriole. The pencil-like vessels do not terminate in the ordinary closed capillaries but continue as expanded capillaries called *ampullæ*, which have porous walls and continue as venules. The endothelial cells of these ampullæ are long, irregular, and contractile; some are branched and the branches become continuous with the branches of the reticulum cells. Spaces or clefts exist between the endothelial cells permitting communication between the lumen

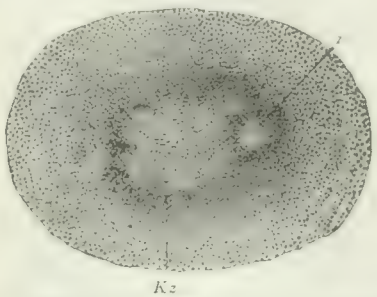

FIG. 4632.—Cross-section of a Malpighian Corpuscle of the Spleen. × circa 75. *a*, arteriole; *kz*, germinal center.

of the ampulla and the pulp spaces. The venules begin as the ampullæ terminate and are, thus, also continuous with the pulp spaces. Connected with the endothelium of the venules are the processes of the reticulum cells so that the reticulum forms a circular and longitudinal arrangement about the walls of the venous sinuses. The smaller veins soon pass into the trabeculæ and unite to form large channels that ultimately form the splenic vein just inside of the hilus of the organ.

From the above it will be seen that unlike those of other organs the capillaries of the spleen are open, allowing communication with the pulp spaces.

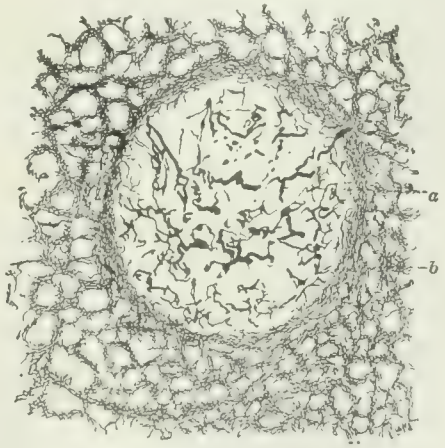

FIG. 4633.—From the Human Spleen. × 80 (chrome-silver method): *a*, Larger fibers of a Malpighian body; *b*, reticular fibrils (Gitterfasern). (Böhm, Davidoff and Huber.)

The spleen is subject to rhythmic contractions, one per minute, and about eighteen per cent. of its volume is lost at each contraction. These contractions are produced by the smooth muscle tissue of the capsule and trabeculæ and seem to be analogous to the peristaltic action of the stomach and intestine. When the cardiac impulse sends the blood into the arteries the blood passes into the ampullæ and through the porous walls into the pulp spaces. When the rhythmic contraction occurs the blood is forced into the veins and at the same time the arteries are closed.

In this manner the erythrocytes of the blood current become constituents of the pulp and may again pass into the venules. In like manner the leucocytes made in the spleen may readily gain access to the venous channels in great numbers as is shown by the fact that they are seventy times more numerous in the blood of the splenic vein than in that of the splenic artery. Such is called, by Mall, an *open circulation*.

Small lymphatics are found in the capsule and trabeculæ but not in the pulp. They drain the lymph to the hilus and thence to the celiac group of nodes.

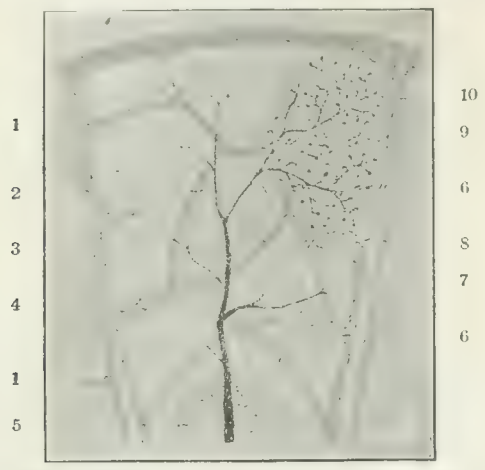

FIG. 4634.—Diagram of a Lobule of the Spleen. 1,1, Intralobular trabecula; 2, artery to one of the two compartments; 3, intralobular artery; 4, interlobular trabecula; 5, Malpighian corpuscle; 6,6, intralobular vein; 7, interlobular vein; 8, spleen pulp cord; 9, intralobular venous spaces; 10, capsule. (Mall, Johns Hopkins Bulletin, 1898.)

The *nerves* are *myelinated* and *amyelinated*. The former are less numerous and seem to be sensor in function; they are probably distributed to the capsule, trabeculæ, and adventitial sheaths of the blood-vessels. The amyelinated nerve fibers follow the blood-vessels, form plexuses around them and are mainly for the muscle tissue of the blood-vessels and that of the capsule and trabeculæ. Some nerves may be traced into the pulp but the exact mode of ending is still in doubt.

DEVELOPMENT.—The spleen is a purely mesodermal derivative, although it develops in close relation with the stomach and alters its position with the change of position of the stomach. It appears as a slight enlargement between the layers of the dorsal mesogastrium, in embryos of nine millimeters length. This thickening is due to a multiplication of mesothelial cells. Soon (ten to twelve millimeters) the deep cells become distinctly mesenchymal and a delicate capillary network appears. A connective-tissue framework develops between the vessels and in this meshwork leucocytes appear and begin to multiply forming lymphoid tissue first around the blood-vessels. The blood sinuses give rise to the pulp spaces. The lymphoid tissue is first pronounced during the fourth month. Later giant cells and erythroblasts appear (fetuses fifteen to thirty centimeters) and from this time to birth the formation of erythrocytes is probably the most important function of the spleen. Nucleated red blood cells, erythroblasts, are numerous from this time to birth. The splenic corpuscles are said to be first found during the seventh month of intrauterine life. Toward the end of gestation the erythroblasts begin to decrease so that at birth they are greatly reduced and are said to disappear in early childhood.

PHYSIOLOGY.—Whether the spleen has any other function than to assist in the production of leucocytes and the destruction of useless red blood cells is still in doubt. Its removal is attended with no important disturbance, indicating that its importance is not of the highest. After its removal the lymph nodes enlarge somewhat and the red bone marrow becomes more active; these two processes seem to indicate the functions of the spleen. Its function, during fetal life, of manufacturing red blood cells ceases shortly after birth; this becomes prominent, however, when the usual blood-making organs (red bone marrow especially) become diseased. Possibly the disintegration of red blood cells in the spleen indicates initial steps in the production of the coloring materials of the bile as all the splenic vein blood is carried directly to the liver by the portal vein.

The spleen is not a quiescent organ but undergoes periodic change in volume, the systole and diastole occupying, in the cat and dog, about one minute. In these contractions the spleen loses about eighteen per cent. of its volume. These alterations resemble

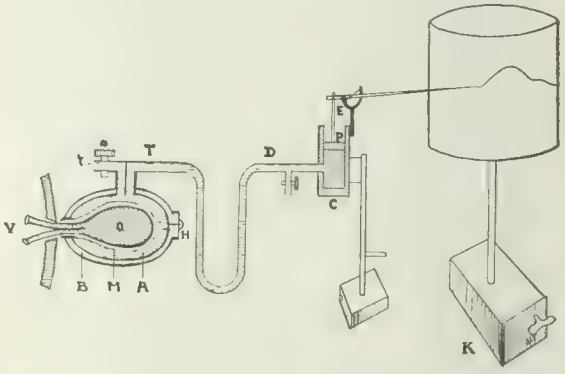

FIG. 4635.—The Oncometer. B. Metal box in two halves, opening on the hinge H; M, thin membrane; A, space filled with oil; O, organ enclosed in oncometer; V, vessels of organ; t, tube for filling instrument with oil; T, tube connected with D, which opens into cylinder C; C is also filled with oil; P, piston attached by E to a writing lever; K, kymograph.

the peristalsis of the gastrointestinal tract and are due to the rhythmic contraction of the smooth muscle tissue in the capsule and trabeculæ, and not to any changes in the arterial pressure, as shown by Roy. By these contractions the blood which has flowed into the pulp, through the openings in the ampullæ, under arterial pressure is returned to the veins and forced out of the spleen. Schäffer and Moore have shown that the spleen responds to changes in arterial blood pressure after digestion, for a period of five hours, the spleen steadily increases in volume and then gradually returns to its former condition.

The change in volume was first shown by Roy. The instrument for measuring the volume is the *oncometer* and the recording apparatus the *oncograph*. The oncometer (Fig. 4635) is a metal box, B, with rigid walls. The box is hinged, H, and the opposite edges are grooved to accommodate the vessels of the spleen. The spleen is withdrawn through an opening in the abdominal wall and enclosed in a membrane, M, to prevent contact with the oil and to prevent escape of the oil at the opening for the vessels. The spleen is then placed in the box and the tube, D, is connected with the cylinder, C, and the system is filled with oil. The rod of the piston, P, is connected with the lever, E, of the recording apparatus. The end of the lever is then brought into contact with the revolving surface of the kymograph. The variation in volume is indicated by the displacement of the oil and the amount is shown by the lever of the recording apparatus, which

gives a continuous record. The timing of this record may be accomplished by a simultaneous metronomic tracing.

The medullated nerve fibers from the cerebrospinal system pass to the celiac ganglion of the sympathetic system, chiefly from the ventral divisions of the sixth, seventh, and eighth thoracic nerves though some higher and lower participate. The center is in the medulla oblongata. The sympathetic fibers extend from the ganglion and accompany the branches of the splenic artery to supply their musculature and the muscle tissue of the capsule and trabeculæ. If the nerves be stimulated the spleen decreases in volume; if the nerves be cut the volume increases. In asphyxia the spleen is small and contracted indicating a stimulation of the oblongata by the venous condition of the blood. Even after removal of the spleen, the organ may be induced to give changes in volume by perfusing it with blood. This would seem to indicate that the contractile mechanism is, to a certain extent, independent of the nerve system.

H. E. Radasch.

Spleen, Diseases of the.—General Considerations.—Developmentally the spleen belongs to the mesoblastic tissues. It is derived from the mesogastrium and in its origin is closely related to the pancreas, but has none of the hypoblastic elements which enter into the formation of the latter. It first appears during the second month of fetal life and develops slowly, so that it is not complete until nearly the end of that period. Structurally, and, as will be seen later, to some extent physiologically, the spleen is closely allied to the lymphatic nodes or glands. The framework of the spleen is connective tissue, which is massed especially in the capsule, giving the general form of the organ; in the trabeculæ, which are processes running from the capsule into the substance of the viscus, and dividing it into smaller parts; and, finally, in a fine meshwork which fills these parts and divides them into minute spaces, the so-called pulp spaces of the organ. Connected with this fine connective-tissue meshwork are many stellate branching cells. The walls of the pulp spaces are lined with small or large endothelial cells. In the meshes of the connective-tissue framework, that is in the pulp spaces, are great numbers of small round cells or lymphocytes. The blood supply is the splenic artery, whose main divisions run along the trabeculæ of the organ, then, subdividing into smaller branches, pass into the so-called pulp. Upon the walls of, or around, the smaller arterioles are clustered here and there masses of lymphoid cells which constitute the Malpighian bodies of the spleen. These bodies correspond in a general way with the lymph follicles of the lymph nodes, and the pulp spaces of the spleen correspond to the lymph sinuses of the nodes. The pulp spaces constitute the beginnings of the venous radicles of the organ, which gather up the blood to pass it on to the splenic vein. The nerves of the organ are derived from the celiac plexus and the right vagus, and to some extent they accompany the branches of the splenic artery.

The size and weight of the spleen vary considerably even in conditions of health. During the first year of life it weighs from 15 to 20 grams, in adult life from 140 to 200 grams.

Anatomically the spleen stands in close contact with the stomach, and the blood supplies of the two are closely related. In some of its functions also it is associated with the stomach and liver. It is therefore not uncommon to find it classified as belonging to the digestive system.

From what has already been said with regard to the structure of the spleen, its close kinship to the lymphatic apparatus, and its anatomical relations to the digestive organs, we may expect that it will but rarely become the seat of primary disease, but that it will participate largely in systemic disorders and in local disturbances, especially those involving obstruction to the circulation in the portal system. In fact, apart from the extremely rare cases of primary malignant disease of the spleen, there are but two affections in which it appears to play the primary or chief rôle. These are the splenic form of leucemia, and the disease or group of diseases which has lately been designated as splenic anemia. It is, however, still an open question whether in either of these the rôle of the spleen is primary. We can only say that in some of the cases included in these categories such seems to be the case.

Abnormalities.—Absence of the spleen is met with in some cases of acephalic monsters and in premature fetuses with imperfect development of the skull. Litten records two cases in which no spleen could be found in bodies otherwise perfect, but as one of them dates back to the sixteenth century, the condition must be an exceedingly rare one. Supernumerary spleens, on the other hand, are extremely common, being found in about one body in four. In number they vary from one or two up to forty. They are found near the hilus of the spleen, in the gastrosplenic omentum, in the great omentum, and even in the pancreas. In size they are usually small, 0.5 to 1·centimeter in diameter, but they may reach considerable proportions. The absence of the usual symptoms after splenectomy in some instances has been explained on the basis of the presence of supernumerary organs.

A recent study of Parsons shows that there is great variation as to the number and arrangement of the notches and fissures of the spleen. On the anterior border he found that some spleens had no notch, while, when they were present, they varied from one to eight in number. About one-third of the specimens examined showed notches on the posterior border and one-fifth had fissures on the parietal surface.

Abnormal Placement.—Congenital abnormalities in the position of the spleen are observed in rare instances. The most interesting of these is the placement of the spleen in the right hypochondrium in cases of transposition of the viscera. The spleen may be found outside the usual limits of the abdomen in cases of large umbilical hernia, and has even been found in the left thorax in connection with defect of the diaphragm. Von Löwenwald records a case in which the spleen was found attached upon the spinal column.

Movable or Wandering Spleen.—The spleen is normally in position in the left hypochondrium, touching the ninth, tenth, and eleventh ribs, its long axis almost in the line of direction of the tenth rib, its upper and posterior end being about two centimeters from the vertebral column and its anterior and lower extremity being about three centimeters from the margin of the ribs in front. It is suspended by several folds of peritoneum, one passing from the greater curvature of the stomach to the hilus, another from the upper end of the spleen to the diaphragm, and a third from the diaphragm to the splenic flexure of the colon. The last of these suspends the spleen as in a sling and is its chief support.

The normal spleen enjoys a certain amount of mobility, and may be depressed from above by effusions in the left thorax, emphysema, or tumors of the left lung, etc., or may be displaced upward by fluid in the abdomen or by distention of the colon with gas or feces. In the condition of movable or wandering spleen, however, all the suspensory ligaments are lengthened or relaxed and the spleen is displaced downward into either the abdomen or the pelvis.

Etiology.—The condition may be one of the features of a general splanchnoptosis produced by trauma, such

as sudden falls, or by lifting heavy weights, but is most commonly a result of the persistent dragging of an enlarged and heavy spleen upon its attachments, especially likely to be seen in such affections as malaria, leucemia, or splenic anemia.

Morbid Anatomy.—The spleen itself may present any one of the various types of chronic enlargement, or in rare instances it may be normal. The ligaments are all stretched, and with them the splenic artery and vein. The latter may be dilated to enormous size. The tail of the pancreas and the greater curvature of the stomach are dragged down with the spleen and deformity or dilatation of the latter organ may result. The pedicle of the spleen may become twisted upon itself with secondary atrophy of the organ, or even, in case of complete obstruction of the circulation, with gangrene.

Symptoms.—There may be no symptoms whatever, and the displaced viscus may be discovered by accident. There may be pain due to the weight and pressure of the spleen in an abnormal location, or dragging pain due to the stretching of the ligaments. In many instances the patients are neurasthenic and present characteristic symptoms of that disorder.

Diagnosis.—This rests upon two points: First, the recognition of a solid tumor in the abdomen or pelvis as the spleen; and, secondly, the demonstration of the absence of the spleen from its normal situation. The first is usually easy, if the possibility be present to the mind, the smooth, hard, rounded external surface, the sharp anterior border with its notch or notches, and the rounded ends being characteristic. The second point depends upon the absence of splenic dulness in the left hypochondrium. Litten suggests the observation of the colon when distended with fluid, and then again evacuated as an aid to diagnosis, but this is not usually required.

Treatment.—An abdominal bandage or binder may be sufficient to retain the spleen in its normal place; if not, operative measures are called for. A number of instances are on record of successful suturing of the spleen in its proper bed, but splenectomy seems to be the preferable operation.

Acute Hyperplasia of the Spleen; Acute Splenic Tumor; Acute Splenitis.—*Etiology.*—In all the acute infectious diseases an acute enlargement of the spleen may be met with, especially in malaria, typhoid, pyemia, pneumonia, and the exanthemata. The exact significance of this change in the spleen has not yet been clearly determined. That in all cases of bacterial invasion of the blood the spleen plays the part of a filter is well known, and also that even in cases in which the bacteria are not numerous in the blood, such as typhoid fever, they nevertheless abound in the spleen. We also know that in these cases there is always a more or less active hemolysis going on in the spleen. So much is clear. The interpretation of these facts and many kindred ones developed by experimentation has furnished a difficult problem. Metchnikoff and his followers regard the spleen as a center for the manufacture of phagocytes, and therefore as an active agent in the protection of the body against microbic invasions. Extensive experiments have been conducted upon normal and splenectomized animals to test the part played by the spleen in this relation. The results of such investigations as those of Kanthack, Tizzoni and Cattani, Blumreich and Jacoby, have been entirely indecisive of this question. Jawein has recently published the results of a long series of experiments, from which he concludes that the essential function of the spleen is one of hemolysis, that its enlargement in the acute infectious diseases is in exact proportion to the extent of the hemolysis occurring in each particular case, and that in the cases in which no hemolysis occurs there is no splenic enlargement. After full consideration of all these data Rolleston concludes that the spleen in fact is and behaves like a lymphatic gland broken up and embedded in erectile tissue. The Malpighian bodies and adenoid tissue play much the same part that lymphatic glands do elsewhere, while the open, loose, vascular tissue of the organ serves rather as a filter in which various bodies are deposited by the blood, perhaps to remain, perhaps to undergo subsequent changes.

Morbid Anatomy or Pathology.—The spleen is regularly swollen, the capsule stretched, and in many instances it shows patches of thickening. The organ is usually soft, but may be even firmer than normal. On section the pulp is usually found to be deep red and soft, or even diffluent. In some instances the Malpighian bodies show more prominently than usual and the cut section at first sight looks as though studded with miliary tubercles; in other cases these bodies are quite obscured by the swelling and congestion of the pulp. Microscopical examination shows the enlargement to be due to congestion and swelling of the pulp or the glomeruli or both, together with some increase in cells. The chief increase is in cells resembling those of the normal splenic pulp, but multiplication of the living cells of the pulp spaces may be observed, as well as large multinucleated or ovoid and polyhedral cells whose origin is not clear. In some instances small areas of softening, looking like small abscesses, are met with. These are the so-called focal necroses seen also in the liver, kidneys, and lymph nodes in various infectious disorders.

Symptoms.—Apart from the change in size this affection is usually devoid of symptoms. In some instances, however, it is attended with a sense of weight, or distinct pain, in the left hypochondrium, and the organ itself may be tender to pressure. The enlargement of the spleen is detected by palpation, as a rule; but in some instances the spleen may be enlarged and yet not be palpable. In such cases the results of percussion must be relied upon, but they are always very uncertain and often deceptive.

Treatment.—From what has been already said it is apparent that acute hyperplasia of the spleen is in itself a symptom of many disorders, not a primary disease. The treatment of the primary affection is all that is required.

Chronic Hyperplasia of the Spleen.—*Etiology.*—Chronic hyperplasia of the spleen, like the acute affection, is not a primary disorder but a symptom seen in a variety of affections—congenital or acquired syphilis, rickets, prolonged fevers, especially typhoid —and most of all, in chronic malaria and in leucemia or pseudoleucemia. The enlargement observed in the affection known as splenic anemia will be considered elsewhere.

Pathology.—As a rule the enlargement of the spleen in this condition is marked, amounting in some instances to an increase of ten or fifteen times the weight of the normal organ. The spleen may, however, be but little larger than normal. The enlargement is usually symmetrical, so that the organ preserves in general the normal outline, and the notches and fissures can be seen or felt. The organ is usually harder than normal, and the change of consistence may be very marked. The capsule may show some patches of thickening, or in many instances it is generally thickened and a chronic perisplenitis with adhesions to the surrounding parts, the diaphragm, abdominal wall, intestines, stomach, etc., is a feature of the condition. The appearances upon section vary greatly. As in acute hyperplasia, the Malpighian bodies may be lost in the swelling of the pulp, but more often they are notably enlarged and prominent. The color may be uniformly dark, deep brown, or even black, but is more frequently mottled, red, and gray. The trabeculæ may be thickened to such an extent that they are readily visible as bands of fibrous tissue running in from the capsule of the organ and interlacing

in a complicated network. Pigment may be collected in such masses as to be visible.

The microscopical picture varies even more than the gross. The enlargement may be due to uniform hypertrophy of both the pulp and the reticular tissue, but in most cases the increase in fibrous tissue is the more striking feature of these cases. The trabeculæ may show extreme hypertrophy, and even the meshwork of the pulp may be greatly thickened. The glomeruli may in some cases be enlarged, while in others they are almost obliterated by the hyperplasia of the pulp cells and the connective tissue. The endothelial cells of the pulp spaces may show increase both in size and in number. Pigment is often found in the cells, either of pulp or glomeruli, and even in the connective-tissue reticulum. This pigment regularly gives the reaction for hemosiderin, and is, therefore, probably a derivative of the hemoglobin of the blood.

Symptoms.—The symptoms of chronic hyperplasia of the spleen are those of enlargement of the organ, or are disturbances secondary thereto.

A sense of weight or oppression in the left hypochondrium is most common; this rarely amounts to positive pain. By pressure upon the stomach nausea or vomiting may be induced, and in some instances vomiting of blood in considerable quantities occurs. Any of the abdominal viscera may be disturbed in function by the pressure of an enlarged spleen, and at least one case is on record in which the pressure upon the uterus resulted in hemorrhages, which were attributed to fibroid tumor of that viscus. The enlargement of the spleen may cause it to fill the left hypochondrium, or the whole half of the abdomen, or even to pass over into the right half and occupy the right iliac fossa as well. As has been already noted, the enlargement is regularly symmetrical, the spleen maintaining its accustomed shape, the anterior edge being sharp and notched and the lower end rounded, so that it is easy to recognize the tumor as the spleen.

Treatment.—As with the acute enlargement, treatment must usually be directed to the underlying complaint—syphilis, rickets, malaria, or the blood diseases. By such means the enlargement may be reduced to some extent; but if true fibrous hyperplasia or hypertrophy has taken place, the organ cannot return to a normal size. Usually the improvement produced by medicinal treatment is slight. An abdominal belt, properly fitted, will sometimes relieve distress of an enlarged spleen by supporting it.

In the more serious cases splenectomy may be required, but it is astonishing how little disturbance patients may have from a spleen large enough to fill the whole left half of the abdomen, without any treatment.

Rupture of the Spleen.—*Etiology.*—Rupture of the spleen is a rare occurrence. It may occur in a normal organ, but is relatively much more frequent in the enlarged spleen of malaria, typhoid, or the blood diseases. In the case of a normal spleen considerable violence to the abdomen is required to rupture the organ. It has occurred in cases of severe falls or blows upon the abdomen or of crushing of the body by great weight, such as the passage of a vehicle over it. In the case of an organ already enlarged by disease, rupture may occur spontaneously or as the result of slight violence. The explanation of this fact is not difficult in view of the pathological changes. Rupture seems to be especially common in malarial spleens, and for this reason is much more frequently observed in the tropics than in the temperate zones. Playfair is said to have seen twenty cases of rupture of the spleen during two and a half years in the East Indies. In one case within the writer's knowledge the enlarged spleen of a primary splenomegaly (splenic anemia) was ruptured by a slight fall upon the abdomen.

Pathology.—The spleen may be torn in various directions. There seems to be no rule as to the location or extent of the tears, which are often multiple. Usually the capsule as well as the substance of the organ itself is torn, and the escaping blood is poured into the abdomen. The tear may be in the pulp alone, the capsule remaining intact, and the hemorrhage being into the organ itself. In case of extensive adhesions of the spleen to the neighboring viscera and parieties, the hemorrhage may be encapsulated and so prevented from entering the peritoneal cavity. Litten says that when the spleen is adherent to the stomach or intestines, rupture may occur in such a way that the blood is poured into one or both of these parts. Rupture of the spleen is frequently associated with rupture of other viscera, most often the liver.

Symptoms.—These are essentially those of any abdominal injury associated with internal hemorrhage. There is usually severe pain referred to the splenic region and accompanied by local tenderness and muscular rigidity, pallor, rapid and feeble pulse, air-hunger, faintness or unconsciousness, possibly vomiting, and in some instances convulsions. In a case of splenic rupture during the course of typhoid fever recently reported by Conner and Downes the leucocyte count rose rapidly from 8,000 to a maximum of 68,000. The diagnosis is not likely to be made until the abdomen is opened, unless the presence of an enlarged spleen has been previously known and the location or nature of the operative violence be such as to suggest the result.

Treatment.—The only treatment must be laparotomy with suture or packing of the wound in the organ, or splenectomy. In a case recently reported by Eisendrath, attempts to suture a rupture of the spleen failed because the sutures would not hold in the softened substance of the organ and splenectomy had to be performed. The accident is generally fatal, but a few instances of successful operation are on record.

Infarcts of the Spleen.—Infarction of the spleen may arise either by the plugging of a splenic artery by a thrombus derived from some other part of the body, or by a local thrombosis. The thrombi which are carried to the spleen by the circulation have their origin in almost all cases in an endocarditis affecting the left side of the heart and resulting in the formation of thrombi upon the diseased valves. In some instances atheroma of the aorta may be the underlying process. Litten mentions the possibility of air or fat emboli, derived in one case from the opening of a vein and in the other from a broken bone, passing the capillaries of the lung and ultimately lodging in the spleen; but such occurrences, though possible, must be rare indeed.

As a result of an endarteritis of a branch of a splenic artery or vein, thrombi may form in the spleen itself, and either block the vessel at their point of formation or be carried farther to act as emboli in some of the smaller branches of the artery.

Pathology.—As the result of the occlusion of a branch of the splenic artery we have the circulation cut off from the area supplied by the artery in question. The resulting infarct usually appears as a wedge-shaped area in the periphery of the spleen, the base often being on the surface of the organ, paler in color than normal, and surrounded by a deeper zone of hemorrhage. The paler color is due to the death of the cells of the infarcted area, which undergoes the process of degeneration commonly termed coagulation necrosis, and becomes the so-called white infarct. Later, the degenerated cells are absorbed or replaced by connective tissue, and only a scar is left to mark the site of the infarct.

It was formerly supposed that the whole infarcted area immediately after the arrest of the circulation became charged with blood by an inflow from the veins, and that this blood was later absorbed to give rise to the appearances of the white infarct, but Litten has proved this not to be the case.

The deep red granular infarctions in which the tissue is found infiltrated with red cells as in an apoplexy Litten finds to be produced most often by a thrombosis in one of the branches of the splenic vein. They, therefore, do not represent a stage in the life of the ordinary infarct, but a condition due to a somewhat different process. In either case the terminal condition remains the same.

The most important question from the clinical standpoint with respect to these infarcts is whether they are septic or aseptic. If aseptic, the process follows the course indicated above. If septic, in which case they have developed usually in the course of a pyemia, the infarct may undergo suppuration and an abscess of the spleen result.

With either of these two forms there is usually associated more or less perisplenitis, the greater development of this feature being, of course, seen in the suppurative cases.

Symptoms.—Localized pain, sometimes quite sharp at the time of the lodgment of the thrombus, swelling of the spleen, and in some instances a localized friction rub to be heard over the spleen are the only symptoms of the condition.

Treatment.—There is no direct treatment of the condition, and, as a rule, none is required. The cases of suppuration will be considered under abscess.

Abscess of the Spleen.—The chief cause of abscess of the spleen, as indicated in the last section, is the lodgment of an infected thrombus, derived most often from some pyemic focus. Abscess of the spleen may, however, arise from the extension of a suppurative inflammation from some neighboring organ or from the perforation of a gastric ulcer. It is also met with, probably from the formation of infected thrombi, in cases of typhoid, typhus, and, most especially, recurrent or relapsing fever. Abscess of the spleen is also said to have developed in malarial fever; but if so, it must have been due to a secondary infection. Some cases of abscess have been attributed to injury, and in other cases no definite cause of the abscess formation could be disclosed.

Pathology.—The majority of the abscesses of the spleen are small. If multiple, they are scattered through the organ and the intervening tissue is but little changed. Larger abscesses may, however, form, and in some instances the organ is reduced to a sac of pus. Such an abscess has been known to rupture into the stomach, the colon, the peritoneal cavity, or through the diaphragm into the pleura; or, if the lung is adherent, even into the lung itself.

Symptoms.—Many of the smaller abscesses of the spleen, especially if deeply placed, run their course without definite symptoms. With the larger abscesses, particularly those on the surface, there may be pain and tenderness in the region of the spleen, enlargement of the organ, and the irregular or intermittent fever of septic conditions. If the abscess be very large, it is possible that fluctuation may be obtained. In doubtful cases exploratory puncture has been tried, but is too hazardous to be justifiable. If the abscess rupture, symptoms will depend upon the course which the pus takes, that is, whether it enters the peritoneum or discharges into the stomach, colon, pleura, or lung.

Treatment.—Naturally the treatment of this condition is purely surgical. In rare instances repeated aspiration has been successful. In the majority of cases incision and drainage are required. In some few cases splenectomy has been performed for this condition.

Splenic Anemia.—Clinical interest in affections of the spleen at present centers in the question whether there is a definite symptom-group which can be denoted by the title splenic anemia. After a thorough consideration of all the data obtainable Osler concludes that from among the conditions with which anemia and enlarged spleen are associated a well-defined disease may be separated and may well be designated as chronic splenic anemia. Various other names—splenic pseudoleucemia, splenic lymphadenoma, splenic cachexia, primitive splenomegaly, and Banti's disease—have been proposed for the disease, but for many reasons the simplest designation seems the best.

Incidence.—The affection is a relatively rare one. Rolleston records thirty-seven cases. Osler by inquiry among the members of the American Association of Physicians secured the details of twenty-six cases which could be grouped under this title, and has reported fifteen cases which he himself has observed. The disease is met with both in childhood and in adult life. Of a total of forty-nine cases, thirty were males, nineteen females.

Etiology.—In this relation the striking thing is that no adequate explanation of the affection can be had. There is no malaria, no syphilis, no tuberculosis, no leucemia, in short, no apparent cause for the splenic enlargement.

Symptomatology.—The symptoms of the affection may be briefly summarized as a remarkably chronic enlargement of the spleen, associated with more or less marked anemia, frequently accompanied by hematemesis, and in a few cases showing jaundice or ascites at a late stage. The splenic enlargement may exist for five, ten, even twenty-five years. The size of the spleen varies greatly, but in many instances the spleen is decidedly enlarged. Even with very large spleens the patients, as a rule, have no great pain, but complain only of a sense of weight and pressure or occasional dragging in the left side.

The anemia which accompanies the condition is usually of a moderate grade. Of Osler's cases the average count of the red cells was 3,425,000 per cubic millimeter, the average hemoglobin estimation forty-seven per cent. The hemoglobin is relatively lower than the count of the red cells. The leucocytes occasionally show an increase, but are generally below normal. The differential count of the leucocytes shows nothing characteristic.

Gastrointestinal hemorrhage is one of the characteristic features of the disease, especially in the form of recurrent hematemesis. Occasionally the blood may appear only in the stools. Such bleeding may be repeated from time to time for many years.

In many of the cases the liver is notably enlarged, but without definite disturbance of its functions; in other cases the enlargement is associated with signs of obstruction and the cases suggest cirrhosis of the liver with secondary enlargement of the spleen. Ascites and jaundice, when they do occur, are terminal events in the development of the disease. To this stage the title of Banti's disease may be given. The course of the disease may cover ten to twelve years.

Pathology.—Chronic obstruction of the splenic vein produced by endophlebitis or thrombosis may produce all the characteristic symptoms of splenic anemia, enlargement of the spleen, anemia, leucopenia, and recurrent gastric hemorrhage. It should also be noted that there is close resemblance between splenic anemia and some cases of the tropical infection with trypanosomes, kala-azar. These should, however, show the parasites in the blood or lymph nodes. There is a chronic hyperplasia of the spleen with increase of connective tissue, atrophy of the pulp, and degeneration of the Malpighian bodies. The spleen preserves its general outlines; the capsule may be thickened. The weight of the organ may reach two or three pounds, but never attains the figures met with in Gaucher's disease or leucemia.

Large-cell Splenomegaly (Gaucher's Disease).—In 1900 under the caption of primary splenomegaly, endothelial hyperplasia of the spleen, the writer described a rare affection of the spleen apparently

identical with the descriptions of Gaucher (1882), Collier (1895), and Picou and Raymond (1896). Since that time this affection has been definitely separated from the group of splenic anemia and passed into literature as Gaucher's disease by the careful clinical and pathological studies of Brill, Mandlebaum and Libman. The disease closely resembles splenic anemia (the differentiation has only recently been established) but is distinguished by certain definite features. (1) It always develops in childhood. (2) There is a distinct familiar tendency. Collier and the writer both reported two cases in sisters. Brill observed three cases in one family. (3) Progressive enlargement of the spleen to a size equaled only in leucemia. In one of the writer's cases a girl of seventy-two pounds weight had a spleen which weighed twelve and one-half pounds! (4) A marked enlargement of the liver. (5) A brownish-yellow, wedge-shaped, thickening of the conjunctiva extending from the cornea outward toward the canthus. (6) Greater chronicity than is usual in splenic anemia, some of the patients having this condition for twenty to thirty years. As in splenic anemia, the blood shows moderate or severe secondary anemia with a leucopenia, and there is a diffuse bronzing of the exposed areas of the skin and possibly of the body. The most distinctive feature, however, is the pathologic lesion of the spleen. The spleen is enormously enlarged, the fibrous hyperplasia is excessive, and microscopically there are irregular spaces, apparently the enlarged and deformed spaces of the splenic pulp, filled more or less completely with very large endothelial cells, having clear cytoplasm and two or more nuclei, with occasional giant cells. In the original description of Gaucher the condition was termed a primary epithelioma. The writer, after careful study of many sections from his case, concluded that the condition could not be regarded as a new growth, but was an unusual form of hyperplasia of the organ. In this view he has been supported by Harris and Herzog, although these observers do not agree in the view that the endothelial cells, which form so striking a feature of the picture, may later undergo transformation into fibrous tissue. A similar structure has been observed by Picou and Raymond, Collier, Harris and Herzog, and Banta. A remarkable feature of the writer's case was the marked pigmentation found in the spleen, retroperitoneal lymph nodes, and the liver. The lymph nodes also showed changes analogous to those in the spleen, and in the intralobular connective tissue of the liver there were groups of cells closely resembling the large endothelial cells of the spleen. As a rule the changes observed in the liver are those of a simple cirrhosis. The enlargement of this organ may be marked, but is not nearly so striking as that of the spleen.

Moderate enlargement of both external and internal lymph nodes is found in some of the cases, but this enlargement is not comparable to that of leucemia or pseudoleucemia.

Treatment.—The only treatment so far found effective in these cases is the removal of the spleen. Sippy tabulated seven splenectomies for this condition, to which Harris and Herzog have added twelve. Out of the total of nineteen, fourteen recovered and five died. In the majority, at least, of the recoveries the condition has been completely relieved by the splenectomy. Osler regards recurrent hematemesis as the most important indication for operation.

Tumors of the Spleen.—Although the spleen is frequently involved secondarily in cancer and sarcoma, primary tumors of the spleen of any form are exceedingly rare. Both solid and cystic tumors have, however, been met with. Among the cystic tumors Litten distinguishes three groups: (1) Uni- or multilocular cysts of non-parasitic origin, including serous, blood, and lymph cysts; (2) echinococcus cysts; (3) dermoid and atheromatous cysts. These are very rare. Among 235 cases of echinococcus of the abdominal organs Finsen found the spleen the seat of the parasite in only 2, and Neisser in 900 cases of echinococcus collected from literature found 28 cases of echinococcus of the spleen. The only peculiarity of these cystic tumors is the sense of fluctuation which may be obtained upon palpation. Naturally this can be had only when the cyst has reached a considerable size. In the case of echinococcus it is claimed by some that a peculiar hydatid crepitation may be obtained upon palpation, but so great differences of opinion as to its occurrence exist, even among those who have had opportunity to study these cases, that one must doubt the value of the phenomenon in diagnosis.

Fibroma, cavernous angioma, and lymphangioma of the spleen have all been observed, but are all exceedingly rare. Carcinoma, so frequent secondarily in the spleen, is almost unknown as a primary growth. Litten says that there are ten primary cases recorded in literature.

Primary sarcoma is also very rare, secondary sarcoma of the spleen not very uncommon. A number of cases of removal of sarcomata of the spleen are on record.

The symptoms and diagnosis of these various tumors present no unusual features by reason of their occurrence in the spleen.

The treatment must be the removal of the organ. With the recent advances of surgery removal of the spleen has become much more frequent, and has been attended with much greater success than was formerly had. Splenectomy has, of recent years, been employed for the relief of two conditions, hemolytic jaundice and pernicious anemia, in which the relationship of the splenic enlargement to the cause of the disorder is not yet clear. In both conditions remarkable improvement has been said to follow the operation. For the details of the operation and its results one may refer to the elaborate articles of Jonnesco, Bessel-Hagen, Warbasse, Bolton, and Warren. From the standpoint of medicine the interest of splenectomy lies in the effects produced upon the organism by the operation, and the light which is thereby thrown upon the function or lack of function of the spleen.

Effects of the Splenectomy in Animals.—Ewing briefly summarizes the results of the work of several observers as follows: Splenectomy in animals is followed by moderate reduction in red cells lasting for from one to twelve months, by relatively greater loss of hemoglobin more slowly restored, and in some cases by the appearance, during the first year, of megalocytes. Leucocytosis follows the operation, but its extent and duration are very variable. A polynuclear leucocytosis is observed during the first days or weeks, followed by relative or absolute lymphocytosis during the first year, while during the second year distinct eosinophilia may be observed.

With these changes in the blood are associated marked cellular hyperplasia of the marrow, approaching at times that of leucemia, and often also affecting the lymph nodes. In the swollen nodes an excessive number of nucleated red cells have been found by Winogradoff, Tizzoni, Gibson, Komloff, and Grünberg.

Effects of Splenectomy in Man.—Ewing also gives a résumé of this subject. In comparatively healthy subjects splenectomy has often been performed without affecting the blood more than does any other laparotomy. In many graver cases the loss of blood and the shock of operation give rise to a considerable grade of secondary anemia. The red cells in favorable cases are restored in from one to three months, but in less favorable cases there may be more persistent anemia. The restoration of hemoglobin seems to fail behind the improvement in cells rather more than in most secondary anemias. The operation is usually followed by considerable polynuclear leucocytosis

(15,000 to 50,000) which commonly lasts from two to six weeks, but may continue for months, in which case the polynuclear cells may be largely replaced by lymphocytes. Eosinophilia has been observed in a few cases in the second and third years.

In traumatic cases suffering from large hemorrhages splenectomy, especially when complicated by infection, may lead to very profound anemia, marked by extreme loss of red cells, the presence of very many large, pale, sometimes polychromatic, and dissolving red cells, nucleated red cells, and to a high grade of leucocytosis. Among the leucocytes there may be a considerable proportion of large, pale mononuclear cells and myelocytes, so that the blood resembles that of acute leucemia. This condition, however, is transitory and the blood may improve rapidly.

Leucemia and amyloid degeneration of the spleen are contraindications to splenectomy. In other conditions the choice of operation may depend entirely upon the general condition of the patient. Beyond a moderate persistent leucocytosis or lymphocytosis, and possibly a slight delay in the restoration of hemoglobin, there are no specific effects of splenectomy in man.

It therefore appears that whatever the function of the spleen, the organ is not indispensable, and its functions may, in case of need, be performed by other parts or organs. The changes found in the bone marrow and in the lymph nodes of animals after splenectomy suggest that it is these parts that are called upon for extra work, and indicate in this way that the functions of the spleen must be, in part at least, those of the marrow and lymph nodes.

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Spondylotherapy.—This neologism was primarily employed in my book on this subject, the first edition of which was published in 1910. It referred to physiotherapy and pharmacotherapy of the spine based on a study of the visceral reflexes of Abrams.

Spondylotherapy was first interpreted as the exploitation of an exclusive system and it was identified with osteopathy and chiropractic. To make, confusion worse confounded, some so-called drugless healers exploited the term spondylotherapy to abet their exclusive methods of practice. In the preface of my book, an emphatic protest is made against exclusivism in medicine which is a composite practice and demands the employment of all the resources of science bearing on the treatment of disease.

Osteopathy which preceded the birth of chiropractic, is a system of anatomic abnormalities and their correction. "Its nosology is a lesion, its symptomatology, a subluxation." Chiropractic presumes disease to emanate from displaced vertebræ which pinch the spinal nerves. The spinal centers are referred to in osteopathic and chiropractic text-books "with a dogmatism and certainty begotten of beneficial results."

Spondylotherapy concerns itself only with the excitation of the functional centers of the spinal cord by different methods, which may be executed and demonstrated with the same certainty in the living subject as is done by the vivisectional experimentalist.

This phase of medicine, I have neologized as clinical physiology. Thus human, and not animal physiology, is made the basis of clinical physiology. In this way, one may disprove by clinical observations many apodictic data created in the laboratory. The pathology of spondylotherapy (referred to by J. Madison Taylor,[1] as reflexopathology) is founded on clinical physiology and its methods embrace the therapeutics of the reflexes. The committee on Standardization of the American Electrotherapeutic Association, reports (Sept., 1914) as follows:

> "In spondylotherapy the employment of mechanical vibration fills one of the most useful rôles in therapeutics. It is easily controlled and as practical and effective of application in the hands of those familiar with the methods of employing it as spinal percussion."

Each segment of the spinal cord must be regarded as a unit endowed with motor, sensory, vasomotor, trophic, and reflex functions with regard to the peripheral distribution of the roots of the nerves which emerge from and enter it. Man is essentially a reflex animal and even consciousness depends upon the action of the reflexes.

The physiologic mechanism designated as a reflex surpasses in its sensitivity any apparatus yet devised by human ingenuity and it was the utilization of the reflex which enabled the writer in a recent book[2] to demonstrate the electric nature of matter and to advocate supplanting the archaic cell-doctrine by the electronic theory.

Many reflex acts are so perfectly coordinated that one is constrained to believe that, in the spinal cord, there exists a subsidiary brain. All diseases are manifested by a direct and indirect symptomatology; the latter embrace the reflex symptoms. Pharmacology and physiotherapy are utilized in inhibiting or exciting reflexes to cure disease.

When the oculist contracts or dilates the pupil, he employs reflexes in treatment. Thus, in iritis, the most important remedy is atropine because, among other effects, the eye is put at rest owing to the factitious iridoplegia. Vasomotor pharmacotherapy is exhibited by the use of the group of nitrites for inducing vasoconstrictor paralysis, or the ergot group for effecting contrary results. Surgery has invaded a like reflexotherapeutic field in the treatment of spasticity by rhizotomy. Here, the object is to inhibit afferent impulses from the muscles which excite the cells of the anterior horns of the cord to send out excessive motor reflexes to the muscles.

The mechanism of a reflex is receptive, conductive (embracing nerve fiber and central cell), and effective (action of the peripheral organ). In medical

literature, I have repeatedly referred to certain visceral reflexes evoked by cutaneous irritation. The reflexes in question are endowed with more than mere physiologic interest. Such reflexes react on the viscera and the reaction may be utilized in a diagnostic and therapeutic direction. The evidence heretofore adduced in explanation of the results achieved by electric, hydriatic, mechanic, and balneary treatment of disease was naught else than a mere array of words conceived only in conjecture.

The visceral reflexes may be elicited from forces employed at the periphery or at a spinal center (over the segments or where the spinal roots emerge). Applied at the latter situation, the visceral reflexes are of greater amplitude and of longer duration. It is, therefore, evident that, in the treatment of disease by aid of reflexes, the elicitation of central reflexes is preferable.

In the spinal cord there are centers for the contraction and dilatation of the viscera. In the norm, these centers are in physiological antagonism. When neither reflex predominates a reflex equilibrium is established. The moment one reflex gains the ascendancy over its antagonist, the reflexes become disequilibrated.

Demonstration of the Visceral Reflexes.—Prior to the advent of roentgenology, the conventional physical methods were employed to demonstrate the visceromotor reflexes (contraction and dilatation of the viscera). The Roentgen rays have given a decided impetus to the recognition and acceptance of the visceral reflexes of Abrams. Lebon and Aubourg presented before the Société de Radiologie Médicale de Paris, comparative radiographs showing modifications of the large intestine, after stimulation of different vertebral spines by my methods. They had ascertained upon administering castor oil, then a bismuth suspension, and finally examining the subject with the *x*-rays, that electrical stimulation of the right vagus in the neck caused contractions of the ascending colon, sufficiently marked to be plainly visible on the screen at each excitation of the nerve. Similar stimulation of the crural or sciatic nerves produced little or no change in the colon. Vigorous percussion of the seventh cervical spinous process caused the cecum to rise and the ascending colon to become broader; such effects were observed in all persons examined excepting one—a woman with marked enterospasm and constipation. Percussion of the dorsal spines had no effect on the colon until the lowest ones were reached; percussion of these, or of the lumbar spines, brought about contractions of the colon in all its divisions.

Dr. Patrick S. O'Donnell and other expert roentgenoscopists have shown that, after the ingestion of the conventional bismuth meal, it takes approximately one hour and fifteen minutes for the stomach to void its contents, whereas after stimulation of the fifth dorsal spine, the stomach voids the bismuth in one and one-half minutes.

Snow[3] shows by a series of excellent skiagrams the diminished volume of the heart and aorta by stimulation of the seventh cervical spine, and observes; "The heart, aorta, stomach, liver, or spleen may be made to contract at the will of the operator, producing effects available for the correction of impaired functions. If the skilled practitioner will use vibration in cases to which it is applicable, he will be rewarded by results which cannot be attained by drug-therapy." A number of cases reported by Snow demonstrate the correctness of the latter conclusion.

Dr. George Jarvis, whose accuracy as an observer and skill as a surgeon are conceded, authorizes me to say that, in his research work embracing a new departure in surgery the publication of which is anticipated, in anesthetized subjects at the operating-table, the visceral reflexes may be elicited with a strong sinusoidal current (one electrode at the sacrum, and the other over definite vertebral regions) as described in Spondylotherapy. The stomach reflex is elicited (contraction of the organ) to approximately one-fourth of its original volume. Associated with the latter reflex is a marked anemia of the stomach. The gall-bladder reflex of contraction is likewise evocable.

The subjects were under narcosis with nitrous-oxide and oxygen, and in addition, in some instances, even scopolamine and morphine were used. When spinal anesthesia was alone employed, although visceral reflexes could be elicited, they were not as accentuated as under narcosis.

With the ophthalmoscope, bronchoscope, or cystoscope one may note that one can at will produce anemia or hyperemia of the retina, bronchial or vesical mucosa, by stimulation of definite spinous processes.

Methods.—For the purpose of stimulating or inhibiting the functions of the spinal segment or radices of the nerves, only brief mention can be made of the following methods in order of efficiency:

1. Concussion or percussion; 2. Electricity; 3. Pressure; 4. Freezing.

1. *Vibromassage or Mechanical Vibration.*—This has achieved some distinction as a remedial measure, but owing to its indiscriminate application without regard to physiological principles, most of the results attained by its use must be attributed to suggestion. The manipulation of definite vertebral spines corresponds with the elicitation of definite reflexes, but if the vertebræ are promiscuously handled counter-reflexes are evoked, which may often accentuate the reflexes in action and thus intensify the coexisting symptoms.

In the therapeutic elicitation of the visceral reflexes by spinal concussion the only kind of apparatus which is effective is one giving the percussion stroke; all other motions (oscillations, shaking, friction) interfere with the results. In other words, it is concussion or percussion and not vibration which is effective. The neurologist utilizes percussion and not vibration for eliciting the tendon reflexes and a like argument holds when the visceral reflexes are solicited.

In the absence of a reliable apparatus, effective results may be achieved by aid of a pleximeter and plexor; the former being placed in apposition with the vertebral spine and struck with the plexor. The results are even more effective with a pleximeter encroaching on both sides of a spinous process.

It must be emphasized that, in the employment of a stimulus, if the latter is too prolonged the visceral reflexes become exhausted and a condition other than that sought for ensues.

2. *Electricity.*—The sinusoidal current is used almost exclusively by the writer for evoking the visceral reflexes. Many of the sinusoidal machines on the market are such in name only and do not achieve the results. The method of application in general is to place one large electrode at an indifferent point (sacral region), and the other over definite spinous processes.

Practically all the tendon reflexes may be elicited by percutaneous application of a rapid strong sinusoidal current to definite spinous processes. The reflexes are bilateral, in contradistinction to the conventional cutaneoperipheral reflexes, which are unilateral. This centrotherapeutic application of stimulation will elicit tendon reflexes in some instances even though they are otherwise absent, and explains some of the immediate effects secured in locomotor ataxia and in poliomyelitis to restore nutrition of the implicated muscles.

By sinusoidalization of the skin over definite regions of the cortex, using an interrupting bipolar electrode, it is possible to obtain contractions of the muscles of the arms and face.

The galvanic and faradic currents, the interrupted low-tension current of Leduc, and thermopenetrating currents are of little or no value in the elicitation of visceral reflexes by vertebral excitation.

The high-frequency current, applied by means of a double vacuum electrode, to either side of definite spines, will elicit visceral reflexes of great amplitude and long duration.

3. *Pressure.*—Visceral reflexes may be excited by deep pressure at the vertebral exits of the various spinal nerves. Visceral pains and the pains of intercostal neuralgia may be thus inhibited by continuous pressure. Pressure is of great value in spondylodiagnosis. At one time, certain itinerant physicians won great renown in diagnosis by eliciting tenderness in definite vertebral regions based on a chart published by Dr. Sherwood in 1841. In 1834, the Griffin brothers, English physicians of prominence, sought to popularize vertebral tenderness as a diagnostic aid. My investigations show the importance of the latter observations, and a synopsis of the same is presented:

Disease	Points of greatest tenderness
Appendicitis	8th or 9th dorsal, or 2d lumbar, right side.
Bladder, rectum, and anus	1st to 3d sacral (both sides).
Cholecystitis	10th and 11th dorsal (right side) and tip of 11th rib.
Gastric disease	4th to 7th dorsal spines painful on pressure when lesion (like an ulcer) is located on lesser curvature between cardia and pylorus. At spine or side of 10th dorsal, lesion of the fundus. From 10th to 12th dorsal, lesion is at greater curvature close to pylorus.
Heart disease	3d to 6th dorsal, left side.
Ovarian disease	3d lumbar, on side of disease.
Renal affection	10th to 12th dorsal spines on side of disease.
Tubal disease	At or below 3d lumbar, on affected side.
Uterine disease	4th lumbar spine

Spondylodiagnosis.—(1) Electric current or persistent friction of the skin over tender area causes a red spot to appear. (2) Absence of typical painful points. (3) Accentuation of vertebral tenderness by manipulation of the suspected viscus. (4) Elicitation of dermatomes. (5) Segmental analgesia of the viscera. (6) Tenderness is superficial and if the skin is pushed to one side, deep pressure causes little pain. (7) Unlike tenderness of a spinal neuralgia, rubbing the part does not provoke a localized spasm of muscle. (8) In tenderness of visceral origin, there is no deformity nor rigidity of the vertebral column and movements are, as a rule, painless.

In a large number of cases examined by Dr. George Jarvis, with relation to vertebral tenderness in visceral disease based on the foregoing table, and corroborated surgically, the following conclusions are formulated; (1) In no case would conclusions based on the spondylodiagnosis have led one astray as to the organ involved; (2) Spondylodiagnosis alone does not usually yield a complete pathological diagnosis; but it does accurately point out which organ is involved and, in connection with other "clinical findings," permits of the greatest accuracy.

4. *Freezing.*—In the treatment of localized areas of vertebral tenderness, nothing in the experience of the writer exceeds cold as a remedial measure. The technique of psychrotherapy is fully described in my work on Spondylotherapy.

In trigeminal neuralgia, freezing is executed over the site of the Gasserian ganglion and over the two upper cervical vertebræ. Jarvis and Endelman,[6] observe that for promptness and efficiency, freezing is surpassed by no other therapeutic or operative method in the treatment of pain of dental origin, or any structure of the face innervated by the trigeminus. In postextraction pain, it is magical. Their conclusions are based on a series of 200 cases of trigeminal pain.

Comparison of Methods.—It is only possible in a general way to say what is the most efficient method for eliciting the visceral reflexes. Like all cells, the neurones do not react to the same stimulus. Weak stimulation as a rule increases, and strong stimulation decreases the activity of the cells.

Unfortunately few physicians are sufficiently skilled in physical diagnosis to determine for themselves the amplitude and duration of the visceral reflexes. Thus, in a patient with an aortic aneurysm, the following comparative results were obtained in eliciting the aortic reflex of contraction:

Method.	Duration of treatment.	Duration of reflex.
Concussion.	1 minute to 7th cervical spine.	12 minutes.
Rapid sinusoidal current	1 minute to both sides of same spine.	36 minutes.

Take again the normal stomach reflex of contraction and we have the following results:

Method	Duration of treatment.	Duration of reflex.
Slow blows directly to spinous process	One-half minute.	3 min., 35 sec.
Slow blows to both sides of spinous process	One-half minute.	16 minutes.
Slow sinusoidal current to both sides of spine	One-half minute.	8 minutes.

The vasodilator lung reflex employed by the writer in pulmonary tuberculosis may likewise be cited. The duration of the reflex refers to the duration of dullness and the stimulus is applied to the tenth dorsal spine:

Method.	Duration of treatment.	Duration of reflex.
Concussion	1 minute.	45 seconds.
Rapid sinusoidal current.	1 minute.	6 minutes.
Slow sinusoidal current	1 minute.	No result.
High-frequency current.	1 minute.	4 min., 10 sec.
Paravertebral pressure...	1 minute.	10 minutes.

When pressure exceeded one minute, the dullness was of short duration.

The reflexes are more easily exhausted by pressure than by any other method.

For discharging visceral reflexes, the rapid sinusoidal current is always more efficient than the slow current. With different sinusoidal machines one secures discordant results.

Pharmacological Methods.—Insomuch as adrenalin acts exclusively on the sympathetic, and pilocarpine on the autonomic fibers, these drugs are used by the writer as synergists to augment the amplitude of the visceral reflexes.

Physiology of Spondylotherapeutic Methods.—Physiologists are not in accord whether the spinal cord, like the peripheral nerves, reacts directly to stimuli. The clinician, however, has evidence to show that the spinal cord is excitable to direct stimulation.

Experiments show that most nerve cells discharge their motor impulses at a rate of about ten per second and if these cells are stimulated artificially the motor discharge is about the same rate as the normal. This reaction of the nerve cells is endowed with a definite rhythm which has been compared with the rhythmical beat of the heart. (At a meeting of the American Association for the Study of Spondylotherapy on Sept. 20, 1916, Planck exhibited a sinusoidal apparatus connected with a compressing armlet, thus enabling the current to be delivered rhythmically with each beat of the heart.)

Concussion.—This is a mechanical stimulus and is equivalent to a blow, pressure, pinching, or section. Concussion of short duration augments the excitability of the spinal segments or nerves, but when prolonged the excitability is diminished or abolished.

Sinusoidalization.—This is the equivalent of an electric stimulus. The rapid sinusoidal current is stimulating, whereas the slow sinusoidal current yields a series of electric shocks. In the application of the latter current to the spine, motor effects are only exceptionally observed, the action being limited to subduing the sensory component of a spinal segment.

Pressure.—This, when executed upon a mixed nerve, paralyzes the motor earlier than the sensory fibers. If the pressure is applied gradually, the nerve may be rendered inexcitable without demonstrating any evidence of its being stimulated. Pressure on a mixed nerve extinguishes reflex conduction sooner than motor conduction.

Freezing.—Notwithstanding a series of histological examinations made by myself to explain the rationale of this method as a remedial agent, no definite conclusion was attained. The leucocytic infiltration of the tissues which followed the freezing may possibly implicate the process of phagocytosis which in turn would suggest the infectious nature of many neuralgias in which affections, owing to the rapidity of action, freezing may be regarded almost as a specific. The initial contraction of the vessels and tissues is followed by a greater dilatation and turgescence. When the temperature is sufficiently low, the excitability of all the nerves is diminished, but the limited duration of the reduced temperature in psychrotherapy excludes this factor.

Therapeutics of the Reflexes.—*Heart Reflex.*—Attention was first directed in 1898, to the phenomenon now known as the heart reflex of Abrams.[6] This reflex which is easily demonstrated by percussion and the *x*-rays, has been confirmed by Zulawski, in Germany, Merklen and Heitz[7] in France, Sir James Barr and Sir Thomas Allbutt in England, and by notable investigators elsewhere.

In a communication by Cohen (May 24, 1915) to the College of Physicians, Philadelphia, forty-three illustrations were presented demonstrating the effects of concussion of the seventh cervical spine on the heart and aorta. He comments, "One of the phenomena that has been neglected by many who might be supposed to seek every means at their command to help those who come to them for relief is the heart reflex of Abrams." The reflex in question is a contraction of the myocardium of short duration in health (longer duration in myocarditis) and attains its greatest amplitude and duration by stimulation (usually concussion) of the seventh cervical spine. The heart reflex of contraction is of great diagnostic value. The murmurs in relative valvular insufficiency may be made to disappear temporarily by concussion of the seventh cervical spine which, by causing myocardial contraction, reduces the size of the cardiac orifices, thus enabling the valves to close the ostia.

In many instances, even in the norm, concussion of the seventh cervical spine may elicit a systolic murmur varying in duration from one-half to three minutes. The duration of a normal heart reflex is approximately two minutes; in myocardial disease it may persist for several hours. In the treatment of cardiac insufficiency, elicitation of the heart reflex, yields immediate results or none at all. My experience with this reflex in cardiopaths enables me to conclude that if in its elicitation no results are achieved, very little may be anticipated from cardiotonic medication.

The reflex just described is that of contraction but there is counterreflex, known as the heart reflex of dilatation, superinduced by concussion of the ninth to the twelfth dorsal vertebræ, or better still by concussion between the third and fourth dorsal spines.

Angina Pectoris.—In the form of this affection which I have called the cardiectatic variety dependent on cardiectasia, immediate relief frequently follows elicitation of the heart reflex of contraction but in the conventional variety, this reflex will accentuate the symptoms. In the latter variety, one may achieve results by evoking the heart reflex of dilatation.

When one irritates the nasal mucosa by various inhalations, etc., the heart reflex of contraction ensues. The value of amyl nitrite inhalations in the treatment of angina pectoris is universally conceded, but when this drug fails to bring relief, the failure may be attributed to irritation of the nasal mucosa which, by inducing the heart reflex of contraction, still further accentuates the paroxysm. In such instances and, in fact, in nearly all instances, the action of amyl nitrite is aided by previous cocainization of the nasal mucosa, which eliminates the irritant factor of the inhalations.

Functional Cardiac Neuroses.—These, if they are dependent on vagus hypotonia, are often amenable to treatment by concussion of the seventh cervical spine which acts by stimulating the vagus. If the neuroses are dependent on vagus hypertonia, equally good results may be achieved by stimulating the depressor nerve. The writer has empirically established the fact that stimulation of the latter is best effected between the third and fourth dorsal spines.

It is known that some functional forms of arrhythmia may arise from vagus stimulation, which not only shows the heartrate, but may also create irregularities in rhythm. By eliminating this vagus influence by the atropine test,[8] the irregularities will disappear thus demonstrating the neurogenic character of the arrhythmia or bradycardia. This test may be eliminated by pressure for one-half minute between the third and fourth dorsal spines which maneuver, like atropine, depresses the vagus action.

Hypertension.—In 1904[9] I directed attention to the fact that, hypertension is often a condition which is desirable and not to be opposed, insomuch as the vasoconstriction may compensate a failing heart. This viewpoint has since then been conceded. In such instances, vasoconstrictors are injurious and the correct course to pursue is to strengthen the heart and the blood-pressure will fall of its own accord. A single *séance* of concussion of the spinous process of the seventh cervical vertebra will at once reduce the pressure provided it is due to cardiac enfeeblement. When there is no cardiac enfeeblement, pressure may often be reduced by concussion between the third and fourth dorsal spines. At the latter point, we stimulate the depressor nerve. If, coincident with this stimulation, percussion of the lower abdomen is executed, areas of dullness caused by dilatation of the splanchnic vessels may be elicited. The physiologist knows that stimulation of any centripetal nerve augments blood-pressure and the essential factor in this reflex rise is

vasoconstriction of the splanchnic area. The only exception to the foregoing rule, is stimulation of the depressor nerve, which lowers pressure by dilating the splanchnic vessels.

The Splanchnic Circulation.—Many factors are concerned in hypertension and hypotension but the splanchnic vessels are practically ignored. The latter have the greatest effect on bloodpressure and the vessels in question are sufficiently capacious to hold practically the entire bloodvolume of the body.

It is many years since I first directed attention to the splanchnic circulation.[10] Since then, many writers have added to the literature on the subject, notably, Robt. T. Morris,[11] and more recently, A. B. Hirsch, in a communication to the College of Physicians of Philadelphia on Jan. 25, 1915.

The splanchnic circulation may cause hypertension or hypotension, more frequently the latter. In the former instance, cardioptosis is nearly always associated with a defective splanchnic vasomotor mechanism which causes cardiac enfeeblement, and to compensate the latter there is a constriction of the vasomotors which causes hypertension. In such instances, a forcible lifting of the abdomen during the time bloodpressure is taken will cause a fall in pressure. If hypotension is present, the latter maneuver will cause the pressure to rise.

Constriction of the splanchnic vessels may be attained by concussion of the fifth, sixth and seventh dorsal spines, whereas stimulation of the depressor nerve will cause the converse condition.

Aneurysm.—Since the writer reported[12, 13] forty cases in his own practice of thoracic and abdominal aneurysm symptomatically cured, the "Abrams method," has been extensively employed by others in this country whose reports may be found in the literature. No other adjuvant measure, not even rest, was employed. Snow's contribution[3] is specially interesting insomuch as a series of radiograms are shown illustrating variations in volume of aneurysms superinduced by elicitation of the aortic reflex of contraction (concussion seventh cervical spine). The Minerbis, of Italy, Houlie, in France, and other foreign writers have contributed to the literature on the subject.

After the lapse of years, the enthusiasm of my early reports has been modified by conservatism which enables me now to conclude that in early cases, the "Abrams method" is practically a specific, but in late cases all that can be achieved is a relief of symptoms, and that can be done more rapidly than by any other known method.

Exophthalmic Goiter.—In this condition, concussion of the seventh cervical spine is practically a specific. Even after a single séance of concussion one may note a reduction of the pulse from ten to thirty beats per minute, and likewise a diminution in the size of the struma. From many reports of physicians, the results have been practically uniform. The following is an excerpt of a letter from a physician who has successfully treated many cases: "It is only a question of time when physicians will and must recognize your specific treatment, and when it will be regarded as criminal negligence for the physician to invoke surgery before giving your method a trial."

Respecting the rationale of the method, the reader is referred to my work on Spondylotherapy and to a contribution in International Clinics, vol. iv., 22d series, p. 35.

Goiter.—Among many letters received from physicians, one question is paramount: Will concussion of the seventh cervical spine cure simple forms of goiter? The reply to this question may be given as follows: In goiters showing vascularity of the gland (soft and tender with systolic blowing or pulsation) there is some chance of reduction, but when there is fibrosis of the gland no results can be expected. Enlargement of the thyroid is frequently a compensatory phenomenon like kidney hypertrophy to compensate for the secretory deficiency of its fellow, or when polycythemia occurs in high altitudes to make the most of the deficient supply of oxygen. Similarly, the thyroid enlarges because it is required to supply itself with iodine conveyed to it by the blood. Here iodides or thyroid extract if given early prove curative.

Lung Reflexes.—The lung reflexes of contraction and dilatation may be elicited by stimulation of definite spinous processes. G. Auld,[14] in commenting on "The Lung Reflexes of Abrams," observes, "it was not, however, until recent years that anything like a satisfactory demonstration of the presence of bronchodilator, as well as bronchoconstrictor fibers in the vagus was made by Roy and Brown, and during the present year this seems to have been conclusively established by the work of Dixon and Brodie. But it undoubtedly stands to the credit of Abrams, to have proved, at least seven years since, by a simple clinical observation that the vagus must contain bronchodilator as well as bronchoconstrictor fibers." It is impossible to refer in detail to the value of the lung reflexes in diagnosis and treatment and we must be content with a consideration of the author's method of treating bronchial asthma.

Asthma.—The author's theory of asthma has been discussed elsewhere (Spondylotherapy, p. 309). By concussion or sinusoidalization of the fourth and fifth cervical spines, one may elicit the lung reflex of contraction and it is this maneuver which is employed by the writer in the treatment of essential asthma. This method may also be used to arrest a paroxysm. While my results are comparatively good, they do not tally with the enthusiastic reports from others who employ in preference the sinusoidal current; one electrode over the spines of the fourth and fifth cervical vertebræ and the other electrode over the sacrum. Perhaps the climatic conditions in San Francisco may have much to do with my results. Owing to the enfeeblement of the bronchial musculature in asthma some time may elapse before results are achieved and, until that time has arrived, it is necessary to employ a palliative for the relief of the patient.

Cardiac Asthma.—This may be confounded with bronchial asthma but concussion of the seventh cervical spine by inducing the heart reflex of contraction should inhibit the paroxysm, but will accentuate it if of bronchial origin.

Stomach Reflexes.—The stomach reflex of contraction elicited by stimulation of the spines of the first three lumbar vertebræ is of undoubted value in the treatment of motor insufficiency of the stomach. Concussion of the fifth dorsal spine will dilate the pylorus. This fact has been utilized for the following purposes: (1) To relieve pylorospasm; (2) to facilitate rapid absorption and hasten the elimination of nauseous drugs from the stomach; (3) to eliminate the action of the gastric juice on drugs destined for action on the intestinal tract; (4) in the treatment of gastric affections; (5) to aid duodenal intubation.

In my method of duodenal intubation, the ordinary stomach tube will pass directly into the duodenum during the time pressure is made at the fifth dorsal spine. Cardiospasm may be overcome by sinusoidalization between the third and fourth dorsal spines.

Intestinal Reflexes.—That of contraction (stimulation of first three lumbar spines) is utilized in the treatment of atonic constipation and the reflex of dilatation (stimulation of eleventh dorsal spine) in spastic constipation. Since using my method of duodenal intubation, I have found that stimulation of the tenth dorsal spine will augment the pancreatic secretion. The pains of a duodenal ulcer may be precipitated by opening the pylorus which permits of the passage of chyme. Augmentation of the pancreatic secretion

by the method cited will arrest the pains of a duodenal ulcer as such maneuver alkalinizes the chyme.

Authorities are practically agreed that the passage of a tube beyond the sigmoid flexure is impossible. By pressure at the eleventh dorsal spine which dilates the sigmoid flexure, colonic intubation is possible.

I have recently investigated the action of vertebral concussion on the appendix and found by fluoroscopic examination (bismuth subcarbonate previously ingested) that concussion of the tenth dorsal spine empties it and that concussion of the first lumbar spine will dilate it. I have already utilized the foregoing maneuver with excellent results in several cases of chronic appendicitis.

Concussion of the twelfth dorsal spine contracts the cecum. This latter observation is of importance in bearing on the recent observations of Reed[15] concerning the etiology of essential epilepsy.

Liver Reflexes.—These consist of contraction and dilatation of the organ. The former is utilized in the treatment of hepatic toxemia and is likewise available in intestinal autointoxication. Contraction and dilatation of the gall-bladder may be attained by vertebral stimulation over definite spinous processes.

Splenic Reflexes.—The splenic reflex of contraction is employed in the treatment of splenomegaly. In latent malaria, one may precipitate a typical paroxysm by discharging the splenic reflex of contraction (concussion of the second lumbar spine). It is assumed that the occurrence of the latter is due to the mechanical extrusion into the circulation of the plasmodia which have lodged in the organ. In suspected malaria, one may find plasmodia in the blood after inducing the splenic reflex of contraction even though absent before this maneuver is executed. Concussion of the eleventh dorsal spine enlarges the spleen.

Examinations of the blood made for me by a competent hematologist (Alfred Roncovieri, M. D.) developed the following: (1) Average increase of erythrocytes after concussion of the eleventh dorsal spine only, 300,000; (2) average percentage increase of hemoglobin after concussion of eleventh dorsal spine only, five per cent.; (3) average increase of leucocytes after concussion of second lumbar spine only, 2,800; (4) average increase of red cells after alternate concussion of second lumbar and eleventh dorsal spines, 650,000; (5) average increase of hemoglobin after the latter (alternate concussion), ten per cent.

Therapeutics of Miscellaneous Reflexes.—*Gynecological.*—The uterus reflex may be discharged by stimulation of the first three lumbar spines. Sinusoidalization is the preferable stimulus. The degree of uterine contraction is determinable by palpation or directly through a speculum. An anemia of the uterus accompanies the contraction and elevation of the ovaries. Chas. L. Ireland, M. D., comments as follows: "I will say that up to one year ago I had always contended that when an ovary was prolapsed, surgery was the only recourse and I had good reasons for so thinking. By the use of the sinusoidal current to provoke the uterus reflex, absolute cure resulted in nine cases, *i.e.* reposition of the ovaries ensued." In a later communication Ireland prefers stimulation of the tenth, eleventh, and twelfth dorsal vertebræ for the reduction of prolapsed ovaries.

Dislocated uteri without adhesions are amenable to the same treatment.

Uterine hemorrhage, relaxed vagina, and rectocele are amenable to treatment by spondylotherapy.

In agalorrhea, concussion or sinusoidalization of the third and fourth dorsal spines, will after three or four treatments stimulate the mammary glands to normal activity.

Several of my students engaged in obstetrical practice contend that during labor, one may demonstrate paravertebral points of tenderness corresponding to the lumbar vertebræ and that pressure over these areas will in most instances either mitigate or arrest the pains and thus contribute to painless labor.

Dr. D. V. Ireland contends that by concussion of the twelfth dorsal spine he has in several instances restored a movable kidney to its normal position.

Vasomotor Reflexes.—Vasoconstriction of the blood-vessels is best attained by stimulation of the seventh cervical spine and vasodilation, by stimulation at the tenth dorsal spine. These effects may be observed with the ophthalmoscope and bronchoscope. In one case seen with Marie, in Paris, in an individual with a defect in the cranium, contraction of the meningeal vessels could be directly observed during concussion of the seventh cervical spine.

The vasomotor reflex of contraction has been utilized in various ways, notably in the control of hemoptysis (sinusoidalization), migraine (angioparalytic form), urticaria, etc. Thus, Dr. Myer Solis-Cohen refers to the instantaneous relief secured by concussion of the seventh cervical spine in a severe case of urticaria following the use of diphtheria antitoxin; itching and rash quickly evanesced. Cohen used the same method of treatment successfully in a rebellious case of migraine.

Dr. Hugo Summa and Louis Schreiber recently presented before the Ophthalmic Society of St. Louis a patient with corneal ulcers of many years' duration which had resisted treatment by many competent oculists. Acting on the theory that, by provoking the vasomotor reflex of contraction, not only would contraction of the vessels ensue but likewise augmented tone, concussion of the seventh cervical spine (séances daily) resulted in cure within one week.

Bladder Reflex.—Contraction of the wall of the bladder and its sphincter may be observed with the cystoscope when stimulation of the fifth lumbar spine is executed. The bladder reflex may be utilized in atonic conditions of the bladder musculature.

Prostate Reflex. Stimulation of the twelfth dorsal spine with a strong rapid sinusoidal current causes a reduction in the size of the prostate. With the finger palpating the gland during the action of the current with an interrupting electrode, this effect may be observed provided the stage of active parenchymatous and muscular hyperplasia has not been succeeded by an overgrowth of fibrous tissue. Results in treatment (provided the latter is not present) are immediate, irrespective of the stage of prostatism.

Thymus Reflex.—This has been utilized by the writer in the treatment of pertussis, and the reflex is invoked by concussion of the seventh cervical spine. According to numerous reports received from physicians throughout the United States, this method of treatment has arrested the paroxysms in from three to seven days. In the latter reference, the substernal dullness noted by me in pertussis was ascribed to an aortectasia but since the writer's method of defining the thymus gland has been perfected,[2] the paroxysms of pertussis are referred to hypertrophy of this structure.

Albert Abrams.

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Sponge.—(*Éponge fine*, Codex Med.) The household articles known by this name are the horny or silky skeletons of several species of invertebrate animals belonging to the order *Ceratosa*, in the great group *Parazoa, Spongiozoa*. The commercial sponges are colonial in their life-relations, although the outlines of individuality are very obscure. They are soft, porous, gelatinous bodies perforated by numerous openings communicating with irregular, ramifying cavities within them, as well as with digestive and respiratory chambers, and more or less regular tubes or canals. These minute chambers are lined with flagellated cells, which are probably the organs of nutrition as well as those by whose movement a constant stream of water is kept flowing into the sponge through the fine pores and out through the large openings. Sponges are all aquatic, and those of commerce all of marine origin, growing upon rocks or other firm foundation, at a depth of from six to a hundred or more feet below the surface of the water. They are of slow growth, requiring from three to six years to attain a useful size. The mode of collection varies with the depth at which they are found, as well as with the habit and outfit of the collector; sometimes they are torn off the rocks by tongs or hooks, sometimes dredged for, but more generally they are gathered by divers from boats; these again may go down unprotected for three or four minutes at a time, or, equipped with modern diving-suits, make longer and deeper searches. Finally, the cultivation of sponges by fastening bits upon boards or sticks, and then sinking them to the bottom, has been proved practicable. When the sponges have been brought to land they are rubbed with sand or bruised to break up the soft parts, or exposed to the air until decomposition sets in, and then repeatedly washed and squeezed until they are clean and dried. Upon being marketed, they are carefully trimmed and assorted, according to kind, fineness, size, and shape, into numerous grades.

There are several distinct kinds, dependent upon the species producing them:

1. The *Levant* or *Turkey Sponge*, from *Euspongia* (*Spongia*) *officinalis* Linn., the finest and most expensive of all, from the waters surrounding the Grecian Islands, Asia Minor, Syria, etc. It has a soft, fine, very elastic texture, a light color, and great toughness of fiber. In shape it is rounded, tuberculated, lobed, hemispherical, cup-shaped, or irregular; it is very free from its gelatinous flesh when prepared for the market.

2. The *Zimocca Sponge*, from *Euspongia zimocca* O. Schmidt; also a fine, strong, valuable sponge, but harsher to the feeling than the preceding, and not nearly so expensive.

3. The *Mediterranean Bath Sponge*, from *Hippospongia equina* O. Schmidt; in large, soft, rounded masses, with a loose texture and very large reticulating canals.

Besides these, this country is supplied in great abundance with cheap sponges from the West Indies; they are very inferior in texture and durability to the Mediterranean products: they are:

4. The *Reef Sponge, Euspongia officinalis tubulifera* the common, cheap, fine "slate sponge." It is coarser, less elastic, and very much more tender than the Turkey sponge, and is of more or less conical shape, with a broad, cut base.

5. The *Sheepswool, Velvet*, and *Grass Sponges*, from various species of *Hippospongia*.

Composition.—Sponges contain a considerable quantity of fine sand, and sometimes pebbles, entangled in their meshes, which can generally be removed by mechanical means; there is also a varying amount of calcareous concretions or fragments, which stick more tenaciously and often have to be dissolved by dilute acid. These being removed, the remainder is nearly all a peculiar elastic, durable, nitrogenous substance called *spongin*, closely related in composition and texture to silk. Besides this, there are a little iodine, bromine, salt, etc.

Uses.—These are mostly mechanical, and familiar to every one. Carbonized sponge, *Spongia usta*, now obsolete, used to be given for the same conditions for which iodide of potassium is now used, and owed its value to the presence of that element.

In surgery, sponges were for a long time used for packing and dilating cavities, and as absorbers of blood in operations, but the general acceptance of aseptic methods in surgery has caused them to be looked upon less favorably than formerly. For surgical operations the fine, soft, Turkey sponges, though dear, are the best.

Sponge tents, now but little used, are made by soaking fine, tough sponge in melted cacao butter, or in mucilage or alcohol, and winding very hard to a cylindrical shape with strong twine; when dry or cold the cord is removed and the surface is filed or pared to shape.

Ether sponges are fine Turkey sponges of large size, requisite fineness, and of a regular cup-shape. No inhaler has yet been made so safe or comfortable to the patient as these, but they are wasteful of ether.

W P. Bolles.

Spokane, Washington.—This city of 121,000 inhabitants is situated in the extreme eastern portion of the state, about midway between the northern and southern boundary. It has an elevation of about 1,900 feet above sea-level, and lying east of the Cascades and west of the Rocky Mountains, represents a different type of climate from that of the Puget Sound district described under "Seattle."

The principal climatic characteristics are given in the following table.

As is seen in this table, the climate of Spokane is a dry one with a small rainfall, a comparatively low relative humidity, and a very considerable range of temperature throughout the year. It is always to be remembered that a dry climate is never equable. In variations of temperature Spokane resembles such places as Boston, New York, or Chicago, as will be seen in the chart under "Seattle." It can occasionally be very cold in winter and very hot in summer. "The transitions from cold of winter to heat of summer," says the local Forecaster, "or *vice versa*, occurs gradually by comparatively small changes of mean daily temperature from day to day. Sudden violent changes of temperature seldom occur here." "The topography of the country surrounding Spokane," continues the same authority, "is well adapted to give to this place its peculiar climate. Situated in eastern Washington at an elevation of about 1,900 feet above sea-level, and about midway between the Cascades and Rocky Mountains, Spokane is near enough to the vast Pacific Ocean to be under its climatic influence to a great extent. While the Cascade range intercepts precipitation from the northern Pacific coast that might otherwise be excessive, and the mighty range of the Rocky Mountains to the eastward and spurs to the northward of Spokane deflect far to the eastward of this place the intensely 'cold wave' that yearly comes from the extreme north and pours down along the eastern slope of the Rocky Mountains into middle, eastern, and southern portions of the United States."

The prevailing winds are from the southwest, which temper the cold of winter and the heat of summer. "The place has a remarkable freedom from violent winds." Thunder storms are rare.

Although the rainfall is small, 18.85 inches for the year, there is a very considerable number of cloudy and partly cloudy days, and the percentage of sun-

Spokane, Washington, Lat. 47° 40′ N.; Long. 117° 25′ W. U. S. Weather Bureau Observations.

	Jan.	Mar	May.	Aug.	Oct.	Dec.	Spring	Summer.	Fall.	Winter.	Annual.
Temp. degrees Fahr.—											
Average or normal	27°	39°	56°	68°	47°	31°	48°	66°	48°	29°	48°
Mean of warmest	33°	48°	68°	83°	59°	37°	58°	80°	58°	36°	58°
Mean of coldest	20°	30°	45°	54°	33°	26°	37°	53°	33°	23°	38°
Av. daily range	13°	18°	23°	29°	26°	11°	21°	27°	25°	13°	20°
Highest or maximum	55°	74°	95°	104°	86°	57°					104°
Lowest or minimum	−30°	−10°	29°	38°	12°	−18°					−30°
Humidity											
Average relative, per cent.	84	66.5	57	44.5	65.5	84	60.5	46.5	67	82	65.3
Precipitation—											
Av. in inches	2.3	1.51	1.62	0.5	1.51	2.62	4.1	2.7	4.7	6.8	18.85
Wind—											
Prevailing direction	S.	S. W.	S. W.	S. W.	N. E	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.
Weather—											
Clear											97
Partly cloudy											112
Cloudy											156
Percentage of possible sunshine	22	52	61	72	48	18	57	73	52	25	52

shine is only moderate, lower annually than that of Boston, New York, or Chicago, and but little higher than that of Seattle in winter, but considerably higher in the other seasons of the year.

The average death rate in 1911 was 13.51 per 100,000, and the four most frequent causes of death were organic diseases of the heart, cancer, tuberculosis, and pneumonia. The health department is efficient, and there is inspection of bakeries, markets, restaurants, and the milk supply. The water supply is from wells and is distributed by means of pumping stations. Analysis shows it to be exceedingly pure, "passing through miles of sand and gravel it becomes perfectly filtered." It is also abundant. There are 139 miles of sewers, and the drainage appears to be adequate. There are numerous parks and playgrounds.

Spokane is a very rapidly growing city, and it is on the line of many railroads running in various directions. With an efficient health department, a pure water supply, a low death rate, and a dry climate, living conditions in Spokane are both wholesome and agreeable.

Edward O. Otis.

Sporozoa.—A class of protozoans which includes a somewhat heterogeneous assemblage. All agree, however, in being parasitic and in forming spore-like reproductive bodies. Many important diseases, such as malaria, are caused by these parasites. See *Protozoa.*

A. S. P.

Spring Lake Well.—Ottawa County, Michigan.

Post-Office.—Spring Lake. Hotel. Cottages.

Spring Lake is reached by electric roads from Grand Rapids, Muskegon, and Grand Haven, by Grand Trunk Railway, and the Pere Marquette Railroad; also by the Goodrich Transportation Company's boats from Chicago to Grand Haven and thence two miles by boat or electric railway to the resort. The town is located on a beautiful sheet of water of the same name, eight miles long and about half a mile wide. The resort owes its rise to the citizens of Chicago, who frequent it in considerable numbers (Walton).

The Magnetic Mineral Springs are located in the main grounds to the left of the hotel. The following analysis of the water from these springs has been made by Professor C. Gilbert Wheeler:

One United States Gallon Contains:

Solids.	Grains.
Potassium chloride	4.2880
Sodium chloride	405.5330
Calcium chloride	113.4200
Magnesium chloride	36.2000
Sodium bicarbonate	0.9537
Calcium bicarbonate	0.1808
Iron bicarbonate	1.0060
Magnesium bicarbonate	0.0640
Manganese bicarbonate	0.0647
Magnesium bromide	2.1700
Sodium sulphate	16.7000
Silica	0.5030
Alumina	Traces.
Lithia	Traces
Total fixed residue	611.0832
Temperature 50° F.	
Specific gravity	1.0094

Emma E. Walker.

Sprue.—*Synonyms:* Psilosis, Tropical diarrhea. Sprue is a dysenteric condition occurring with greatest frequency in tropical countries. It is characterized by the passage of voluminous, frothy, putty-colored, sour-smelling stools; very marked flatulence giving the abdominal wall a parchment-like appearance; an inflammatory condition, atrophy, and finally denudation of the mucous membrane of the alimentary canal, this process being most intense in the mouth and small intestine; a decrease in the size of the liver; and a marked tendency to relapses and fatal ending.

Sprue has always been regarded as essentially a tropical disease and very few observers have mentioned it as occurring elsewhere. Carnegie Brown[1] is about the only writer who still holds to this idea. He would limit the distribution of sprue to Asia and India. This position, however, in the light of cases reported in recent years by observers undoubtedly capable of diagnosing the condition correctly, is untenable.

History.—E. J. Wood[2] has recently collected, and in a paper presented before the Association of American Physicians, May, 1915, gives a remarkably full history of reported cases of sprue in the United States, and it is to his article that I am indebted for most of these data. The disease was first mentioned in America in the writings of John Brickell[3] in 1737. The first account of any accuracy was the study of Hillary in the Barbados in 1776, using the term "Aphthoides Chronica." And the description he gave

at that time has been little changed in the light of more recent studies.

Following Hillary, Twining in 1835, Grant in 1854, and Cunningham in 1877, all writing from India, described cases of sprue, noting it as a peculiar form of diarrhea. It was not, however, until 1880 that the disease was clearly defined by Manson, at which time he gave it the name it now bears. In the same year, working independently of Manson, Van der Burg described the disease under the term "Indische Spreuw." In 1881 the Lettsomian Lecturer, Fayrer, described it under the name of "Chronic White Tropical Diarrhea." Since that time sprue has occupied a rather definite place in the literature concerning tropical diseases. Possibly one of the best early papers is one mentioned by Rogers[9] in his monograph on dysenteries, that of Goodeve, of the Calcutta Medical College, writing in 1870, in which he describes the disease under the terms "Chronic diarrhea, white flux, cachectic dysentery." The term psilosis was first introduced in the nomenclature by Thin in 1883.

The earliest cases reported occurring in the Southern States are those of Graham,[4] of Savannah, who in 1905 reported four cases which had originated in Georgia. Graham had become familiar with the disease in the Philippines.

In 1907 Harris,[5] of Atlanta, reported several cases of sprue and although he was inclined to doubt his diagnosis, when Searcy, of Alabama, in the same year reported pellagra, yet the picture Dr. Harris outlines in many of his cases is a true sprue picture, and Wood quotes him as stating in a personal communication that there exists in Georgia many cases exactly corresponding with accepted descriptions of sprue; so it is highly probable that Dr. Harris was correct in his first diagnosis and that many of his cases were sprue. In 1911 Simon,[6] of New Orleans, reported a case of sprue. In 1912 Wood[7] in his monograph on pellagra mentions the incidence of sprue in the States, but does not add any cases. In 1914,[8] in conjunction with Allan, of Charlotte, the author reported five cases which he had observed. Three of these cases were from Porto Rico, two from China, and one was in a native North Carolina woman who had never been outside of her State. The comparatively recent recognition of pellagra and its consequent rapid spread over the entire country makes the serious consideration of sprue very timely.

Etiology.—Sprue seems to have a seasonable incidence, waxing and waning periodically. Rogers[9] shows that sprue is most frequent in the tropics just after the rainy season and is rarest in the dry cold months of the year. There have been too few observations in the United States to reach any definite conclusion relative to the periodicity in this climate. However, the few cases we have observed would seem to indicate the spring months as the periods of greatest incidence. So far as age and sex are concerned, Rogers, out of forty-seven cases, had none below ten years of age, the greatest number of patients being from thirty-one to forty years old; the next from twenty-one to thirty. While Rogers reached the conclusion that there was little difference in the occurrence between the two sexes, Bahr,[10] in his investigation in Ceylon in 1915, reached a different conclusion; he says "among the Europeans the majority, nineteen out of thirty-six cases occurred in females; which, taking into consideration the disproportion, two to one of European males to females in Ceylon, denotes a special liability of the female sex to the disease.

The etiology has, since the time of Manson's first description, been a source of great controversy. Castellani and Lowe advanced the protozoan theory, basing their claims upon the very long course of the disease, the eruption on the tongue and mucous membrane of the mouth, the anemia and the chromatin bodies they found in the red cells. They think the point of entrance through the intestinal canal. Thin and McFadden advanced the bacterial theory, but this did not receive much attention. Very early in the history of sprue the Dutch and French observers advanced the fungus theory. Begg[22] is probably the most staunch supporter of the helminthic theory and based his treatment (yellow santonin ad nauseam) on this hypothesis. His work, both as to cause and treatment lacks confirmation.

The most recent work on the etiology of sprue has been by Bahr in Ceylon and Ashford[18] in Porto Rico. These two observers, working independently, reached the conclusion that sprue is due to a Monilia, but differ in the species they found. Quoting from Bahr's article,[10] he says, "Kohlbrugge in 1901 found in the intestinal mucus, in the lymphoid patches of the intestinal canal, in the epithelial covering of the tongue and of the esophagus great broods of yeast cells which he regarded as being the positive organism and resembling *Monilia albicans*. His results have been partially confirmed by Le Dantec." Against the fungus theory, Castellani and Lowe, while they admit that fungi are found with extreme frequency in the mouth and intestines of sprue patients that live in the tropics, claim the same fungi may be found in the stools of healthy people and in people suffering from other diseases; that fungi cannot be considered the true etiological agents in this disease because they represent secondary infections; further they say that by giving large doses of sodium bicarbonate these fungi can be made to disappear from the stool and the frothy character does not manifest itself, although the disease will continue. Bahr meets these objections by showing that these yeast cells occur intracellularly in the scraping of the tongue lesions early in the disease, but at a later stage can only be found in the deeper layers of the tongue; that the desquamation of the cells and the subacute inflammation of the tongue and esophagus are changes that occur from the growth of an organism of a lower order of virulence; further that the general infection of the intestinal mucosa was found in sprue autopsies, but no such general infection was found in other conditions. Bahr rather conclusively proves that the yeasts are the responsible factor in sprue and sums up his conclusions in the statement: "There is no evidence in favor of the sprue yeast fungus being otherwise than identical with the thrush fungus, *Monilia albicans*, an organism possessing a very low pathogenic power, but it is possible that along certain unknown conditions more or less peculiar to the tropics this power may become greatly augmented." Major Ashford reaches practically the same conclusion regarding the responsibility of the yeast, but finds a Monilia that has not heretofore been described.

Ashford[18] summarizes his findings biologically as follows: (1) A Monilia, not heretofore described, and of undetermined species is apparently found constantly in cultures from inflamed tongue or feces of persons suffering from sprue in Porto Rico. (2) This Monilia has been found in the center of a cooked loaf of bread baked in an endemic zone. (3) This Monilia has been found in certain cases of fermentative disturbances of the intestines in which the complete picture of sprue is not developed. (4) The Monilia is found in only three per cent. of persons apparently entirely healthy, or at least free from any gastrointestinal disturbances. (5) The complement-fixation test is positive for all of the reduced number of cases of complete sprue in which it has thus far been applied and negative for several times that number of persons without sprue. (6) This monilia is not only productive of mycotic septicemia in small laboratory animals injected with virulent cultures but will produce severe and intractable mycotic ulcers in their tissues when

they are relatively immunized to the extent of preventing a mycotic septicemia."

Pathology.—The pathology of sprue has unfortunately been very little studied. Begg in his monograph gives a rather exhaustive account of autopsy findings. He does not, however, add anything new to the subject. Most writers on the subject have confined themselves to a few brief statements. The most striking pathological fact is the great loss of all fat. As Bahr says, these all present external appearances of a chronic starvation and practically all the organs weigh about half the normal. One of the cardinal features of a sprue picture is the diminution in the size of the liver. In Bahr's cases the liver showed both fatty degeneration and symptoms of a beginning yellow atrophy. Bahr does not mention the pancreas, but others have reported it as being atrophied and there is, as pointed out above, an absence of pancreatic activity. The heart shows nothing particular except the general atrophy. Bahr reports the finding of a Gram-positive hyaline body, non-acid-fast, in the endothelial cells of the smaller veins of the spleen and failed to find these same bodies in twenty-five spleens in which death occurred from other causes. He regards them as a degenerative product and possibly characteristic of sprue. The intestinal canal shows the most marked picture. This consists of a thinning of the mucosa, an atrophy of the villi and tube glands, small round-celled infiltration with patches of chronic venous congestion. There are small ulcers and often denudation of areas, the mucous membrane being replaced with fibroid tissue. There is much glary mucus present.

The urine, as a rule, shows nothing particularly abnormal. The saliva is acid. The blood picture is usually that of a secondary anemia. The stool, which is the most characteristic part of the pathology, is described below under Diagnosis.

Diagnosis.—There has been in the past considerable debate as to the position occupied by sprue. There have been many claims that it was not a definite clinical entity; it has been confused and identified with pellagra and many other tropical and subtropical conditions in which there was as the most prominent feature a persistent diarrhea. Stuart[11] and Burnett[12] and more particularly Musgrave and Jackson[13] are of the opinion that it is not a disease entity. Jackson regards it as a manifestation or a complication of many of the diseases of warm climates which are characterized by a diarrheal process. Burnett and others[14] are more inclined to regard it as either a part of the clinical pellagra picture or as a "pellagra sine pellagra." This state of affairs has resulted from the fact that there comes from each writer a different description as to its most salient features; and further from the lack of an uniformity in nomenclature. It is in many places synonymous with hill diarrhea—a position wholly without ground. Even Manson gives Cochin-China diarrhea as a synonym; Osler, Stiles, and others regarding this term Cochin-China diarrhea as meaning an infection with the *Strongyloides stercoralis*.

Regarding the identity of sprue and pellagra I see no reason to confuse the two diseases. They have in common sore mouth, diarrhea, secondary anemia, and loss of flesh and strength. There are many other diseases that have the same, notably true chronic gastritis and intestinal phthisis. Sprue has none of the nervous skin, uterine, vaginal, and rectal symptoms of pellagra; while on the other hand pellagra is not characterized by the marked and essential distention that accompanies sprue and usually not by the early morning type of diarrhea found in sprue. The stools in the two conditions are entirely different, both in gross appearance, in chemical composition and microscopically. The pellagra stool is large liquid, but is composed of food remains hurried through the alimentary tract. The intimate admixture of fine bubbles of gas, the intense acidity, and the characteristic picture of partially split fat is entirely absent. The pellagra stool is frequently accompanied by tenesmus, blood, and mucus, which is seldom if ever seen in sprue. The color of the sprue stool is uniformly white, due to the presence of leucobilirubin; it is described as being "putty colored," and is large and voluminous. None of these characteristics are found in the pellagra stool. The chemical difference in the stools in the two diseases depend mainly upon the establishment of pancreatic activity. This is lost seemingly in practically all cases of sprue and has so far not been reported lost in pellagra. P. H. Bahr[15] found that fat absorption varied from seventy to eighty per cent. and there was an entire absence of pancreatic ferments. Pratt and Spooner[16] tested out the pancreatic function in a case of sprue with the Einhorn-Schmidt thymus test and with a Sahli glutoid capsule and found pancreatic insufficiency uniformly. Myers and Fine[17] found fat utilization good in the series of pellagra cases they tested out. Wood reports pancreatic findings in several cases of pellagra.

The microscopical picture of the stool in sprue in mainly one of partially split fat and fat droplets. There are few food remains seen; in fact, one sees little of anything except fat in the sprue stool. In the pellagra stool this is notably absent and there are seen many food remains, mucus, and very often blood.

Treatment.—In the treatment of sprue a great number of remedies have been recommended, such as potassium chlorate with morphine and bismuth, powdered cuttle-fish bone, colloidal silver, phenyl salicylate (salol), betanaphthol, mercuric chloride, cyllin and izal (cresol preparations), acetozone, and ipecacuanha. A few years ago Begg brought forward yellow santonin as a specific remedy, but Rogers, Manson, and Castellani, working in India, have all failed to confirm Begg's results, and Ashford[24] working in Porto Rico, says, "Santonin, therefore, if it has any such specific action as that intimated by Begg, does not seem to be superior to a carefully supervised diet, especially a milk diet."

Rest in bed is obviously essential. The use of any drug as a specific is at present purely empirical. Moderate use of alkalies seems rational. In severe cases the exclusive meat diet, or exclusive whole milk diet seems irrational. The fruit diet is simply a monosaccharid diet, and this in conjunction with skimmed milk seems to be the best diet to use in severe cases. For a full discussion of the various diet cures the reader is referred to the work of Manson[21] or Castellani and Chalmers on Tropical Diseases.

The advent of cold weather, particularly cold nights, has apparently been of greater benefit than any other single factor. Houston B. Hiatt.

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Spurzheim, Johann Christoph.—Born at Trèves, on the Moselle, in 1775. He received the degree of Doctor of Medicine at Paris in 1820. Previous to this time, however, he had been associated with Gall in the publication of a large treatise on the anatomy and the functions of the nervous system—a book in which the latter author develops his ideas with regard to the new science of phrenology. After receiving his medical degree he went first to England and then to America, where he died in 1834. The title of the book referred to above is the following: "Anatomie et physiologie du système nerveux en général, et du cerveau en particulier, avec des observations sur la possibilité de reconnaître plusieurs dispositions intellectuelles et morales de l'homme et des animaux, par la configuration de leurs têtes," by Gall and Spurzheim, Paris, 1809. Of the few books published independently by Spurzheim, it will suffice to mention here only one, as follows: "Observations sur la phrénologie, ou la connaissance de l'homme moral et intellectuel, fondée sur les fonctions du système nerveux," Paris, Strassburg, and London, 1819. A. H. B.

Sputum is the term employed to designate the portion of the expectoration that is derived from the trachea, bronchi, and their ramifications. It is sometimes used to include the secretions from the upper air passages, and even to include the saliva and buccal secretions; it is better, however, to employ the term expectoration to designate the collective material discharged from the mouth and to use the term sputum in the restricted sense above indicated.

For its *collection*, special receptacles are provided. The simple paper spit-cups are inexpensive and convenient; there are also metal cups adapted for carrying in the pocket. For the hospital ward a simple porcelain cup is much used. The principle to be observed in disease is that all the expectorations shall be collected and disinfected or destroyed by burning. This is particularly important in the case of tuberculous sputa, the dried particles of which are so apt to become mingled with the dust in the air and infect those who inhale them. The cup used in the sick-room should contain disinfectant, such as solution of carbolic acid or corrosive sublimate. Specimens for laboratory examination should be collected without disinfectant solution, advantageously in a clean wide-mouth bottle.

The *amount* of the sputum in health is very small, scarcely more than a few cubic centimeters in twenty-four hours, while in disease it may increase up to 1,000 c.c. or more. The amount and character are dependent on the nature and extent of the disease process, a fact which renders observations of the sputum of value in clinical practice.

As regards *appearance*, sputa, if homogeneous, are recognized as mucoid, purulent, serous, or sanguineous for reasons which these terms suggest. Most sputa, however, are admixtures of two or three of these types and are designated accordingly; *e.g.* the mucopurulent sputum in many cases of bronchitis.

The consistence varies from liquid to extremely tenacious, according to the amount of mucus; serous and hemorrhagic sputa and purulent sputum, when composed of pure pus, are liquid, while a pure mucoid sputum exhibits a high degree of tenacity.

The *color* of sputa is subject to great variation. If mucoid in character, they are transparent and nearly colorless; when the number of leucocytes is considerable, they are opaque, yellowish, or, in case of nearly pure pus, greenish at times from the presence of the *Bacillus pyocyaneus*. This latter color may also be imparted by bile pigment in icterus and in perforation of a liver abscess into the lung; if the abscess is amebic, the sputa have the color of anchovy sauce; unchanged blood imparts various degrees of reddish coloration, which may be characterized as rusty, prune-juice, bright or dark red, according to the condition; methemoglobin, hematin, and hematoidin formed by decomposition of the hemoglobin, impart colors varying from bread crust to chocolate or brownish red. Sometimes decomposed blood gives a greenish or yellowish hue.

Pure mucoid, serous, or sanguineous sputa are usually without *odor*, but where there is admixture of purulent products a slightly sweetish odor is observed; while in sputa containing pure pus and products of putrefactive decomposition a fetid odor is present, sometimes exceedingly offensive.

Chemical tests are occasionally applied to sputum to determine the relative amounts of mucin and albumin. *Mucin* is estimated from the amount of reducing substance (glucosamin) formed when the protein constituents are hydrolyzed with acid. The procedure is to add to the sputum two volumes of alcohol, shake and filter through a hardened filter paper, washing with alcohol. The precipitate is removed from the filter, boiled with ten per cent. hydrochloric acid for three hours in a flask with a return condenser, neutralized with NaOH, acidified with acetic acid and protein matter precipitated with phosphotungstic acid, the filtrate being brought to a known volume and reducing substances determined with Fehling's solution, the calculation being the same for glucosamin as for glucose. Mucin is calculated on the basis of 33.6 per cent. content of glucosamin. To test for *albumin*, the sputum is well mixed with three per cent. acetic acid and after standing for some time filtered and to the filtrate potassium ferrocyanide solution added. The precipitate formed indicates the amount of albumin. Where exact quantitative determination is desired, the filtrate may be rendered nearly neutral, sodium chloride added, the albumin coagulated by heat, filtered off and weighed. Albumoses may be tested for in the heat filtrate by the biuret test or may be precipitated by saturation with zinc sulphate, collected on a filter, washed with zinc sulphate solution and the quantity determined from the nitrogen by Kjeldahl.

In general, mucin indicates hypersecretion and albumin, an admixture of inflammatory exudate. Accordingly, the former is practically alone found in chronic bronchitis while in tuberculosis a distinct trace of albumin will accompany the mucin. Much albumin is present in pneumonia and pulmonary edema.

Macroscopic examination may be conducted by observing the material, spread in a thin layer, either between glass plates or in a petri dish, against a dark background. In this way fragments of lung tissue, elastic fibers, fibrinous casts, spirals, and particularly the cheesy masses of tuberculosis and actinomycosis may be observed. For the recognition of spirals and casts of the bronchi it is also of service to observe the sputum when suspended in a considerable quantity of water.

Microscopic examinations are conducted: (*a*) By the direct examination of selected portions under the microscope, a procedure particularly valuable in examinations for crystals, the various epithelia, and for pus. (*b*) By the examination of the sediment ob-

tained by centrifugalizing the sputum after it has been diluted with an aqueous solution of sodium hydroxide (about two- or three-per cent. strength), and warmed.

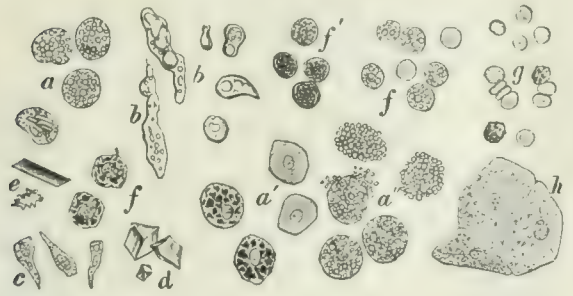

Fig. 4636.—Cells and Crystals of the Sputum. *a*, Alveolar epithelia; *b*, myeline drops; *c*, ciliated epithelia; *d*, calcium carbonate crystals; *e*, hematoidin; *f*, leucocytes; *g*, red blood corpuscles; *h*, squamous epithelia. (Magnified.)

This sediment is especially adapted for the detection of elastic fibers. (*c*) By the examination of stained smears, which may be prepared as follows (W. H. Smith): Smear a selected portion thinly and uniformly on a cover-glass, fix by heat (passing through the flame three times without burning), cover with aniline-gentian violet, heat to steaming, wash off with Gram's iodine solution, cover with the solution and steam, decolorize as much as possible with ninety-five-per-cent. alcohol, wash a few seconds in alcohol-ether, wash in water, stain for a few seconds in strong aqueous eosin, wash with Löffler's methylene-blue, cover with this, steam, decolorize slightly with ninety-five-per-cent. alcohol, wash in absolute alcohol, then in xylol,

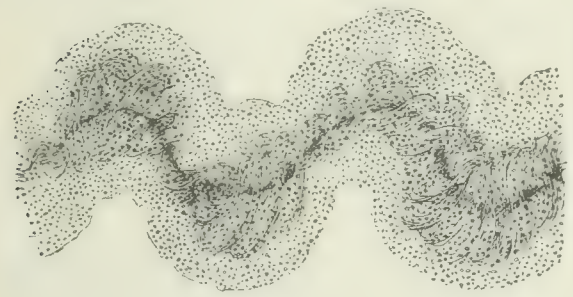

Fig. 4637.—Curschmann's Spirals. (Magnified.)

and mount in Canada balsam. In this preparation red blood corpuscles, cell protoplasm, eosin granules, cilia of epithelial cells, and capsules of bacteria are stained red, nuclei blue, Gram-staining bacteria black or deep violet, and Gram-decolorizing bacteria blue. Tubercle bacilli are not differentiated. (*d*) By the examination of smears stained for tubercle bacilli. In conducting this process by the direct method, the sputum should be examined in a thin layer against a black background and cheesy and purulent particles selected. These are smeared on glass slides, being spread by the pressure of the end of a second slide applied at right angles, fixed by heat and stained as described below.

A method of enrichment of the material has been described by Uhlenhuth and modified by Löffler, the technique of which is as follows: a mixture of equal quantities of sputum and fifty per cent. solution of antiformin (ten per cent. sodium hypochlorite containing five to ten per cent. sodium hydroxide) is boiled for not more than fifteen minutes. To every 10 c.c. is now added 1.5 c.c. of a mixture of chloroform one part and alcohol nine parts, the whole thoroughly emulsified by shaking, transferred to appropriate, tubes and finally centrifuged. The film just above the chloroform is removed to a slide, after decanting the supernatant liquid, any excess of fluid being absorbed on filter paper, this is spread and stained as in the direct method.

The time-honored method of staining is that of Ziehl-Neelsen. The smear is covered with carbol-fuchsin solution (ninety parts of five per cent. carbolic acid water and ten parts of a concentrated alcoholic solution of fuchsin), and is steamed but not boiled over a low flame for one to three minutes; it is washed by swilling in fresh water and decolorized by flooding with a two and one-half per cent. solution of sulphuric acid in ninety-five per cent. alcohol until only a very faint pink color remains in the smear. It is again washed in water and finally counterstained with Löffler's methylene-blue (30 c.c. of a saturated alcoholic solution of methylene-blue and 100 c.c. of a 1 to 10,000 aqueous solution of potassium hydroxide) for a few seconds, washed with water, and dried in the air, hastened by shaking. Tubercle bacilli appear under the oil immersion, using cedar oil, as bright red rods, more or less curved, occasionally branched and often staining irregularly, giving a beaded appearance. Clumps in which the rods are crossed or parallel often appear.

An entirely different effect and a very serviceable stain may be obtained as follows:

Solutions: 1. Three per cent. alcoholic solution of crystal violet. 2. One per cent. aqueous solution of ammonium carbonate. 3. Ten per cent. solution of nitric acid (C. P.). 4. Ninety-five per cent. alcohol. 5. Saturated alcoholic solution of Bismarck brown added to water to make a tincture of iodine color.

Procedure: cover smear with a mixture of one part of 1 and three parts of 2 and alternately steam over Bunsen flame and cool three times, wash by swilling in water. Cover with 3, wash, cover with 4 and again wash, repeating the alternate treatment till the specimen is colorless. Cover with solution 5 for three minutes, dry, and examine under cedar oil with immersion lens. Tubercle bacilli stain violet with a brown background.

Abscess.—When the abscess empties itself through a bronchus there is likely to be a considerable quantity of liquid, purulent sputum with a more or less offensive odor. This same periodicity in the appearance of pus is observed in empyema and bronchiectasis, but elastic fibers, which are present in abscess, are usually absent in these conditions. Crystals of cholesterin, fatty acids, leucin, tyrosin, or hematoidin may accompany the large number of pus cells; the blood pigment, if intracellular, probably indicating some previous hemorrhage, if free a discharging abscess from a neighboring organ. In hepatic abscess, bile pigment or *Ameba coli* may be present, and the sputum may be in part mucoid or watery. The presence of hooklets of *Tenia echinococcus* or ova of *Distoma pulmonale* or *Distoma hematobium* indicates infection with these parasites.

Actinomycosis.—The presence of the ray fungus in small (one-tenth to one-fortieth inch in diameter), round, yellowish masses, glistening and granular in appearance, is pathognomonic of the pulmonary seat of this disease. They are not always to be found. The general characters of the sputum are those of a chronic putrid bronchitis.

Asthma.—The amount of the sputum varies. It is apt to be more copious at the end of the attacks, and to be viscid, mucoid, and whitish, or pink from blood. Its occurrence in small pear-like masses is quite characteristic. Unfolded, these masses are seen to be Curschmann's spirals, which are more common early in asthma than in any other disease, and aid in differ-

entiating true asthma from the reflex type. Charcot-Leyden crystals are almost constantly present; eosinophiles are usually numerous, and free eosin granules may be present. The condition of eosinophilia is in general a manifestation of increase of autonomic tone and the occurrence of these cells in the sputum is evidence that the asthma is a local vagotonia. Occasionally leucocytes and epithelial cells are found which contain yellow and brown masses of pigment, probably derived from the blood.

Bronchiectasis is accompanied by copious, intermittent expectoration which may be odorless, but ordinarily has a rancid fetor, different from that of gangrene, is apt to be darker in color than in simple bronchitis, oily in consistence, has a tendency to form nummular masses appearing like coins (Dittrich's plugs), and casts of the minute bronchial tubes. Pus is usually present, and crystals of hematoidin, cholesterin and fatty acids, and Charcot-Leyden crystals may be found. Unless there is ulceration (abscess formation) elastic fibers are absent. Occasionally the sputa contain inspissated or even calcified portions.

Acute Catarrhal Bronchitis.—In the early stages the sputum is scanty and mucoid or seromucoid. Later, it becomes more abundant and mucopurulent, sometimes sanguineous, the change in character often being accompanied with a fall in temperature. After the lapse of two weeks the expectoration may take on the character seen in chronic bronchitis. When the bronchial capillaries are especially involved in the disease process, there is less admixture of air, and consequently a tendency for the sputa to sink in water; when the disease is limited to these smaller bronchial tubes the sputa may be scanty or absent. Microscopically, the mucopurulent sputum contains many pus cells, eosinophiles and ciliated, cuboidal, or alveolar epithelia, according to whether the larger or smaller bronchi of the alveoli are involved. The bacteria present usually include one or more of the pus organisms, and when the disease is secondary to some infective disease, *e.g.* influenza or typhoid, they may include the specific agent of this infection as well. Diphtheria bacilli are usually not present in the bronchitis which sometimes accompanies this disease.

Chronic Catarrhal Bronchitis.—The sputum is extremely variable, that of the dry type of the disease being scanty and perhaps occurring as tough pellets of mucus, while the expectoration of the moist type is more abundant, sometimes copious, and either serous (thin) or purulent (thin or thick) in character. The purulent secretion is commonly yellowish green in color. Microscopically there is commonly little of interest to be seen; numerous pus cells, a variable number of epithelia, usually cuboidal, bacteria, and ordinarily one or more of the various pus organisms, are present. In rare instances the fetid odor of the sputum justifies us in characterizing the disease as *putrid bronchitis.* The sputum is then usually thin, whitish, and may contain the yellow, dirty masses the size of peas which come from the smaller bronchi and are known as Dittrich's plugs. Microscopically these may contain fatty acid crystals, degenerated epithelia, spirals, and Charcot-Leyden crystals. Fetid sputum more frequently denotes bronchiectasis, gangrene, abscess, phthisical cavities, or empyema.

Plastic Bronchitis.—This is characterized by fibrinous masses, the recognition of which in the sputum forms the only means of diagnosis. If they come from the larger bronchi they do not necessarily present any recognizable form, but when they come from the smaller tubes they appear as casts, corresponding to the ramifications of the tube. In the sputum they may be mere spherical masses more or less obscured by the mucus and pus, but when floated in water their true character may be recognized. Their presence should be suspected whenever expectoration is accomplished by severe effort. In the acute process the sputum, aside from the presence of the casts, is much like that of acute catarrhal bronchitis. Curschmann's spirals and Charcot-Leyden crystals may be present. The chronic form of the disease is even more likely to be overlooked, as the fibrinous masses are more apt to be masked by the other constituents of the sputum, which presents the ordinary features of that which belongs to chronic catarrhal bronchitis.

An empyema that discharges into the bronchi gives rise to purulent sputa which may have an offensive odor. They differ from the sputa of bronchiectasis in the absence of oily appearance, mucous admixture, fatty acid crystals, and fibrinous casts of the minute tubes. The prevailing infecting agents are the *Streptococcus pyogenes* and the pneumococcus, the former being more frequent in children. The presence or absence of tuberculous infection is of importance.

Gangrene of the lung announces itself by a horribly fetid odor, less pungent than that observed in bronchiectasis. The sputum is apt to be tinged with blood, the color often suggesting prune juice, but being at times chocolate-colored from the development of

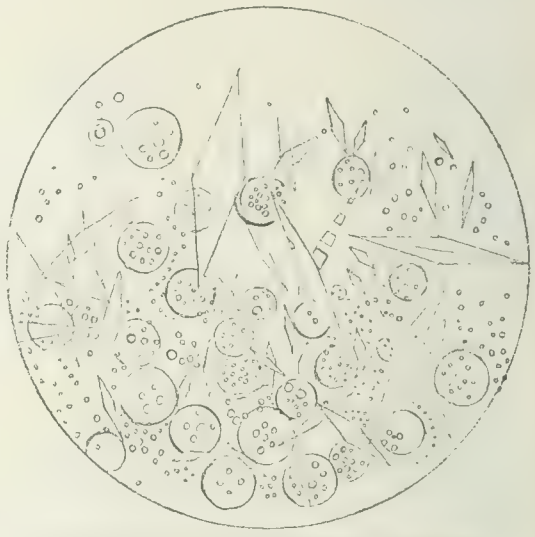

Fig. 4638.—Charcot-Leyden Crystals. (Magnified).

hematoidin when the sputum is retained for some time before being discharged. It is frothy, in part liquid, in part mucopurulent, and may contain small portions of gangrenous lung, dark or greenish in appearance. The débris from the lung tissue does not always contain elastic fibers, as they apparently pass into solution under the strong solvent action of the ferments present. Putrefactive bacteria abound, and forms belonging to the other groups of fungi may be present. Even infusoria of the monad and cercomonad varieties are sometimes observed; they occur as minute, yellowish, slowly moving droplets. Robinowitsch in one case observed a bacillus not identical with, but morphologically resembling, the tubercle bacillus.

Active Hyperemia of the Lungs.—The sputum is characteristic, being serous, not infrequently slightly sanguineo-serous, clear, containing the serum proteins in solution, and, in contrast to other sputa, having a high specific gravity (1.025–1.045).

Passive Hyperemia of the Lungs.—As this is accompanied by a chronic catarrhal bronchitis, the sputum presents the characters of that disease plus two additional features induced by the chronic hyperemia, namely, the presence of blood pigment, which may be in all stages of alteration, and many alveolar epithelia containing hematoidin crystals.

Influenza.—The pulmonary invasion is characterized by the presence in abundance of the specific bacillus in the sputum. This is a small, short, Gram-negative bacillus, 0.5 micron by 0.2–0.3 micron, usually single, showing polar stainings so as to sometimes appear as a diplococcus. It is stained by severing the smear for five minutes with dilute (1:10) carbol-fuchsin solution. Bismarck brown may be used for a counterstain. Early in the acute stage it will be found free in the sputum, but later it is found only in the pus corpuscles. The clinical manifestations are those of bronchitis, either acute or chronic, or of bronchopneumonia. It may be a secondary invader in lobar pneumonia and even in phthisis. The general characters of the sputum, aside from the presence of the influenza bacillus, are in general those common to the particular clinical type of the disease, though in pneumonia it is bronchitic rather than pneumonic in character. When isolation of the bacillus is desired, the following method of W. H. Smith may be employed: A small portion of the fresh sputum is suspended in sterile bouillon, and one loopful of this bouillon is spread evenly over the surface of an agar slant; then a second drop is likewise spread on an agar slant, the surface of which has been smeared with human blood. The influenza bacillus does not grow on the first agar slant, but appears on that which is smeared with human blood—after remaining at 37° C. (98.6° F.) for forty-eight hours or less—in the form of minute colonies, frequently unrecognizable without a lens, and showing in smear preparations the morphology of the influenza bacillus. Stain by floating for five to ten minutes in carbol-fuchsin, one part diluted with twenty of water.

Malignant Neoplasms.—The character of the sputa depends upon the condition which may be produced in the lung by the disease process—*i.e.* upon the bronchitis, bronchiectasis, edema, ulceration or gangrene, that may be present. It may contain lung débris, including pieces of the neoplasm, and may present peculiar appearances, sometimes resembling red currant jelly, while in some forms of sarcoma it appears bright green.

Catarrhal Pneumonia.—In this disease the sputum is less characteristic than in lobar pneumonia. It may present the character of the expectoration of an acute bronchitis, with which the disease is frequently associated, or it may be scanty and mucoid. It may be tinged with blood, generally an unfavorable sign, but it has not the characteristic sanguineous character seen in lobar pneumonia. Mixed infection being the rule, more than one organism is to be expected in the sputum, though early in the disease the primary agent, most commonly the pneumococcus, streptococcus, staphylococcus, or the pneumobacillus, in the order named, is the only or chief intruder. Bronchopneumonias, which are pulmonary complications in specific diseases, are apt to have the organism causing the disease as the primary agent, and accordingly this organism appears in the sputum; but the specific organism may be a secondary invader.

Croupous Pneumonia.—During the first twenty-four hours the sputum may be wanting, or it may consist only of small mucoid masses. In the stage of red hepatization it presents pathognomonic characters, appearing "rusty" from blood and being exceedingly viscid and tenacious. This is sometimes replaced by a coloration ranging from a yellow to a green, more frequently during resolution; due to different oxidation products of hemoglobin. The greenish coloration may be due to a coincident jaundice; when due to delayed resolution, the possibility of a tuberculous condition should be considered. As regards the quantity of the sputum, as much as from 100 to 300 c.c. is commonly raised in a day. Microscopically it shows red blood corpuscles in all stages of degeneration, alveolar epithelia, which are in large number in desquamative pneumonia, and sometimes small fibrinous casts. The stained smears show the infecting organisms if they are the exciting cause of the disease, the pneumococcus appearing as a Gram positive, slightly elongated conical or lance-shaped coccus, which shows a marked tendency to occur in pairs with the broader ends in apposition. It may occur in short chains resembling streptococci. It is usually enveloped by a hyaline zone or capsule which ordinarily need not be stained for identification. Friedlander's bacillus (*B. mucosus capsulatus*), usually a secondary invader, may occasionally cause the pneumonia. It is a Gram negative, encapsulated bacillus. The presence of the pneumococcus in abundance is presumptive evidence of the disease, and is an especially valuable indication in central pneumonia. The sputum is to be watched for complications. A sudden increase of serous fluid indicates edema; a large quantity, dark brown in color, perhaps with elastic fibers, indicates necrosis; while a copious purulent discharge points to the existence of an abscess or a bronchiectasis and the fetid character to gangrene.

Pneumonoconiosis is usually recognized from the characteristic expectoration. The general nature of the sputum is that due to the associated condition, viz., chronic bronchitis, or chronic interstitial pneumonia with its usually copious, mucopurulent, or seropurulent sputum, not infrequently hemorrhagic and sometimes fetid, or tuberculosis. The inhaled dust particles may be free or may be lodged within the leucocytes or mucous and epithelial cells. In anthracosis the color is so dark as to lead to the characterization "black spit;" in siderosis the oxide-of-iron color is seen; while in chalicosis the condition is recognized by the angular particles of silica seen under the microscope; and in amylosis the starch granules are similarly detected, being blue stained with iodine, if desired.

Pulmonary Tuberculosis.—In the acute miliary form, as in early acute bronchitis, the sputum is scanty and mucoid, tubercle bacilli usually not being found, certainly not till softening of the tubercles occurs. In acute pulmonary phthisis tubercle bacilli may be present in enormous numbers, the expectoration being rusty and then mucopurulent, and containing elastic fibers when a process of softening has set in; these features and the presence of the tubercle bacilli constituting the marks which distinguish the disease from ordinary pneumonia. In chronic phthisis the expectoration is variable, the variations in its amount and nature from time to time giving some indication of the activity of the disease. Its heterogeneity is characteristic, some portions being but slightly purulent, others yellowish, purulent, and forming nummular with here and there cheesy masses and possibly even calcareous particles. Microscopically, the important features are the tubercle bacilli and elastic fibers, together with the presence of the purulent organisms that are secondary invaders. Occasionally Curschmann's spirals are present. Nuttall estimates that four billion individual tubercle bacilli may be present in the expectoration in twenty-four hours. Lartigau states that only from ten to fifteen per cent. of those present are ordinarily alive, and that dead bacilli alone may be present and persist in the sputum for weeks. It is generally believed that the forms that take the stain irregularly, presenting a beaded appearance from the presence of unstained spaces, are attenuated in their virulence. E. E. Smith.

Squill.—See *Scilla.*

Stable-fly.—*Stomoxis calcitrans*, is a biting fly which resembles the common house fly somewhat in general appearance. It is easily distinguished, however, by the long proboscis. This fly has been suspected of carrying poliomyelitis and pellagra, but nothing has been proven in this connection.
A. S. P.

Stafford Mineral Spring.—Jasper County, Mississippi.

Post-Office.—Vosburg. Comfortable hotel.

Access.—Via the "Queen and Crescent" route to Vosburg, thence one mile and a half southeast to spring.

The Water is a Calcic Magnesic Bicarbonated Water and Contains per 1,000,000 Parts

	Parts.
Silica	29.5
Sulphuric acid radicle	9.01
Bicarbonic acid radicle	194.87
Nitric acid radicle	None.
Nitrous acid radicle	Trace.
Phosphoric acid radicle	0.033
Chlorine	5.64
Bromine	Trace.
Iodine	0.013
Iron	1.41
Alumina	0.06
Calcium	59.68
Magnesium	2.84
Potassium	0.71
Sodium	5.17
Ammonium	0.031
Oxygen to form Al_2O_3	0.05
	309.017

Sanitary analysis:

Free ammonia	0.031
Albuminoid ammonia	0.022
Nitrogen as nitrates	None.
Nitrogen as nitrites	Trace.
Oxygen required	0.230
Gases:	
Carbon dioxide (free)	7.41 c.c

Radioactivity in 1.000 c.c. water.
Radioactivity in 0.00114 Absolute Electrostatic Units.
Radioactivity in 1.14 Mache's Units.

Bacteriological Examination

The water contains:

Bacteriæ grown on agar-agar at 37.6° C. in 1 c.c.	3-2-2 cols.
Acid forming bacteriæ in 1 c.c.	None.
Fermentation tests for B. Coli Communis	
in 10 c.c.	Negative.
1 c.c.	Negative.
1/10 c.c.	Negative.

Hypothetical form of combination.

	Parts per Million.	Grains per U. S. gallon.
Ammonium chloride	0.091	0.005
Potassium chloride	1.353	0.079
Sodium chloride	8.150	0.475
Potassium iodide	0.017	0.001
Sodium sulphate	5.170	0.302
Magnesium sulphate	1.200	0.070
Calcium sulphate	6.400	0.373
Calcium phosphate	0.108	0.006
Magnesium bicarbonate	17.060	0.995
Calcium bicarbonate	234.05	13.653
Iron (ferrous) bicarbonate	4.490	0.263
Alumina	0.110	0.006
Silica	29.500	1.720
	307.699	17.948
Carbon dioxide free	7.41 c.c.	1.7 cu. in.

The location is a romantic one, surrounded as it is by Indian mounds and relics, and shaded by graceful and towering gums, sycamores, poplars, and pines. The Choctaws gave the name of Bogohama ("Water of Life") to the spring; hence it is inferred that they used it for medicinal purposes. Its properties have been known to the whites, however, only during recent years. The many natural advantages of the spot in the way of charming scenery, salubrious climate, and mineral waters serve to make it a popular spring resort. The foregoing analysis of the water was made by Froehling and Robertson:

The analysis shows a very good calcic magnesic bicarbonated water, with ferruginous properties. It is well adapted for table and domestic use. The water has tonic and diuretic properties, and ought to be useful in the diseased or disordered conditions to which this class of waters is applicable. It has been found to render excellent service in Bright's disease of the kidneys and in diabetes, bladder disorders, and other conditions. The water is bottled and sold throughout the United States.

Emma E. Walker.

Stammering and Stuttering.—See *Speech Defects*, page 816.

Staphisagria.—Stavesacre U. S. The dried ripe seed of *Delphinium staphisagria* L. (fam. *Ranunculaceæ*), without admixture of more than two per cent. of foreign matter.

This seed is derived from a handsome annual or biennial species of larkspur, native of the South European countries, Asia Minor, etc., and also cultivated. The seeds are imported from the south of France and Italy. They were known to the ancients, and for twenty centuries have been used for about the same purpose as at present—killing pediculi and similar vermin.

Description.—About five to seven millimeters (one-fifth to one-fourth inch) long and nearly as broad, flattish-tetrahedral, one side convex, another small and opposite to a pointed extremity, the edges rather acute; brown, gray brown, or sometimes blackish, strongly and coarsely reticulate-wrinkled, containing a whitish, or becoming gray brown, oily perisperm and a small, straight embryo; nearly inodorous; taste very bitter, acrid, and somewhat biting.

Composition.—The seeds contain about twenty-five per cent. of a non-drying fixed oil, and about one per cent. of alkaloids, occurring mostly in the shell, of which the following have been isolated and named: *delphinine*, in fine, large crystals; *staphisagrine*, amorphous; *delphinoidine*, also amorphous; and *delphisine*, in crystalline tufts. Of these, the first is the most important and active, the second least so, while the third and fourth resemble the first, but are weaker.

Action and Use.—Stavesacre is an active and poisonous drug, irritant to the skin and mucous membranes, causing itching, stinging, burning, sneezing, etc., as well as diarrhea and vomiting. Of the alkaloids, delphinine best represents the drug; rubbed into the skin, this causes local inflammation, on the tongue burning and numbness, in the stomach nausea and distress, and, when absorbed, cardiac and respiratory slowing, diminished spinal irritability, and sometimes mental disturbance. The others resemble delphinine, but are less intense. Delphinine reminds one of both aconitine (to which it is botanically related) and veratrine. Staphisagrine is somewhat peculiar; it is not very active, but appears to resemble curare in its action upon striped muscle.

Neither the crude drug nor its alkaloids are given internally; so its exact action has but little practical bearing. It has from a remote time been employed, either by itself or in ointments or other vehicles, solely for the purpose of killing pediculi and related animal parasites, on man and animals. At the present time it is mostly consumed in veterinary practice, kerosene or petroleum, petrolatum, sulphur, and

Unguentum hydrargyri taking its place in human medicine. An ointment can be made with twenty per cent. or so of the powdered seeds, or with from one-half to one per cent. of the alkaloid. The ten per cent. tincture is largely employed for the destruction of scalp vermin.

Larkspur seeds, the product chiefly of *Delphinium consolida* L., and produced in Europe, are almost identical in constituents and properties with stavesacre. They were formerly official in the United States Pharmacopœia, and tincture of larkspur is a very popular application for head lice. They are several times smaller than stavesacre seeds, of about the same form, but with sharper angles and markings, and usually of a jet black color.

Henry H. Rusby.

Starch.—See *Amylum.*

Starvation.—This word means primarily death from complete deprivation of food and water, and secondarily the state of the individual which precedes and leads up to such death. For this state, however, other descriptive words exist, such as fasting, abstinence, and inanition. The *condition* of starvation might be defined as one in which abstinence has been so protracted that while the subject is still living he is no longer able to assimilate food. Such cases have often occurred and one in point, is to be found in Taylor's Medical Jurisprudence. Fasting is voluntary abstinence from ingesta as distinguished from involuntary abstinence. Inanition clinically denotes failure of assimilation as a result of disease.

In an article of this scope it is manifestly out of the question to discuss a subject like simple fasting, whether in mankind or in animal experiment. A vast body of data has been published on fasting metabolism, and the physiopathology of a fasting state which is not carried beyond certain limits. Neither can space be given to the feats of professional fasters, to the unsatisfactory accounts of fasting girls or to therapeutic fasting. Incomplete abstinence from food or extreme underfeeding, such as occurs in famines, and abstinence as a result of disease processes of various kinds, are also subjects which can receive no more than a brief mention.

A distinction between death from want of food and death from want of water cannot be absolute. After some days of deprivation from water a subject can no longer take or digest food. On the other hand, a subject with access to water can dispense with food for a variable number of days and under favorable conditions for very long periods.

If human subjects or animals abstain completely from food, we should not speak of them as starving. We do not so characterize a hibernating animal, whose winter sleeps lasts for months without food or water. The animal is really consuming its own tissues (autophagy) which it has accumulated in advance for the purpose. All its vital functions proceed in the usual manner save that they are almost inconceivably slow.

Acute starvation is most simple when studied in certain small animals in which the finds are fairly constant. Thus without water a pigeon starves in 4 or 5 days. With water and without food it will live 12 days. A guinea-pig will survive 6 days, a rabbit 12, etc. This brief survival of small animals is due to the low nunciated by Richet that the smaller the animal, the more rapid its combustion and the greater the degree of dehydration by the lungs. To this law there are exceptions. Thus a dog will live from 30 to 40 days and in very exceptional cases about twice as long. This is due very largely to the fact that the animal does not perspire, and thus does not become dehydrated. In mankind, as in the dog, the period of survival varies much. A premature infant has been known to survive 7 weeks without swallowing. A normal, well-balanced man can barely survive 20 days, presumably with allowance of water. Insane subjects now and then survive for almost incredible periods with the aid of water. Richet seriously suggests that professional fasters are abnormal mentally. The most celebrated of these, Merlatti, survived after a fast of 50 days. Accurate figures concerning the survival of mankind deprived of both food and water and under tranquil conditions are not available, but 10 or 12 days is the duration recognized in forensic medicine. These figures imply that the subject must be strong, well nourished, and in the prime of life.

Some authorities accept as authentic an experiment made upon a fakir who remained for 30 days in a state of autohypnosis without ingesta of any kind. Richet credits only a similar case lasting 8 days. In regard to hysterical and lethargic subjects everything depends upon the rapidity of combustion. Richet studied lethargy or hypersomnia in two hysteroepileptics, and in one of these the respirations averaged but eight in 36 minutes. With such slowing of combustion, protracted survival without ingesta could well be expected. No tests on these subjects are mentioned. Debove, however, hypnotized subjects, suggesting that food would be unnecessary. The subjects remained in the sleep for 15 days, not only without ingesta of any kind, but with little loss of weight.

In contrast with experimental starvation, the clinical form presents a relatively confused picture. The victims may have been lost in the woods or desert, stowaways on ships, miners or others locked in, and the like. These subjects may at the same time have been exposed to extremes of heat or cold. Frantic at the hopeless outlook, they make prodigious efforts to escape. They may have access to substances containing a little nutriment, or foul water, which technically make the abstinence incomplete. Dampness or moisture in the air, bathing in sea water, tend to mitigate thirst. These subjects cannot survive long but the real causes of death may be exposure and exhaustion or air hunger along with subtotal abstinence.

Chronic starvation, so called, is likewise a complex picture. This is seen notably in a series of diseased states in which there is some form of interference with alimentation or nutrition. Some of these are stricture of the esophagus, diabetes, Addison's disease. In its simplest form it is seen in infantile marasmus in which despite ingestion of aliment the child wastes away. Death following underfeeding is a most unsatisfactory condition to analyze, because other factors may be present either to bring about or accelerate a fatal termination. We can speak of pure chronic inanition only when the physical condition and results of autopsy agree completely with those of acute starvation.

In the typical form of starvation from deprivation of all ingesta the condition seems extremely simple. The body consumes its own fat reserves, and then draws upon its protein as found chiefly in the muscles. The carbohydrates (glycogen) are consumed at an early period. The water is lost by evaporation from the skin and dehydration by the lungs. When forty per cent. of the body weight or as others state when twenty per cent. of its tissue protein is burned up, death will occur, despite attempts at feeding. The exact mechanism is not clear. The oldest explanation was that with the cessation of combustion the temperature falls to such a degree that all vital processes cease (Voit). Richet, however, believes that death occurs as a result of demineralization of the brain or more correctly of loss of its phosphorized fats. Nervous activity is a stimulant of combustion and when a hibernating animal rouses to void its urine and feces,

its combustion is accelerated for the time being. The more rapid the combustion the more rapidly do animals lose their forty per cent. weight. This is as true of the newly born child with marasmus as it is of the hibernating animals. Moreover, it is true of the cold-blooded animal as well. With combustion of but one-tenth that of the mammal, radiating no heat whatever, and capable of even two or three years of abstinence, it still obeys this common law.

Richet is not quite sure that water plays the conservative rôle attributed to it by almost common consent. The use of water during prolonged abstinence from food serves to demineralize the organism; and since but little water is craved by the faster if it probably an error to drink much. That moisture in the air can replace water is shown by experiments on hibernating animals (a marmot actually gained weight in a moist atmosphere), and also by the survival of miners enclosed in damp chambers. In animal experiment, unlike human experience, the giving of water does not appear to prolong life; yet the shipwrecked sailor profits greatly in the absence of drinking water merely from sea bathing.

The loss of weight in starvation is borne chiefly by the fatty tissue (100 per cent.) and the muscles (fifty per cent.). At the other extreme, with insignificant wasting, are the brain, heart, and bones. All the other viscera show atrophy; the liver is reduced to one-half and the spleen two-thirds of its normal size.

The chief criterion in death from pure starvation is rapid and progressive emaciation, as shown by the scales. It is understood that in this condition the respiratory exchanges are not much diminished, more gas being exhaled than is inspired. If with apparent total abstinence from food there is no marked loss of weights, the respiratory exchanges being normal, the case is one of simulation. Of the numerous so-called "fasting girls" all authorities are agreed that owing to absence of complete scientific control not one of them can be regarded as authentic.

In addition to progressive emaciation there are other evidences due to withdrawal of water from the tissues. The blood shows a certain amount of concentration, as a result of which it appears to be richer in cellular elements. In reality the subject is anemic. There is but a slight fall in temperature, the daily loss amounting only to a few tenths of a degree C. While the fat and glycogen are burned up, the non-combustible portion of the tissue proteins continues to circulate in the blood and the latter even contains some of the tissue fats. As a stroke of grim irony, one celebrated faster developed gout during a fast, although he drank water quite freely. The subjects of "fasting urine" and "fasting feces" have received extensive study, notably in animals. The failure of ordinary perspiration causes the skin to become coated with a brownish deposit which prevents exhalation or "insensible perspiration." A peculiar disagreeable odor proceeds from the body. The orifices of the latter and the visible mucosæ seem irritated and congested. There is a very slight loss in height, which, however, may not always be present.

The autopsy finds in death from starvation are commonly summed up as follows: extreme emaciation including loss of all omental fat; the skin adherent to the subjacent muscular tissue, showing complete disappearance of the cellular tissue; atrophy of the gastrointestinal tract; stomach and intestine empty with walls adherent—at times there is a lengthwise shrinking into a cord-like formation; gall-bladder often distended; redness of the orifices of the body; urinary bladder empty; skin shrivelled, with dirty brown coat. Decomposition sets in rapidly.

Death does not always occur under progressive exhaustion. The cause may be fatal syncope or protracted convulsions. Delirium may or may not precede death, but consciousness is said to be always lost if the person survives sufficiently long.

Subjectively there is a painful sense of hunger which attains its acme in about twenty-four hours, after which it becomes less but probably never ceases entirely. It is, however, supplanted in the absence of fluids with a torturing thirst.

Partial Starvation.—By this term is meant, in experimental physiology, the results of withholding from experiment-animals the various classes of necessary nutriment. Death inevitably results from total deprivation of protein, carbohydrates, ash, or water.

If protein is withheld death occurs as a consequence of protein disassimilation, exactly as in ordinary starvation. If the animal is fed on fat, there is a sparing of protein but the result cannot be averted. Some authorities, however, claim that both in protein and carbohydrate deprivation death is prone to occur from some disease as a result of diminished resistance rather than from actual starvation.

On ash-free diet, pigeons survive for a variable period—15 to 29 days—while dogs live from 26 to 36 days. The symptoms comprise hebetude, indifference, tremors, muscular weakness, convulsions, and digestive disturbances. The dog actually lives longer when deprived of all food than when on an ash-free diet. They are able to take nourishment and lose but little weight, while there is little waste of tissue salts. In 26 days a dog lost but 880 grams of weight, 30 grams phosphoric acid and 7 grams sodium chloride (Lusk).

In experimental deprivation from water the phenomena in general resemble those of total starvation, naturally as far as dehydration is concerned. The amount of water in an animal body varies from about sixty to seventy per cent. Water ingested only by the mouth is expelled in four ways, viz., by the urine, skin, lungs, and bowels. The so-called water circulation is naturally active. When animals are given solid foods only they do not at first suffer. Gradually they become weak and shed their hair. Death occurs when fifty per cent. of weight is lost and this as a rule occurs after about twenty-three days.

Medicolegal Relations.—In forensic medicine starvation is reckoned among violent forms of death and as an uncomplicated condition is very infrequent since as a rule it is associated with neglect. The great majority of the victims are children in the first few weeks of life. Other victims comprise aged or otherwise helpless subjects. Total neglect including deprivation of food is classed as manslaughter, but if the victim is deliberately exposed to the weather the crime is murder.

If victims of starvation are seen before death they present extreme emaciation. Said to be characteristic in young and middle-aged sufferers is the withered, shrivelled, inelastic skin seen only in the aged under normal conditions. The odor of the surface of the body and of the excreta is cadaveric.

Was death due to starvation? It is first necessary to exclude the presence of any wasting disease, and of obstruction in the upper ford passages, incoercible vomiting, etc. It must also be determined whether no food was taken or whether there was total failure of assimilation. To show a crime there must be evidence that food was withheld from the victim.

The presence of delirium has been invoked to show that actual disease was present but delirium while not the rule in starvation often occurs in the latter.

Suicide has resulted from starvation, and in recent years hunger strikes by prisoners have become of common occurrence. As in the case of lunatics, suicide is prevented by forcible feeding.

Infanticide in baby farming is a mixture of starvation, neglect, and at times actual murder. To convict a mother or nurse of infanticide it is necessary to prove that the child received no food and that this refusal was with intent to kill. An autopsy will show whether there is food in the stomach but special tests for starch, etc., are also necessary. EDWARD PRREBLE.

Static Electricity.—One of the most prolific sources of relief from human suffering, and coincidentally one most despised by the uninformed, is static electricity.

Two principles well established and yet not always recognized underlie the successful treatment of inflammation: (1) Unresolved stasis with infiltration is the cause of the persistence of early inflammatory pain, and subsequent hyperplasia, and chronic suffering, when not resolved before organization, constitutes chronic inflammation. (2) When an inflammatory process is left to Nature or neglected in other ways it is apt to become chronic; hence, the indication of first importance is the removal of the infiltration in the earliest stages in all non-infected inflammation; and, before pus has formed in felons, boils, and the simpler suppurative processes but never after pus forms.

To resolve early stasis requires a *vis a tergo* of searching and positive character. It is well known that massage is not of great value. The constant or galvanic current has not the requisite potential or voltage to produce the necessary mechanical action, and is also electrolytic. The same is true of the induced or faradic current and also of the sinusoidal current. The high-frequency current is thermic in character and devoid of direct mechanical action, and while it is invaluable in infection, does not even then overcome established stasis but relieves pain by relaxation effected in the tissues. In the acute early stages of inflammation the high-frequency current or radiant light and heat may effect resolution either by removing the cause of infection, or by flushing out the tissues by the hyperemia induced.

Where induration or stasis is once established, however, as following a severe sprain or contusion of a joint, there is but one agent to be relied upon, and that is one or another of static modalities; because (1) it is the mechanical current *par excellence;* (2) it has a potential or voltage that can be regulated or controlled from that needed for the delicate applications to the human eye to the demands of the deepest, most remote, or densest muscular structures of the body; (3) the quantity or amperage of the current is so small that with the greatest voltage the electrolysis is practically nil. The only danger in careless hands is its application where pus is walled in or over other infectious or malignant processes. Static electricity is the most potent, the safest, the least irritating and at the same time the most searching or penetrating means known for resolving stasis, exercising dormant muscles, restoring activity to sluggish viscera, and promoting metabolism local and general.

Four modalities are of relative value in the order named: the static wave current, the static spark, the static brush discharge, and the static induced current.

The static wave current, a one-pole current, is, in the writer's judgment, the most valuable of all electrical currents. It is administered with the patient seated on an insulated platform with an electrode in position on the body, connected to the positive side of the machine. The negative side of the machine is grounded, and the current discharging at the spark-gap. The rate and length of the spark passing regulates the intensity and amplitude of the discharge. During the period of charge the effect is quiescent so far as any muscular movement is concerned. When the current passes from the surface of the body through the tissues in every direction to the electrode, it will be observed that it passes from within outward through the tissues in immediate proximity to the electrode. At the time of discharge a contraction takes place of all structure which may be made to contract, as parts containing muscular tissues, striped or unstriped. The depth to which the contraction takes place depends upon the length of the spark-gap which will determine the amount of discharge and current density immediately beyond the electrode. By this process of charge and discharge the tissue contraction which acts upon the cells induces contraction independent of the neuromuscular mechanism. This is readily demonstrated under the law of independent muscular contraction. (Howell's Physiology.)

The mechanical action so induced effectively expels from the tissues all foreign substances contained therein. It has no effect upon hyperplasia but effectively removes infiltration from the lymph channels. It is because of this action that the effect is so marked and valuable in relieving local infiltrated exudates through the lymph channels, thereby relieving pressure and facilitating metabolism with prompt relief of stasis and swelling in inflammatory affections.

Another important effect of the static modalities, particularly of the static wave current and static spark, is the relief from local muscular spasm as associated with inflammation. No other measure is so effective in relaxing these conditions.

The static indirect spark is in principle and effect the same as the static wave current, but less diffused and more penetrating in its action. The application is substantially as follows: The patient is seated on an insulated platform and a shepherd's crook or other metallic connection passes from the positive side of the static machine to a metal plate placed upon the surface of the platform. The negative side of the machine is grounded and the ball electrode, in the hands of the operator, is also grounded with a chain connected with a water pipe or radiator. The chain is held along side of the handle in the hands of the operator. The sparks are applied usually with a wrist movement, taking pains that the ball approaches the part to be treated just near enough to allow single sparks to escape. The passage of more than one spark at a time increases the disagreeable effects of the application. The length of spark is regulated by the speed of the machine or by placing the balls at the spark-gap a little farther apart than the spark to be administered. For localizing sparks a spark director provided with a hard rubber handle and metal terminal may be placed upon the part to which the spark is to be applied, and the sparks be then applied to a metal ball or ring in metallic connection with the terminal. Practically the same effect as the static wave current is thus produced but with deeper local effect. For the treatment of local joint affections and relief of muscular spasm of the long tendons of the leg or arm, the method with sparks shortens the application by localizing the effect with greater intensity; but in acute cases it is severely painful and must be applied with consideration for the feelings of the patient.

The static brush discharge is one of the most valuable modalities for the treatment of superficial conditions. This is applied with the patient seated on a platform holding a metal electrode connected to the negative side of the machine, the spark-gap being widely open. This is a matter of great importance, lest a spark pass across the spark-gap when the patient would experience a severe muscular contraction of the muscles of the hands and arms, which would be painful and very annoying. The application is made by a special electrode, made of resistant substances of wood or suitable material, in the hands of the operator, with special grounding as when applying sparks, and the positive side of the machine is also grounded. The application is made by moving the special electrode over the surface to be treated, at a distance just far enough away to permit the sensation of hot sand against the skin. The application should be made rapidly, moving the electrode over the affected area. This method of treatment is one of the most valuable for the relief of various superficial edemas, infiltrations, and contusions. Varicose ulcers and phlebitis are remarkably relieved by this modality.

The static induced current is the only two-pole current that is regularly employed. It is taken from the

metallic coating on the outer sides of two Leyden jars acting in circuit with the static machine, and connected with electrodes placed upon the surface of the patient. When the current is administered the intensity of effect is regulated by the length of the spark-gap, the same as for the dose regulation with the static wave current. In the treatment of some conditions the machine is run slow enough to make the spark discharge 120 times per minute. It is used successfully for the treatment of constipation, obesity, and multiple synovitis.

The therapeutics of the static modalities based upon the principles of action of the various methods covers a very large field of indication. The treatment of non-infected inflammation requires the regulation of the electrode and spark-gap to the condition treated and the employment of the wave current, static sparks, and static brush discharge according to the depth and extent of the affection.

Under the above classification it may be employed in the treatment of all forms of neuritis, synovitis, except tuberculous or infected joints, prostatitis, epididymitis, dysmenorrhea, subinvolution, vaginismus, intestinal atony, phlebitis, varicose ulcers, cirrhosis of the liver, and malarial spleen.

In the treatment of joint inflammations the electrode should be applied over the surface and the wave current applied for twenty minutes, followed by brisk application of static sparks. In neuritis the electrode should be placed over the suspected site of the neuritis when the exact location of the lesion will be discovered by the pain produced at that point. In glandular or organic conditions it should be applied over the part with a suitable electrode for a period of twenty minutes, employing a spark-gap that does not cause too great discomfort.

William Benham Snow.

Status Lymphaticus.—(*Synonyms:* Lymphatic constitution; Lymphatic habitus; Lymphatic dyscrasia; Lymphatic diathesis; Lymphatic-chlorotic constitution; Lymphatism; Status thymicus; Status thymico-lymphaticus.)

Definition.—A so-called constitutional disorder characterized by a persistence or hyperplasia of the thymus and by general lymphadenoid hyperplasia, frequently associated with cardiac and arterial hypoplasia and the osseous evidences of rachitis.

History.—The term lymphatic diathesis is an old one in medical literature, and was no doubt applied to certain cases of status lymphaticus as above defined. Inasmuch, however, as scrofulous (see *Scrofula*) or tuberculous adenitis was particularly indicated by this ancient term, and that it was also applied to cases of pseudoleucemia, chlorosis, and leucemia, it is impossible to determine in how far it was definitely employed.

The most prominent anomaly of status lymphaticus, the persistent or enlarged thymus, was recognized by early pathological anatomists like Félix Plater (1614), Ch. Richa (1723), Bichat and Verdries (1726), and by Allan Burns, Franck, Kopp, Friedleben, and a number of others in the first half of the nineteenth century. (See also *Thymus.*) These pioneer students in their close attention to the thymus overlooked the accessory anatomical features of status lymphaticus; an error that has persisted to the present time and which has been productive of considerable confusion, since much of the literature bearing upon such clinical manifestations of status lymphaticus as laryngismus stridulus and sudden death is to be found by reference to the thymus alone. A clear conception of the lymphatic state was possessed by that pathological anatomist of wide and fruitful experience, Carl Rokitansky, who, in his text-book (1842–46), under the head of "Diseases of the Lymphatic Glands," mentions "lymphatic diathesis" or "lymphatic habitus." He observes that hypertrophy of the lymph glands occurs in childhood to puberty, or even beyond to mature life. The nodes of the abdomen (mesenteric and lumbar plexus) are most frequently involved, and this condition is commonly associated with hypertrophic development of other blood-forming organs, as, for instance, the thyroid gland, and more especially a highly developed spleen, "obstructed involution of the thymus," a hypertrophic state of the follicular apparatus of the intestines, and hypertrophy of the nervous centers. Such hypertrophies affect either the whole system or one portion, as, for instance, the glands of the abdomen. Under "Diseases of the Thymus Gland," Rokitansky says: "Its abnormal enlargement is almost entirely restricted to children, in whom we simultaneously observe a great predominance of the whole lymphatic system, rachitis, and hypertrophy of the brain." The hypoplasia of the heart and arteries, now acknowledged to be one of the frequently concomitant anomalies, commanded the attention of Wunderlich, Virchow, Rokitansky, Riegel, Kulenkampff, Bruberger, and Küssner between 1840 and 1880. On the assumption that vascular hypoplasia was fundamentally related to chlorosis, the condition was described by Virchow as the "lymphatic-chlorotic constitution."

Interest in the lymphatic state, both from the clinical and from the pathological standpoint, has recently been awakened, principally through the labors of the Vienna school, of which A. Paltauf, whose contribution in 1889 marked the new era, is a representative. The various morbid anatomical features of status lymphaticus were emphasized by Paltauf and illustrated by a series of careful autopsic studies. He revived the name "constitutio lymphatica," which is widely prevalent in recent German contributions; although, notwithstanding the care with which Paltauf endeavored to demonstrate the accessorial relationship of the enlarged thymus, one finds it still occupying the most prominent and often quite exclusive position in the reports of many recent writers.

Prevalence.—As our knowledge of hyperplasia of the thymus and status lymphaticus increases it becomes unmistakable that its importance has not been duly appreciated. As a result the existence of this morbid condition has been overlooked and both its symptoms and the fatalities directly or indirectly ascribable to it have been misinterpreted. Far from being a rare anomaly status lymphaticus in infancy, childhood, and young adult life is widely prevalent among the inhabitants of the temperate zone in Europe and America. Whether particular geographic peculiarities exist in its distribution is not yet clear, though there is a suspicion that goiter zones and status lymphaticus zones may be identical.

If one brings into this class the infants with convulsions, laryngismus stridulus, tetany, lowered resistance to infections and to anesthetics, those with more or less pronounced rickets, adenoids and hypertrophic tonsils, and eczema, it must be evident that status lymphaticus embraces many victims among our infants and children. It is quite possible, however, that in some quarters the opposite tendency exists of making status lymphaticus too all-embracing, and Kolisko, von Sury, and others warn against it, claiming that our knowledge is still too meager to set up the lymphatic state as a distinct entity in all cases manifesting one or more of the features of its morbid anatomy.

Morbid Anatomy.—*Thymus.*—The predominant anatomical feature of status lymphaticus and the one that attracts attention most readily is the enlarged or persistent thymus gland. In children below the period of puberty the thymus of the

lymphatic state is usually larger than in normal individuals. The enlargement of this organ has been repeatedly noted in infants dying by one of the several usually abrupt modes characteristic of lymphatism, and, as has already been said, this striking anomaly has often been noted to the exclusion of other accessory features. Such expressions as "thymus swollen," "thymus much enlarged," "thymus hypertrophic," appear in the autopsy protocols, together with data referring to the size and weight of the organ. The enlarged organ, which usually retains its bilobed shape, extends from the isthmus of the thyroid well down upon the pericardium, sometimes even to its diaphragmatic junction. Laterally, the thymus spreads after passing beneath the sternoclavicular union, generally expanding into two leaflike lobes which reach a combined width of 5 to 6 centimeters. The thickness varies from 0.5 to 3 centimeters. The length of the enlarged thymus in children varies from 6 to 8 centimeters; and its weight has been recorded as from twenty to fifty-three grams. Recklinghausen reports a thymus "as large as the liver of a new-born infant" in a boy dying suddenly. A vigorous controversy has been waged as to the possibility of asphyxia from compression exerted by the swollen thymus upon the trachea great bloodvessels and nerves at the point where the organ passes through the thoracic dome, the "critical space" of Grawitz, and recent evidence seems to sustain the pressure theory as applicable to several of the recorded cases.

It is generally conceded that the thymus in normal individuals undergoes an involution after the second or third year, and that this involution is usually complete at or soon after puberty (see *Thymus*). But in victims of status lymphaticus the involution of the thymus is retarded, in consequence of which a persistent and sometimes hypertrophic organ is encountered in adults, particularly those less than forty years of age. The location of this persistent thymus corresponds to that in children, and the state of enlargement varies in individuals as shown by the recorded weights of twenty to 135 grams.

Both in children and in adults the thymus of status lymphaticus resembles in appearance the normal organ of infancy. It is pinkish or flesh-like in color; and a distinct lobulation like that of the sweetbread of the calf, often with clearly outlined follicles, is seen. Its consistence is soft. Hemorrhages and consequent ecchymoses are present in certain cases, particularly those in which asphyxia has accompanied the sudden death. At times the thymus is the seat of an active hyperemia, and a few instances are recorded in which a milky juice exuded from the cut organ.

The pathological histology of the thymus of status lymphaticus is not yet thoroughly elucidated, and more careful studies of a large material by the use of recent methods is highly desirable. In a general way it appears that the enlarged organ reproduces the microscopic structure of the normal thymus of infancy, differing only in the multiplication of the lymphoid cells which serve to increase the size of the follicles, and to produce new ones both in the normal sites and in the adipose tissue surrounding the gland proper. The normal division of the thymic follicle into cortex and medulla is usually retained, though the hyperplasia of lymphoid cells tends to invade the medulla and to infiltrate the trabecula of the follicles. Some authors have described an increase of eosinophilic leucocytes in the enlarged thymus, but we have evidence that this is not a constant feature. Endothelioid cell proliferation has also been described.

But while persistence and hyperplasia of the thymus is a prominent characteristic of status lymphaticus, it is not an invariable one, for we may have a non-thymic lymphatism in which general lymphadenoid hyperplasia and arterial hypoplasia exist with a thymus of normal size or one that has undergone perfect involution.

Further, it is well to recall that the anatomical evidences of the lymphatic state may be erased by a number of different causes, and that the thymus is one of the earliest structures so affected. Advanced years, particularly after the fortieth, usually induce rapid subsidence of the enlarged lymphatic structure. Various chronic diseases, and particularly those associated with debility, marasmus, and wasting, act similarly. Some acute diseases may produce the same effect.

Lymphadenoid Hyperplasia.—A generally hypertrophic state of the lymphadenoid tissue is, next after the anomaly of the thymus, the most noticeable evidence of status lymphaticus. This is shown by an increase in the size and number of the lymph follicles in various portions of the body. In the lymph glands, both superficial and deep, it is made apparent by their increased size and also, at times, by enlargement of the individual follicles. Sometimes the superficial lymph glands are not particularly augmented, while those of the abdomen, especially of the mesentery, are affected. Usually the enlarged lymph nodes remain discrete, but there may be a diffuse increase of lymphatic tissue, particularly in the mesentery.

In the respiratory and gastrointestinal tracts the lymph follicles are generally very prominent. The faucial, lingual, and pharyngeal tonsils, with the intervening solitary follicles, and those at the base of the tongue, in the larynx, esophagus, and stomach, participate in the process. In the intestines both the solitary follicles and those aggregated in Peyer's patches are unduly prominent. A distinct adenoid ring may appear occasionally in the duodenum, and more frequently at the ileocecal junction. In the small intestine, and particularly in the lowermost portion of the ileum, the follicles of Peyer's patches may protrude above the surface of the mucosa, sometimes appearing as subspherical projections half a centimeter in height; and such augmented patches may reach a length of nine to eleven centimeters. Here the solitary follicles also project prominently, at times even taking the appearance of polypoid outgrowths. In the colon an increased prominence of the solitary follicles, with their pit-like central areas still remaining, is observed. Taken as a whole, the hyperplasia of the lymphatic structures of the intestines in status lymphaticus closely simulates that seen in the stage of swelling of typhoid fever, and might readily be so mistaken.

The retroperitoneal lymph glands usually participate in the hypertrophy, to the same degree as that observed in the mesenteric nodes; and the bronchial glands are also involved, although not invariably. Of the superficial nodes, those of the inguinal, popliteal, axillary, cervical, supra- and infraclavicular regions may be affected to a varying degree, but usually not extensively. Collections of lymphoid cells have been described in the liver, thyroid, and bone marrow, and Kundrat cites a case in which red marrow was present in the shaft of the femur.

Microscopically these enlarged lymph glands and lymph follicles may show marked hyperplasia of the proper lymphoid elements. But some investigators regard the opposite condition—lymphoid hypoplasia, or "lymphoid exhaustion" as Warthin styles it—as the typical histologic picture of true status lymphaticus. Instead of lymphoid cell proliferation there is an increase of the stroma cells and of the endothelioid cells of the follicular vessels similar to that seen in lymph glands and follicles in certain chronic infections with accompanying lymphadenitis.

Spleen.—A moderate enlargement of the spleen is the rule in status lymphaticus, while the prominence of its Malpighian bodies is more striking. Generally, the splenic pulp is firm, the organ filling its capsule well. In cases of sudden death in individuals of robust con-

dition the splenic pulp is hyperemic. In the midst of the more or less deeply colored pulp the follicles composing the Malpighian bodies stand out with startling distinctness as pale round areas, often measuring two to three millimeters across, and resembling large miliary tubercles.

Histologically one finds the enlarged Malpighian bodies to consist of closely packed small lymphoid cells, generally surrounding the arterioles and supplied with few blood-vessels, thus contrasting sharply with the adjacent pulp tissue with its dilated and engorged blood sinuses. Not infrequently the hyperplastic lymphoid cells of a follicle will infiltrate diffusely into the adjoining pulp tissue, and at times small foci of lymphoid elements, without direct connection with a well-formed follicle, will be found scattered throughout the splenic substance. In the spleen also, "lymphoid exhaustion" may manifest itself by an absolute decrease of lymphoid cells in the pulp and follicles, and a corresponding increase of endothelioid cells which at times may make up nearly the entire bulk of the enlarged Malpighian corpuscles already described as resembling miliary tubercles.

The dilated sinuses of the splenic pulp are filled with blood, and in some cases evidence of extensive hemolysis and the deposit of blood pigment appear in the pulp cells.

Cardiac and Arterial Hypoplasia.—In certain cases of status lymphaticus, particularly those coming under Virchow's class of "lymphatic-chlorotic constitution," a pronounced hypoplasia of the arteries, and sometimes of the heart as well, has been noted. Some authors have described a general arterial narrowing, others a narrowing of the aorta; in fact, so far as the aorta is concerned, a diminution in caliber has been pretty uniformly discovered. In view of our ignorance as to the causation of aortic narrowing, whether real or only apparent and due to varying degrees of elasticity, we are not prepared to assert just what is the nature of the change found in victims of status lymphaticus; but that the aorta, at times the general system of arteries, and rarely the heart, are smaller than the same structures in average normal individuals is unquestionable. Even in adult lymphatic males of full stature and well developed otherwise, an aorta measuring but four centimeters in circumference at its cardiac end has been found, and a circumference of five centimeters at the aortic ring is the rule. These elongated and narrow aortas are usually thin-walled and quite elastic. Rupture of such thin-walled arteries has been reported; and in certain cases in which the heart also was hypoplastic, a patent foramen ovale has been found. Ptosis of the arch of the aorta and of the heart have been found at autopsy, and their existence has been demonstrated during life by *x*-ray examination.

Rachitic Bone Changes.—That there is a close morbid anatomic association of status lymphaticus and rickets is abundantly proven, particularly in the case of lymphatic infants. Still we are not at present in a position to say that all cases of status lymphaticus are associated anatomically with the rachitic dyscrasia, nor do all cases of rickets exhibit the evidences of lymphatism, though its coincidence with enlarged spleen and hyperplasia of the mesenteric nodes is well known. In infants dying in the lymphatic state a mild grade of craniotabes, the rosary, curvature of the long bones or spine, and enlarged epiphyses, have been manifested as rachitic osseous changes; and in older children or adults several instances of rachitic spinal curvature, pigeon breast, narrow pelvis, and curvature of long bones have been found. Microscopically the affected bones present the lesions characteristic of rickets.

Skin.—A thick skin and an increased fat layer have frequently been noted among the anatomical findings. In the skin an increase of the elastic elements has been described as a factor in augmenting its thickness. Pallor of the skin of the peculiar kind known as pasty ("pasteos") is looked upon as an evidence of lymphatism.

Blood.—Observations upon the blood in status lymphaticus are still meager, and a unanimous opinion as to the characteristic alterations has not been reached. One would expect a lymphocytosis in these cases, and this has been reported in a number of cases until it has come to be accepted as the classic blood picture. Thus Ewing, as an early investigator, found a pronounced increase in the number of mononuclear large and small lymphoid cells in the blood of one of his cases, and he suggests that further systematic search may reveal this as a constant condition. In the red cells no abnormality in number or structure has been detected, except in the cases with secondary anemia.

Occasional Features.—In many of the cases of sudden death among the victims of the lymphatic state a pronounced active hyperemia of the thoracic and abdominal viscera, and occasionally of the brain, has been described. Further, particularly in those sudden deaths in which asphyxia figured, hemorrhagic ecchymoses of the pericardium, thymus, pleura, and endocardium were present in the order of frequency of the structures mentioned.

Hypertrophy of the thyroid is a quite common accompanying anomaly. There may be a simple hypertrophy, a parenchymatous goiter, or a cystic goiter. In about one-half of the reported cases the thyroid has been found enlarged.

Edema of the skin, or more commonly eczema, is occasionally found. Edema of the lungs has been discovered in some cases of sudden death in lymphatic individuals; and in lymphatic epileptics dying after one or several attacks, or from rapid status epilepticus, this condition is encountered as the general rule.

Hypertrophy of the brain is mentioned by Rokitansky as one of the features of status lymphaticus, at times combined with cerebral edema or with widening of the ventricles and increase of intracerebral fluid. In some of the recently studied cases one or more of these conditions are mentioned, and, in certain epileptics in the lymphatic state, general cerebral hypertrophy, localized hypertrophy, edema, or hydrocephalus may appear.

Wiesel has noted the aplasia or hypoplasia of the chromaffinic system and, with von Sury, considers it as the final test of a genuine status lymphaticus. By most recent authorities this view is regarded as extreme.

On the side of the sexual organs peculiarities are occasionally encountered. A retarded development of the external genitals and often of the testes, and the delayed appearance of the beard, the pubic and axillary hair in the male, are examples of these. In the female an infantile (and sometimes double-horned) uterus with undeveloped tubes, ovaries, and mammæ, together with a masculine aspect of the whole body, are likewise occasionally found.

Ptosis of the abdominal viscera, especially of the stomach and colon has been noted in both at autopsy and by *x*-ray during life.

Before dismissing the subject of the morbid anatomy of status lymphaticus we should emphasize the fact that a number of the characteristic features are profoundly modified by the individual's state of nutrition. In those victims of status lymphaticus who die suddenly in a good state of nutrition such anomalies as the large thymus, lymphadenoid hyperplasias, and thick fat layer appear prominently; but when nutrition has suffered through the exhausting influence of chronic diseases or the rapid wasting of certain acute affections, these structures atrophy along with the rest of the body. On the other hand, the aortic or arterial hypoplasia, and the osseous changes of ancient rickets are ineradicable, though these, it must be remembered, are not invariably present.

Again, one may find status lymphaticus associated with certain other diseases and their anatomic changes, as, for example, Basedow's disease, struma, scrofula, and pseudoleucemia.

Clinical Manifestations.—Status lymphaticus has been found in a number of diseases in which the association seems to have been more than a mere coincidence.

Thymic Asthma.—Up to very recent times that peculiar spasmodic neurosis known as spasm of the glottis, laryngismus stridulus, child-crowing, thymic stridor, or by the term "asthma thymicum" given by Kopp in 1824, has been looked upon as having its morbid anatomical basis in an hypertrophy of the thymus. But in the last decade more exhaustive studies have disclosed one or several of the other features of the lymphatic state in these cases, and there need now be little hesitancy in considering this affection as one of the clinical evidences of the latter condition and in describing it in this connection.

Thymic asthma, a disease of infancy, may be defined as a paroxysmal suffocation, and is not uncommon cause of sudden death, especially between the fourth and tenth months. Its symptomatology has been well described by Kopp, and more recently by Pott. In a typical fatal attack the child suddenly jerks its head backward with a sharp noisy inspiration like that of whooping-cough, but sharper and shallower; the eyes are upturned, fixed, and pupils dilated; the face has a painful, anxious expression, is blue at first and then pallid; the nostrils are dilated. The tongue swells and arches so as to press against the hard palate, while the veins of neck become engorged and stand out prominently. The arms assume a condition of tonic extension with fists clinched and thumbs turned into the palms. The legs become extended, great toes abducted and dorsally flexed. An attitude of opisthotonos is assumed by the spine. A convulsive tremor of the facial muscles and an ineffectual gasping inspiratory attempt follow. Suddenly the spasm ceases, the face becomes ashy, then cyanotic; the tongue and lips are livid; and after one or two minutes the child is a corpse. Urine and feces are involuntarily passed especially if artificial respiration is attempted. The heart ceases its activity at the onset of the paroxysm; its sounds are inaudible and the pulse is absent. Reflex irritability is lost. In attacks not fatal the clinical phenomena resemble those just described; there is the abrupt onset, the respiratory stridor, the paroxysm of suffocation and convulsive movements of various groups of muscles often with involuntary evacuations, and occasionally with complete loss of consciousness. Friedleben, one of the older observers, states that these attacks occur most frequently in well-nourished infants, though they may appear in the debilitated. The interval between the spasms may be hours, days, or weeks, though they tend to increase in frequency and severity. Twenty to forty attacks have been noted in twenty-four hours. The period of the first dentition is the one particularly prone to this affection, though it has been recorded in the new-born infant. The so-called idiopathic spasm of the glottis of adults is probably dissimilar at least in so far as its relations to status lymphaticus are concerned, though this point has not been definitely settled. Attacks of laryngeal stridor with suffocative symptoms suffered by some epileptics and classed as prodromes or equivalents are probably related to thymic asthma.

Thymic asthma and thymic sudden death in infants stand so closely allied as to make a separate consideration unnecessary, for while many infants have succumbed suddenly, in which, for want of actual observation or for lack of trained observation, none of the symptoms of thymic asthma has been described, it is highly probable that one or more of the convulsive phenomena just mentioned actually preceded death. Many of these sudden deaths in infants are tragic occurrences, and not infrequently they have called for medicolegal investigation. Some of the children in seeming good health have expired abruptly in the presence of spectators or even in their parents' arms (Grawitz and others); they have been found dead in bed, and suspicions of foul play have been entertained against a mother or nurse under these circumstances; or death has been ascribed to suffocation in the bedclothes. Some, at least, of the deaths from fright recorded among children doubtless belong to this same category, and here also probably belong those occasional instances in which animals like cats or dogs have been suspected of causing the death of infants, as in those popularly described as "cats sucking the breath."

As to the etiology of thymic asthma and thymic sudden death the controversy aroused by Kopp's theory is still waging. Kopp maintained that the weight of the enlarged thymus on the heart, lungs, and great vessels induced the spasm of the glottis either by direct pressure or by irritation of the recurrent laryngeal nerve. Even to the present time the mechanical theory advanced by Kopp is accepted by some authors, or the modification of it proposed by Grawitz, who held that direct compression of the trachea is produced by the swollen thymus at the point where it emerges from the dome of the thorax ("critical space"), particularly when the head is suddenly drawn backward. Ever since the time of Friedleben's masterly studies upon the diseases of the thymus (1858) the pressure theory has been combated, and a large controversial literature has appeared. That the mechanical factors are concerned in some of these cases seems undeniable, but even in those in which the marks of tracheal compression are indubitable, it is still impossible to say that compression alone was the active agency in exciting the spasm or the sudden death. Because of the inadequacy of the mechanical theory to explain the majority of the cases, the tendency in the last few years has been more and more toward the view advanced by Pott, and extended by Paltauf. Pott believed the fatal issue to be ascribable to sudden arrest of the heart, though he charged the cardiac affection to the results of pressure of the suddenly congested and already hypertrophied thymus upon the trachea, pulmonary artery, and right auricle. Paltauf also ascribes thymic sudden death to a spasmodic arrest of the heart, but he goes beyond the thymus and looks to status lymphaticus as the responsible condition. He points out that the enlarged thymus coexists with general lymphadenoid hyperplasia, and arterial hypoplasia—that is, with the lymphatic state—and that the victims of this dyscrasia possesses a lowered vital resistance and a particular proneness to convulsive disorders, among which cardiac or respiratory spasm or paralysis are the most dangerous. In this light, spasm of the glottis or thymic asthma becomes a reflex respiratory spasm, and thymic sudden death a reflex cardiac paralysis, both in some way dependent upon the exaggerated irritability incidental to status lymphaticus.

Opposition to the mechanical theory has been recently revived by von Sury who strongly opposes the view that pressure on the trachea is in any way responsible for thymic asthma or thymic sudden death.

Infantile Eclampsia.—That teething fits are often associated with rickets has been pointed out by a number of authorities. The relationship of infantile eclampsia and status lymphaticus has not been emphasized, but there is reason for believing that this convulsive neurosis, like glottic spasm, occurs in lymphatic children. In a few cases eclampsia and spasm of the glottis have been noted in the same infant in which status lymphaticus was disclosed at

autopsy. As we shall see in the section following, tetany is one of the neuroses frequently combined with eclampsia and one in which status lymphaticus has been found to exist. It therefore appears quite proper, even in the absence of an abundance of direct evidence, to discuss the general convulsions of infancy in their present connection; and the writer is of the belief that more careful study from the point of view just indicated will show the correctness of this position. In one case he had the opportunity of performing an autopsy on a six months' infant dying of general convulsions, and found a large thymus with pronounced hyperplasia of the intestinal and splenic follicles, and hypertrophy of the mesenteric glands.

Idiopathic Tetany of Infancy.—Closely allied to spasm of the glottis and eclampsia is the carpopedal spasm of infancy which is, by most recent authors, classed as infantile idiopathic tetany. Tetany in infancy may manifest itself by carpopedal contractures alone, which occur in intermittent attacks or very rarely as a persistent spasm; it may exist as a latent affection, only showing under certain conditions of irritation; it occurs in combination with laryngeal spasm, or with laryngeal spasm and eclampsia. Its relations to rachitis have been repeatedly pointed out, and discussions as to the invariable association of craniotabes and tetany and the causative influence of the former have frequently arisen. The association of tetany and status lymphaticus has been emphasized particularly by Eschereich, whose opportunities for the study of this and its allied neuroses have been especially good. He affirms that the lymphatic state may exist as a complication of tetany, and that it is of especially grave import. The various anomalies of status lymphaticus have been disclosed in autopsies on victims of tetany, although not always recognized in their proper connection.

Epilepsy.—A mention of persistent thymus in epilepsy was made in 1890 by Kruse and Cahen, based on their finding this anomaly in autopsies on two epileptics. The association of epilepsy with status lymphaticus has been particularly emphasized by the writer as the result of his studies in the Pathological Laboratory of the Ohio Hospital for Epileptics. In autopsies upon the victims of idiopathic grand mal, particularly in young and robust individuals, evidence of the lymphatic state occurs with a regularity that suggests more than an accidental relationship, though the tracing of a possible causal connection between epilepsy and status lymphaticus is at the present time largely a matter of speculation. I have already noted that a clinical kinship has been traced between epilepsy and the neuroses above mentioned, particularly infantile eclampsia and spasm of the glottis, and, as already suggested, these neuroses have been associated both with rickets and with the lymphatic state. As for epilepsy, no less an authority than Gowers has concluded from purely clinical and statistical observation that rachitis must be looked to as a fundamental factor in the occurrence of teething fits and more remotely of the epilepsy which so frequently follows in a victim of infantile eclampsia. My studies in the morbid anatomy of epilepsy have revealed the evidence of an ancient rickets in a proportion of cases, and the anomalies of status lymphaticus as a relatively constant occurrence in the subjects of idiopathic grand mal dying under circumstances favorable to the retention of the anomalies of the lymphatic state.

Epileptics are very prone to sudden and often tragic deaths, as by asphyxia (sometimes mechanical, sometimes not), "syncope," "heart failure" without anatomical cardiac lesions, rapid status epilepticus, edema of the lungs, "cramps," and drowning, and I have endeavored to define an affinity between the sudden death in epilepsy and that seen in such neuroses as thymic asthma, the various forms of thymic sudden death of infancy, and those in adults presently to be described.

Death in Surgical Narcosis.—Gradually, but more particularly since the report upon Kundrat's observations, we are coming to learn that status lymphaticus is to be held responsible for most of the deaths in chloroform anesthesia, and probably for many of those occurring in surgical narcosis by the use of other agents like ether, nitrous oxide, etc. Our information concerning chloroform sudden death is particularly definite because of the almost exclusive use of this drug in Austria and Germany, where, to the present time, thorough autopsies with the possibility of discovering the existence of status lymphaticus have alone been practised. Unquestionably when we come to make a careful anatomical analysis from the standpoint just indicated we shall find the conditions attending anesthetic accidents in America identical with those recorded in Europe; though the impression now seems to prevail that chloroform *per se* is the especially dangerous anesthetic in victims of the lymphatic state.

As to the time and mode of death no regularity has been determined. Any stage of anesthesia from the first few whiffs to the completion, or during the period of recovery, or even several hours after the narcosis and operation have been ended, may be selected as the fatal moment. Death may be very abrupt with evidence of cardiac and respiratory failure, or the patient sinks more gradually with enfeebled pulse and shallow respiration. Methods of resuscitation, such as avail in the ordinary accidents of anesthesia, are here fruitless.

For their protection in cases of the often distressing accidents of surgical narcosis it is important that the surgeon and anesthetizer keep clearly in mind this now well-established association of status lymphaticus. Unfortunately, our means of antemortem diagnosis in status lymphaticus are at present quite unsatisfactory, particularly in the case of adults. In children the existence of adenoids, enlarged tonsils, enlarged superficial lymph nodes, and osseous rickety changes, together with a history showing eclampsia, laryngismus stridulus, or idiopathic tetany, should be seriously considered as having grave prognostic importance.

Death from Trivial Surgical and Medical Procedures.—Closely allied with the sudden death in surgical narcosis are those which occasionally follow minor operations. In some of these, especially those in which incomplete anesthesia has been employed, it is questionable in how far the anesthetic or the shock of the operation is to be held accountable for the fatal termination. Illustrations of this point are the deaths which have followed operations for the removal of nasopharyngeal adenoids. Here a partial anesthesia is commonly employed, and most of the sudden deaths have been found under these conditions.

Although the point has not yet been prominently emphasized, I am personally inclined to the belief that careful study will reveal all the unexpected deaths following adenoid operations (including those on hypertrophied tonsils), either with or without anesthesia, to be associated with status lymphaticus. It is at least pertinent to recall that the lymphatic overgrowth making the basis of nasopharyngeal adenoids and enlarged tonsils is one of the manifestations of status lymphaticus.

Allied to the accidents just alluded to are the deaths occurring in other minor operations done in incomplete anesthesia, and heretofore ascribed either to the anesthetic alone or to the shock and drug effect combined. A well-known illustration is the occasional fatal accident during or after the extraction of a tooth. The occasional deaths after minor accidents, and following various trivial operations in which no anesthetic is used, will doubtless gradually find their way into the group of neuroses associated with the lymphatic state whose victims are characterized

by their deleterious susceptibility to psychical and physical shock.

A particularly appropriate illustration concerns the sudden deaths following the injection of curative sera, of which the first pronounced example was in the case of the young son of Professor Langerhans, of Berlin, who died suddenly a short time after the injection of a small dose of diphtheria antitoxin, used by his father for preventive purposes. At the time of the occurrence this case excited much discussion, and various theories were put forward to explain the accident, especial stress being laid upon the possible toxic effect of the antitoxin. However, the autopsy revealed certain evidences of status lymphaticus like swollen spleen with prominent follicles, enlarged tonsils and pharyngeal follicles, hyperplastic intestinal follicles, and slight rickety thickening of the costosternal margin; and while these were not taken into serious consideration during the immediate examination, they were dwelt upon later, and by such experienced students as Paltauf, Eschereich, and others, it was concluded that this unfortunate accident was one of the fatalities of the lymphatic state in which, perhaps, anaphylactic shock is more than ordinarily dangerous to life.

Eschereich reports the case of a lymphatic child who died in a salicylic-acid pack. Galatti records a similar fatality after an external application for eczema; the child developed tonic and clonic convulsions, and died in twenty-four hours, and here Kolisko found, along with the eczema, edema of the brain, rachitis, and anemia with evidence of lymphatism. In connection with his case Eschereich points out the danger of narcosis, prolonged hydrotherapeutic treatment, or weakening therapeutic measures in children with status lymphaticus.

Sudden Death in Adults, and Death in the Water.—Abundant evidence has accumulated to show that adults, especially young, apparently strong individuals, are, like infants and children, the subjects of status lymphaticus and therefore exposed to such accidents as sudden death under the various circumstances just related, as that in surgical narcosis and after trivial operations. Death in the water by so-called "drowning" is one of the modes noted more particularly in adults, though mentioned in the case of some infants. In some of these fatal accidents the victims have been found dead with no external evidence to indicate the mode of termination. Others have died before spectators by a variety of tragic methods. A number have expired in the water with so-called "cramps" or by "drowning," in which the usual postmortem findings of fatal immersion were absent. Most of these occurrences have demanded medicolegal investigations, and their importance from this standpoint is so great that it seems desirable to illustrate the subject by citing some typical cases.

Nordmann describes the case of a twenty-six-year-old scavenger, in apparent good health, who was found dead in the situation of his work. Autopsy showed the body of a medium-sized, strongly developed man, with diffusely ecchymotic skin; tonsils and papillæ of the tongue prominent; lungs congested and moist; heart ecchymotic; flesh somewhat thickened, tough, and pale; liver and kidneys dark and hard; thymus persistent and enlarged, measuring $7\times5\times1.5$ centimeters; lymph glands in neck, axilla, and mesentery much enlarged and pale; aorta narrow (5.5 centimeters in circumference above valve), wall thin and smooth.

Another case, noted by Nordmann, is that of a twenty-five-year-old man who died suddenly without assignable cause while playing cards with several companions. Section (by Kaufmann) revealed a thymus gland, thin, but as large as the palm of the hand; general hyperemia; flaccid, slightly dilated heart, and slight enlargement of lymphatic glands and follicles.

Still another case recorded by Nordmann illustrates a form of sudden death after bathing. A soldier in good physical condition, twenty-six years old, went bathing on a warm August afternoon with a number of comrades. All precautions were taken as to the proper temperature of the water. He entered the water slowly, swam about for two or three minutes, and returned to the shore. After emerging from the water he complained of chilliness, suddenly stiffened his extremities, became pale, turned his eyes upward, and with a long-drawn inspiration fell to the ground. He was assisted to a sitting posture, where Nordmann found him pulseless, with a deeply cyanosed face, and after two or three spontaneous attempts at breathing respiration ceased. Artificial respiration and stimulation were of no avail. On autopsy the body was found to be well formed, in good nutrition, with pronounced rigor, and cyanosis of the face. The brain was merely congested. The thoracic organs were entirely normal. Bronchial glands were somewhat enlarged, gray-black, and a little firmer than usual. A thymus gland, larger than a fist, lay in the anterior mediastinum, dark red in color, with follicles plainly visible. The tonsils were enlarged, as were also the lymph glands, and the follicles of the tongue and spleen. The thyroid was symmetrically enlarged.

Several instances have been reported in which people in apparently good health suddenly fell into the water, and, although at once removed, before death by asphyxia could possibly have occurred, could not be resuscitated. A thirteen-year-old boy fell unexpectedly from on board a ship in the docks, and although immediately removed from the water, could not be revived. The autopsy was conducted by von Recklinghausen, who reports, aside from an enlarged thymus, enlarged tonsils and lymph glands, nothing abnormal. Another case noted by von Recklinghausen is that of a man, twenty-seven years old, who, while bathing in a forbidden spot, was suddenly accosted. He arose from the water frightened, and at once fell, to sink below the surface. He was promptly dragged from the water, but did not revive. Section of the body of this large, lean, well-formed man showed a general hyperemia; flaccid, dilated heart, with a tough myocardium and normal valves; and slight narrowing of the ascending aorta. The lymph glands in the neck, axilla, mesentery, and the tonsils were enlarged and pale; the follicles of the spleen, tongue, and epiglottis were swollen (intestinal follicles not mentioned). In the anterior mediastinum a persistent thymus measuring $9\times6\times1.5$ centimeters was discovered.

At least two well-authenticated examples of thymic and lymphatic hyperplasia in individuals sinking suddenly while swimming are described by Nordmann in his excellent paper upon the relation of the thymus gland to sudden death in the water. These two cases Nordmann credits to von Recklinghausen. A twenty-year-old mechanic, while swimming, uttered a sharp cry and sank beneath the surface, and, though promptly removed from the water, was dead. On postmortem examination his body was found to be lean; the organs were generally congested; the lymphatic glands in the neck, axilla, and groin were enlarged, along with the spleen. The follicles in the nose, glottis, and tongue were very prominent. The thymus was persistent and measured $10\times6\times1$ centimeters. In the other case a man twenty-eight years of age suddenly sank while swimming beside some companions. He was at once removed from the water, but death had already taken place. The body was well nourished. The noticeable features of the section were the enlarged tonsils, lymph glands, and spleen; and the hyperplastic follicles of the tongue, spleen, and intestines (Peyer's patches). The heart was flaccid, and the aorta measured but 4 centimeters at its origin. The thyroid was enlarged. The persistent thymus was $10\times8\times1$ centimeter in size.

In this class of cases it is believed that the fatal

termination results from a reflex laryngeal or respiratory spasm and cardiac paralysis.

Lower Resistance to Infection.—A predominant peculiarity of the constitutional condition which we are considering is, as Paltauf and others have shown, a lowered vital resistance, and this is apparent in the event of certain acute infections. Diphtheria, as demonstrated in Eschereich's clinic by Moriz Daut, tends to assume a particularly severe type and to prove frequently fatal in lymphatic infants and children. Between the years 1890 and 1897 there were seventy-nine deaths from diphtheria in the clinic at Graz, and twenty-three of these showed status lymphaticus. Susceptibility to diphtheria in lymphatic children shows itself in several ways. Thus in the midst of an otherwise mild epidemic the lymphatic victims may die early in the attack with no diphtheritic anatomical lesions to explain the unexpected ending. There are hoarseness of the voice, hoarse cough, and a tendency to suffocation. Only a thin false membrane is present in the throat and larynx, and nowhere is there a mechanical obstacle to explain the hoarseness and dyspneic symptoms. One or two days after entering the hospital the children become much worse; after coughing, severe dyspnea and cyanosis appear with a small, weak, irregular pulse; consciousness is lost, and death supervenes in spite of various heroic efforts at resuscitation, including intubation or tracheotomy. In another class of cases there is a pronounced tendency to rapid extension of the diphtheritic exudate into the bronchi and bronchioles with bronchopneumonia following. Here, of course, the anatomical findings fully explain the fatal termination. This also holds true for the septic type of cases with early death; but the point is made that subjects of status lymphaticus are, from their constitutional weakness, especially prone to suffer severely from this infection. All the ordinary therapeutic efforts for diphtheria fail in these cases, and such is likewise the case with the extraordinary measures like tracheotomy and intubation. It is here also that the specific serum, the antitoxin of diphtheria, fails to exert its usually prompt and beneficial results. Even in early cases in which antitoxin usually produces a marvellous effect, none follows, and this seems to be independent of the dosage, for Daut, in his cases, used the antitoxin promptly and freely. It is very desirable for physicians generally to be clearly informed as to the unfavorable prognosis of diphtheria in status lymphaticus, and especially as to the possibility of failure with that sovereign remedy—antitoxin—in this class of individuals. Alike is the danger of accidents following the use of a prophylactic antitoxin injection, and, in the absence of the specific therapeutic response to the remedy, it behooves the practitioner to be on his guard both for his own protection and to spare ill repute to so valuable a therapeutic agent as the antitoxin of diphtheria. We have had, at the Ohio Hospital for Epileptics, three cases of fatal diphtheria in adult epileptics in which we ascribed the unexpected termination to the existence of a status lymphaticus as demonstrated at autopsy. In each of these cases antitoxin treatment was unavailing.

Among other infectious diseases toward which the resistance of lymphatic subjects is lowered may be mentioned cholera as shown by Virchow, pneumonia by Ortner, typhoid fever by Fraentzel, Virchow, and Hiller; while of late cerebrospinal meningitis and poliomyelitis have been added to the list. Ortner found pronounced evidence of status lymphaticus in some fatal cases of anemia after removal of the exciting cause, Bothriocephalus latus, and he holds the connection to be more than a coincidence. In most of the cases just mentioned the especially prominent anomaly was the hypoplasia of the heart and arteries, the cases being, in fact, examples of Virchow's "lymphatic chlorotic constitution."

Lowered Vital Resistance.—Not alone as regards a weakened state in meeting physical or mental stress; withstanding shock or fatigue, or counteracting infection, but in vital resistance as a whole the victim of status lymphaticus is below par. A general myasthenia with lowered arterial tension exists in many cases.

Bronchial Cough.—West has reported several cases in which a harsh, spasmodic, croupy cough was assigned to the irritation of enlarged bronchial lymph nodes and which improved under the administration of creosote. The enlarged and offending glands were looked upon as manifestations of lymphatism, of which the patients exhibited certain other clinical manifestations like enlarged superficial lymph glands, hypertrophied tonsils, palpable spleen, dulness over the upper sternum, and, in half of the cases, evidences of a previous rachitis.

Association with Other Diseases.—As has already been stated, hypertrophy of the thyroid, *i.e.* goiter, has been found in about one-half of the cases of status lymphaticus in adults. This may be simple goiter or it may take the form of exophthalmic goiter. Möbius in 1891, emphasized the concurrence of persistent thymus and Basedow's disease, and this has been verified by Mosler, Spencer, Johnston, White, Ross, Bradford, Hektoen, and a number of others. Several of these cases died abruptly under circumstances strongly suggestive of thymic sudden death as now recognized, and in the several thorough autopsies, besides the persistent and hyperplastic thymus, such lymphatic alterations as prominent intestinal and splenic follicles, etc., have been described. In explanation of this syndrome it is urged that experimental evidence points to some sympathetic relation between the thyroid and thymus as shown by the enlargement of one following the extirpation of the other. It is also suggested that the tachycardia of exophthalmic goiter is analogous with the tendency to cardial paralysis in status lymphaticus.

As long since shown by Virchow, hypoplasia of the heart and arteries is frequently associated with chlorosis, and Copeland and Bamberger noted the coincidence of hemophilia with aortic narrowing. It has also been found that other features of the lymphatic state are associated with the hypoplasia of the heart and arteries, and this, recognized by Virchow, led him to define the condition as the "lymphatic-chlorotic" constitution. Anatomical evidences of lymphatism, especially the persistent thymus, has been noted in myasthenia gravis, cretinism, and infantilism. The frequent concurrence of tuberculosis, especially of latent or healed lesions, and status lymphaticus is noteworthy.

The extensive hyperplasia of lymphadenoid tissue in status lymphaticus brings it anatomically to resemble some cases of leucemia and pseudoleucemia. In the latter conditions we not only encounter enlargement of the lymph glands and lymph follicles, but hypertrophy or lymphoid overgrowth of the thymus as well. There seems, however, to be little or no clinical analogy between these affections. The blood changes, like the anemia, and the disturbance of balance in the various kinds of leucocytes are either entirely absent in status lymphaticus or but imperfectly exhibited by occasional lymphocytosis. Ewing has shown that while the enlargement of the intestinal follicles may reach the extent observed in less pronounced pseudo-leucemia, in the latter disease the small nodules of lymphoid tissue grow laterally for some distance before producing much elevation of the mucosa, contrasting with the sharply circumscribed, abruptly projecting follicles of status lymphaticus. The nodules of pseudo-leucemia frequently ulcerate at their central points owing to improper blood supply, here again differing from the well-vascularized follicles of lymphatism. Ewing remarks: "In the majority

of the cases of lymphatic constitution the enlargement of the lymph nodes does not pass beyond the limits of what may be called a physiological hypertrophy, and bears little resemblance to a tumor formation. The spleen is rarely much enlarged. The presence of considerable pigment in the spleen pulp is too ordinarily seen to be interpreted positively as the result of an excessive blood destruction, such as characterizes the severe anemias. Yet it must be admitted that the very considerable degree of pigment deposit reached by the two cases referred to above* indicates that in some instances the blood has suffered severely. These children are, however, not usually anemic, but in excellent health, and even the sickliest of them do not resemble cases of infantile leucemia, pseudoleucemia (von Jaksch), or chlorosis. As for the hyperplasia of the lymphoid marrow, it may be said that the normal limits of lymphoid marrow are as yet by no means definitely settled. Such hyperplasia may be seen also in the secondary anemias, and in any case the hyperplasia of the lymphoid marrow may be regarded as merely a part of the general and more or less physiological hypertrophy of the lymphoid structures of the body."

Diagnosis.—Paltauf distinguishes two varieties of status lymphaticus, one rachitic, the other non-rachitic. In the first group a pale skin, well-developed fat layer, enlarged spleen and thymus, with lymph glands and follicles in varying grades of enlargement, and the epiphyseal changes of rickets are prominent; while in the second the pale skin, rich fat layer, and pronounced hyperplasia of the lymph glands and follicles, with a thymus above the average, are encountered.

As a rule, the subjects of status lymphaticus appear in what we are pleased to call a well-nourished condition, though its anomalies are sometimes found in debilitated subjects, particularly in infants advanced in rickets. The lymphatic infants usually appear plump and well-fed; the adults are robust, even inclining to moderate corpulence, and the young adult males are generally well-built, well-nourished, and even decidedly athletic in appearance. In infants, however, notwithstanding the appearance of good nutrition, a condition of perfect health is contradicted by the peculiar pallor of the skin and the flabby state of body. The skin is both pale and of the condition called pasty, giving, as the Germans describe it, the "pasty habitus." A tendency to eczema, either of the head or universal, is quite common in lymphatic infants. In adults the thick, coarse skin, and muddy complexion are found.

For purposes of diagnosis, aside from the general features just noted, it becomes important to discover, if possible, the evidences of a general or local hyperplasia of lymphatic structures and of narrowing of the arteries where this is associated. The hypertrophy of the faucial, lingual, or pharyngeal tonsils, of the "pharyngeal ring." with augmented prominence of the follicles at the base of the tongue, should, if accompanied by enlargement of the cervical, axillary, or inguinal glands, suffice to arouse suspicion, as Ewing says. The mesenteric glands may occasionally increase until they become distinctly palpable tumor-like masses. Generally the spleen is enlarged to a point which can be determined by careful exploration. Hypertrophy of the thymus manifests itself by increased substernal dulness, and has, especially in infants, been detected during life and confirmed at autopsy. By expert percussion the dulness of the thymus can be outlined, and the organ is said to be enlarged if its dulness extends 1 cm. or more beyond the sternal border. Auscultation discloses the inspiratory stridor of thymic asthma, most audible over the sternum. Röntgenology has also been of signal service in the detection of the enlarged thymus as well as by disclosing the ptosis of the aortic arch, and of the digestive tube. In adults, and especially in the well-nourished, enlargement of the thymus of the relatively moderate grade incidental to status lymphaticus is not easily demonstrable by physical examination. It may be possible under exceptionally favorable conditions to detect hypoplasia of the peripheral arteries both by their reduced size and by their increased tension, and Ortner noted an absence of aortic pulsation in the neck in his cases which he regards as pathognomonic if found in a muscular subject. Hypertrophy of the left ventricle, and dilatation of this chamber have been mentioned as accompanying aortic hypoplasia.

The frequent association of rachitis with status lymphaticus should always be in mind, and when one or more of the osseous manifestations of rickets appear, along with lymphatic enlargement, increased thymic dulness, etc., a diagnosis of the lymphatic state may safely be hazarded. In infants a mild grade of craniotabes, retarded closure of the fontanels, retarded dentition, the rosary, enlarged epiphyses of the long bones, and curvature of the legs and spine are found in varying degrees in those cases of status lymphaticus which are associated with the rachitic dyscrasia. In adults, marks of one-time rickets may still be demonstrable, especially such as pigeon-breast, spinal curvature, narrow pelvis, bow-legs, etc.

The blood changes of status lymphaticus are, as has already been said, too indefinite to permit of diagnostic discrimination.

Etiology and Relationship to Associated Clinical Manifestations.—We are still in the dark as concerns the etiology of the strange constitutional condition whose morphological characteristics have been portrayed. It is well established that some relationship exists between rachitis and status lymphaticus, and one would be inclined to call the latter the lymphatic form of rachitic were it not that cases are encountered without manifest evidences of rickets, that is to say, we have a non-rachitic status lymphaticus. The frequency with which the conditions coexist, especially in infants where changes of rickets retain their prominence, argues for the direct relationship of the two affections, and I am inclined to believe that more exhaustive search, especially such as is comprehended by histological studies of the epiphyseal bone changes, would demonstrate the presence of rachitic lesions in cases of the lymphatic state where none of the coarser anatomical manifestations are to be found. It is, in fact, quite probable that status lymphaticus and rickets of a gross or a microscopically demonstrable grade will be found to be invariably associated. Were this the case we would still be a-field in the question of etiology, since the direct exciting element in the causation of rickets is as yet unknown. Of all the theories, however, the one attributing rickets to an infectious agency seems most plausible, and adherents to this view are rapidly increasing. According to this theory, rachitis is the result of a microbic infection, not necessarily due to a single bacterial species, but to one of several of the pyogenic organisms which act slowly, and which elaborate poisonous products capable of producing the osseous or other alterations found in the disease. The view that rachitis is caused by a slumbering or latent pyogenic infection, like a focus of middle-ear or mastoid disease, of cranial sinus infection, tonsillar infection, or from the teeth, and that the gradual or periodic discharge of toxins from this focus induces the rickets, is particularly inviting, and even at the present moment claims some experimental data in its support. If we accept the infectious theory of rickets it becomes easier to reconcile its association with status lymphaticus, for the latter then becomes its lymphadenoid form, in which the various lymphatic structures gives a hyperplastic reaction in response to the chronic

*Cases reported by Ewing.

intoxication. That various forms of lymphatic overgrowth result from infections has long been definitely determined, and at the present moment we witness the tendency to include such pronounced diseases of the lymphatic system as pseudoleucemia and even leucemia in the category of infectious diseases. In the face of this tendency it seems entirely reasonable to look to the enlarged lymph nodes, lymph follicles, and swollen spleen of status lymphaticus as the products of a slowly acting latent infection, or to the gradual or periodical discharge of attenuated pyogenic products from a hidden focus of infection.

As to the relations which exist between status lymphaticus and the clinical phenomena associated with it we possess but little information. We have already found that the theory of reflex cardiac paralysis has been admitted to explain the sudden deaths of status lymphaticus, the increased susceptibility of the heart to various forms of irritation being a part of the lowered vital resistance incidental to this constitutional disorder. This hypothesis has been generally accepted, but it still leaves something to be desired in the way of more fully explaining the exact mechanism by which the cardiac paralysis is induced.

The causal relationship between status lymphaticus and such convulsive disorders as spasm of the glottis, eclampsia, idiopathic tetany of infants, and epilepsy is largely conjectural. Escherich, who regards spasm of the glottis (thymic asthma) as one of the syndromes of tetany, attempts to account for these neuroses by an hypothesis somewhat like the following:

If, from analogy with the thyroid, we assume that the hyperplasia of the thymus and its coordinated organs (characteristic of status lymphaticus) is, or may be, the expression of an incomplete or perverted metabolism, the condition (status lymphaticus) might be regarded as a dyscrasia or chronic intoxication, comparable to Basedow's disease or the myxedema of cachexia strumipriva. The changes in the skin and in blood formation, and especially the phenomena referable to the central nervous system, show a decided similarity, but differences are present quite sufficient to distinguish the two dyscrasias. While the strumous diathesis tends to impair the intellect to the point of imbecility or idiocy, we find, in the case of the hypothetical lymphatic-chlorotic constitution, that a latent irritability of the nervous system exists, which reacts to trifling stimuli, ineffective in the case of ordinary individuals, with spasmodic conditions in various portions of the body. To this is added, especially in severe cases, the fatal tendency to syncope, mostly in consequence of some opportune case further acting harmfully upon the heart.

Galatti directs attention to a peculiarity of status lymphaticus which, in my opinion, is a factor of importance in explaining some of the clinical phenomena, viz., the peculiar predisposition to edema. This, as Galatti asserts, is shown by the pasty condition of the skin, by the tendency to eczema, and by the occurrence of edema of the brain. I would add, from my observation upon lymphatic epileptics dying abruptly in a single seizure or from rapid status epilepticus, edema of the lungs as another of the manifestations; an observation already made by Kundrat in a case of sudden death during chloroform anesthesia, by Langerhans in the case of his son's sudden death after a prophylactic antitoxin injection, and by Paltauf in at least one of his cases of sudden death. Galatti holds that slight factors like autointoxications of various kinds may incite this tendency to edema into activity. Piedecocq, in his belief that sudden death in infants with hyperplastic thymus is due to increased intracranial pressure resulting in compression of the medulla, is evidently upon the tack taken by Galatti, though he wishes to ascribe the increased cerebral pressure to compression of the great vessels in the neck caused by a backward flexion of the head, aggravating the pressure already exerted by an enlarged thymus, a theory which has recently been well supported by the demonstration of tracheal stenosis after tracheoscopy (Jackson) or by intubation with a long tracheal tube (Marfan).

Whatever its mechanism, I am, from my observation upon lymphatic epileptics and my reflection upon these studies, strongly disposed to the belief that a periodic increase of intracranial pressure, acting either on the exterior or interior of the brain, or on both portions simultaneously, and manifesting itself as a result of the tendency to edema characteristic of status lymphaticus, is a directly provocative factor of such neuroses as spasm of the glottis, tetany, infantile eclampsia, epilepsy, and the various forms of sudden death incidental to the lymphatic state. According to this view, the clinical phenomena would depend upon the extent and location of the intracranial edema, or, in other words, upon the portion of the encephalon particularly subjected to pressure. In the event of compression of the external portion of the cerebrum, various convulsive disorders of the motor apparatus are provoked; when the balance of pressure becomes so distributed as to raise the intracerebral tension, other more severe symptoms supervene, ending, in case of pressure upon the floor of the fourth ventricle, in sudden respiratory or cardiac failure. Granting the hypothesis just advanced, we are brought one step nearer the explanation of the *modus operandi* of several obscure neuroses whose kinship has repeatedly been recognized on purely clinical grounds, and whose morbid anatomical association is proven by the establishment of the lymphatic state as a common basis for all. Cheatle's dictum that "laryngismus, tetany, and general convulsions are the positive, comparative, and superlative of the convulsive state of childhood, "finds support and elaboration.

As a whole, status lymphaticus may, according to Warthin, be regarded as a chronic lymphotoxemia induced by rickets, syphilis, tuberculosis, or other chronic or latent infection as of the mouth, tonsils, cranial sinuses, middle ear, or bowels, accompanied with a general lymphoid exhaustion and hypoplasia, and a compensatory lymphoid hyperplasia of the thymus.

Treatment.—Recalling the intimate association of status lymphaticus and rickets, treatment, particularly in its prophylactic phase, is clearly indicated. Measures which are efficient in the prevention or treatment of rachitis are, on *a priori* grounds, destined favorably to influence the lymphatic state, and incidentally to control those disorders which result from these constitutional dyscrasias. While not recognizing the kinship of rickets and status lymphaticus, Gowers, for instance, reached the conclusion that a certain proportion of cases of epilepsy were ascribable to rickets, and he urged the prophylaxis of rickets as a means destined to prevent epilepsy. My studies on epilepsy and its relations to the lymphatic state have brought me to this same conclusion, and I agree with Gowers that the prevention of rickets is a matter of great moment in suppressing epilepsy, as well as in favorably influencing such other neuroses as spasm of the glottis, tetany, and infantile eclampsia. It is out of the province of this article to discuss the means, especially those of a dietary and hygienic nature, advised for the prevention of rickets, or for combating it when once established. These agents, with the medicinal aid ordinarily employed, are rationally indicated in the prevention or treatment of status lymphaticus.

On the supposition that the thymus is the chief anomaly of status lymphaticus and the agent in producing an autointoxication, numerous suggestions for

the employment of extracts of the gland have been made. Permanently beneficial results have not been recorded in cases in which thymus extract has been administered, and this is likewise true for the thyroid and adrenal extracts. Mendel, who attributed rickets to disturbance of the internal secretion of the thymus, has reported good results following the exhibition of fresh calves' thymus in doses of one gram for each month of the child's age.

Partial or complete removal of the thymus has engaged the attention of those who adhere to the pressure theory of thymic asthma, and in a number of cases this heroic procedure has been practised. The first case reported by König, and quoted by Blake, was a child nine weeks old, which since it was eight days old had suffered from severe attacks of dyspnea. The thymus was made out to be enlarged, extending to the cricoid in the neck. By means of a transverse incision it was exposed, the cervical portion excised, and the thoracic portion drawn up and anchored by sutures to the fascia over the manubrium. The operation was completely successful in relieving the dyspnea, and healing was uneventful.

The second case, also reviewed by Blake and reported by Siegel, was a boy of two and a half years, who had been tracheotomized for a sudden attack of dyspnea. The insertion of an ordinary cannula did not afford relief, and it was not until a tube had been inserted nearly to the tracheal bifurcation that the dyspnea ceased. A diagnosis of enlarged thymus was made, and the thymus was drawn up and sutured to the fascia over the sternum. Recovery was uneventful, with no recurrence of the dyspnea. Similar results have been obtained by Perrucker, Jackson, and others. To the date 1912 about fifty such operations have been recorded, including the forty-two cases reported by Olivier with twenty-three apparent cures. What interpretation to place upon these cases is uncertain. Whether, for instance, the apparent good results were due to relief of pressure, as König and Siegel believe, or whether due to the extirpation of a portion of the thymus *per se*, or to a changed anatomical relationship of the gland, by which some autotoxic effect was annulled, cannot be decided from two isolated cases. However, these cases are at least suggestive from the standpoint of the surgical therapeutics of status lymphaticus, though it is not probable that such a severe measure as partial extirpation of the thymus will be recommended as a legitimate procedure in any except the class of cases indicated by König and Siegel. In this connection, however, it is well to recall the remarkable results which usually follow the removal of nasopharyngeal adenoids and of hypertrophied faucial tonsils, which, as we have learned, are manifestations of the lymphatic state. After making due allowance for the good effects resulting from the relief of the mechanical obstacles imposed by these enlarged structures, the remarkable change in bodily and facial configuration, and the brightening of the intellect not uncommonly observed in these cases, has suggested to more than one observer the possibility of other far-reaching influences besides those of a mechanical nature. It seems highly probable, indeed, that the removal of the offending lymphatic structures carries with it some deep-seated beneficial effect such as one might imagine to result from the removal of an autointoxication. There is certainly abundant evidence to show that the surgical treatment of the enlarged lymphatic structures of the nose and throat is a rationally indicated procedure in the therapeutics of status lymphaticus; and in this same category will probably come the use of Röntgen rays directed to the hypertrophic thymus gland, the good results of which have been noted also in treating exophthalmic goiter where, as already mentioned, enlargement of the thymus is frequently observed.

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Owing to the confusion concerning the relations of the enlarged thymus to the constitutional disorder, most of the literature bearing upon status lymphaticus will be found under the diseases of the thymus as indicated by such titles as "Hypertrophy of the Thymus," "Sudden Death and Hypertrophy of the Thymus," "Thymic Asthma and Sudden Death," etc.

Therefore, instead of attempting to enumerate the papers in which the anatomical and clinical features of status lymphaticus are more or less explicitly discussed, the student's attention will be invited merely to the leading articles dealing specifically with status lymphaticus in its different aspects. Even in some of these articles the title refers directly to the thymus:

Rokitansky: Path. Anatomie, Wien, 1842–46. Definitely mentions the lymphatic dyscrasia and plainly points out the coordinate relations of the enlarged thymus to the lymph-adenoid hyperplasias.

Virchow: Beiträge z. Geburtsh. u. Gyn., 1872. Discusses the relation of arterial hypoplasia and chlorosis and defines the "lymphatic-chlorotic constitution."

Grawitz: Ueber plötzliche Todesfälle im Säuglingsalter. Deut. med. Wochenschr., No. 22, 1888. Reopens the discussion upon thymic, or, more properly, lymphatic sudden death, and marks what may be called the recent era in the study of status lymphaticus.

Paltauf, A.: Ueber die Beziehung der Thymus zum plötzlichen Tod. Wiener klin. Wochenschr., No. 46, 1889, and No. 9, 1890. Clearly defines status lymphaticus by its morbid anatomical basis, and deals with various forms of lymphatic sudden death.

Pott: Ueber Thymusdrüsenhyperplasia und die dadurch bedingte Lebensgefahr. Jahrb. f. Kinderheilkunde, No. 34, 1892. Deals especially with spasm of the glottis and resulting sudden death. The relation of status lymphaticus as the anatomical basis is kept in view.

Nordmann: Ueber did Beziehungen der Thymusdrüse zu plötzlichen Todesfällen im Wasser. Correspdbl. f. Schweize. Aertze, No. 7, 1894. As its title indicates, this paper deals especially with lymphatic sudden death in the water. Status lymphaticus in its anatomical and etiological relations is discussed, though the thymus claims most attention.

Kundrat, v.: Zur Kenntniss des Chloroformtodes. Wiener klin. Wochenschr., Nos. 1–4, 1895. The relations of status lymphaticus to fatal surgical narcosis are there elucidated together with a number of original cases.

Eschereich: Bemerkungen über den sog. Status lymphaticus des Kindes. Berl. klin. Wochenschr., No. 29, 1896.—*Ibid.*: Tetanie, Traité des maladies de l'enfance, tome iv. Considers the various neuroses of status lymphaticus like tetany, spasm of the glottis, eclampsia, and lymphatic sudden death, and elaborates a theory to explain the association.

Galatti: Zur prognostischen Bedeutung des Status lymphaticus der Kinder. Wiener med. Blätter, No. 50, 1896. Lymphatic sudden death is considered, including a discussion of fatal accidents after antitoxin injections as illustrated by the Langerhans case. Mentions the predisposition to edema.

Ewing: The Lymphatic Constitution and Its Relations to Some Forms of Sudden Death. New York Medical Journal, July 10, 1897. An excellent review of status lymphaticus in its different aspects, with a presentation of most of the literature to that date. Apparently the first article in English dealing with status lymphaticus *per se*.

Ohlmacher: Bulletin of the Ohio Hospital for Epileptics, Nos. 1, 2, and 3, 1898–99. Several papers discussing especially the question of status lymphaticus and epilepsy.

Daut: Ueber die Beziehungen des Status lymphaticus zur Diphtherie. Jahr. f. Kinderheilkunde, Heft 2 and 3, 1898. As shown by its title, this paper concerns the relations of status lymphaticus to diphtheria and contains the most exhaustive study of this phase of the subject thus far published.

Klein: Neuere Arbeiten über die "Glandula thymus." Zusammenfassendes Referat. Cent. f. allgem. Path. u. path. Anat., Nos. 16, 17, 1898. Though primarily considering the diseases of the thymus, this review cites all of the important papers bearing on status lymphaticus, and reviews them briefly.

Blake: The Surgical Aspects of the Status Lymphaticus. Annals of Surgery, June, 1902. The purpose of this American paper is indicated by the title.

Von Sury: Vierteljahrschrift für Gerichtliche Medizin, 1908, brings the literature up to date.

Wartha: The Pathology of Thymic Hyperplasia and the status Lymphaticus. Archives of Pediatrics, August, 1909. Particularly valuable in its data on the gross and Microscopic anatomy, and presents the theory of lymphotoxemia and "lymphoid exhaustion."

Bartel, Julius: Status thymicoplasticus und Status hypoplasticus. Ein Beitrag z. Konstitutionslehre. Leipzig and Wien, 1912. A still more recent review of the literature is embodied in this monograph.

Stavesacre.—See *Staphisagria.*

Steamboat Springs.—Routt County, Colorado.

POST-OFFICE.—Steamboat Springs. Hotels.

ACCESS.—Via Denver, Northwestern and Pacific Railway of which Steamboat Springs is at present the terminus. Under the reorganization of this road, however, it is now being pushed rapidly westward to Salt Lake City. It is connected also by good mountain roads with Laramie City, Wyoming, and with Georgetown, Dillon, Glenwood Springs, Hayden, and other points.

The town of Steamboat Springs is located in a charming valley in northwest Colorado, just over the main range of the Rocky Mountains and near the headwaters of the Yampa River. The site is upon a bend of the Yampa, where, from its northerly flow, it turns sharply to the west. The mountain range here follows the contour of the river, lifting its lofty summits, covered all summer with their ever-melting but never-melted snow, on two sides of the valley to the north and east. Thus is formed a natural basin, sheltered on the side toward the north by its mountain bulwark leaving its southern slope open to the rays of genial sunshine. Three large mountain streams—Soda Creek, Crystal Brook, and Spring Creek—rise at different points along the curve in the mountain range, and, converging as they flow down, join the Yampa on the town site. These streams furnish a never-failing supply of pure water, and, with a group of sixty varieties of hot, warm, and cold mineral springs, make this valley one of the most remarkable natural watering-places in the world. Since the time of the first settlement, a flourishing town containing churches, schools, libraries, banks, newspapers, and other adjuncts of civilization, has sprung into existence. The town and vicinity offer many attractions to the enterprising settler, as well as to the tourist, the sportsman, and the invalid. The climate during the open season—*i.e.* from April until late in December—is ideally temperate, clear, balmy days and cool nights being the rule. The springs, more than one hundred and fifty in number, yield an exhaustless supply of water. They range in temperature from 40° to 153° F. Among the prominent ingredients are soda, magnesia, iron, and sulphur.

Following are analyses of a few of the mineral springs found here:

Steamboat Spring.
Temperature 80° F.
One Pint Contains:

Solids.	Grains.
Sodium chloride	14.62
Potassium sulphate	0.61
Magnesium sulphate	0.85
Calcium sulphate	1.57
Sodium carbonate	5.18
Phosphoric acid	Trace
Silicic acid	Trace
Iron oxide	Trace
Total solids	23.13
Cubic Inches of Gas.	
Hydrosulphuric acid	6.14
Carbonic acid	0.90

Navajo Springs
One Gallon Contains:

Solids.	Grains.
Calcium sulphate	16.28
Sodium sulphate	21.32
Iron carbonate	14.20
Potassium carbonate	12.16
Silica	0.30
Alumina	0.54
Carbonic acid gas	Trace
Total solids	64.80

Bath Spring.
Temperature 103°F.
Flow 225 Gallons per Minute.
One Pint Contains:

Solids.	Grains.
Calcium carbonate	1.71
Sodium sulphate	0.69
Magnesium sulphate	0.76
Sulphuric acid	0.07
Silicic acid	2.79
Phosphoric acid	Trace
Potassa	Trace
Alumina	Trace
Totals solids	6.02

The waters have been found useful in rheumatic disorders and skin diseases, and were resorted to by the Indians for many years before the appearance of the "pale face" in this region. A large bath-house with swimming pool and numerous bath-rooms has been built to utilize the water from the hot springs.

EMMA E. WALKER.

Steapsin.—The lipase of pancreatic juice.

F. P. U.

Steatoma.—By many writers this term is used synonymously with lipoma; but by others it is applied to a hard variety of this tumor, in which the fat cells are of small size and the amount of connective-tissue reticulum relatively large. Such tumors resemble bacon in their gross appearances and have been designated by German authorities "Speck-tumor." In the majority of cases such tumors arise from the atrophy of the fat cells in any ordinary lipoma, and the characteristic appearance and consistence of the growth are, therefore, to be regarded as the result of secondary changes. Other writers apply the term steatoma to any variety of fibrolipoma, and the designation has even in a few instances been transferred to fibromata. By other writers still, atheromata, sebaceous cysts, and dermoid cysts, as well as retention cysts of varying origin containing fatty or pultaceous material, are also called steatomata. The varied and indefinite use of the term would appear to offer good reasons for its abandonment.

ALDRED SCOTT WARTHIN.

Stegomyia.—A genus of mosquitos which includes important disease carriers. The body and legs are banded. *S. calopus* is the carrier of yellow fever.

A. S. P.

Steno (or Stensen) Nicolaus.—Born in Copenhagen, Denmark, Jan. 10, 1638. He began the study of medicine in the university of his native city at a comparatively early age, and in due time was given the degree of Doctor of Medicine. He then visited, one after the other, the different universities of Europe, and finally settled at Padua, in Italy. In 1669 the Grand Duke of Tuscany, Ferdinand II, who resided at Florence, appointed him his First Physician. In 1671 he was recalled to Copenhagen to occupy the Chair of Anatomy in the university of that city; but he soon lost interest in this post, and then went back to Italy. During the remaining years of his life he devoted himself entirely to religious work. He died in Titiopolis, Greece, Nov. 25, 1686.

His discovery of the duct which bears his name—Steno's or Stensen's duct—assures him a permanent place in the history of medicine. The treatise in which the description of this duct first appears bears the following title: "Observationes anatomicæ, quibus varia oris, oculorum et narium vasa describuntur, novique salivæ, lacrymarum et muci fontes detegun-

tur, et ut novum Bilsii de lymphæ motu et usu commentum examinatur et rejicitur," Leyden, 1662.

A. H. B.

Sterility in Man.—Definition.—Sterility in the male is that condition in which he is unable to impregnate the female. As stated in a former article,[4] the condition must be strictly differentiated from impotence, in which latter condition the man is unable to perform the sexual act. The sterile man is not necessarily impotent, while it is also possible for a partially impotent man to impregnate his wife. Thus, a man may be perfectly able to perform the sexual act including ejaculation, but, on account of occlusion of both vasa, due in most cases to a previous double epididymitis, no spermatozoa will be found in his semen and he will be sterile. Again, he may be suffering from hypospadias or epispadias, in which cases, on account of the abnormal positions of the urethral opening, the semen may be ejaculated outside of the female genitals during coitus, and sterility be caused thereby. On the other hand, it is possible for a partially impotent man, one suffering from rapid ejaculation, to manage to get some of his semen into the female genitals, and thus, although impotent, he may still be able to impregnate his partner. As a general rule, however, the impotent man is also sterile for the time being.

It must be remembered, however, when consulting foreign literature, and even some American literature, that some authors make the word "impotence" include both sterility and impotence, calling the former "impotentia generandi" and the latter "impotentia coeundi." In a previous article[5] I have called attention to the fact that this classification often causes great confusion and ought to be abandoned.

Etiology and Pathology.—In order that impregnation take place, a live spermatozoon of the male must come in contact and unite with the ovum of the female. As far as the man is concerned, it is only necessary for him to bring his healthy semen into the cervix of the female, and as long as he is able to do this, he is absolved from any responsibility if impregnation does not occur. In unusual cases, impregnation has occurred merely by bringing the semen in contact with the external genitals, but these cases are the exceptions.

The principal ingredient of the semen is the spermatozoa. These are made in the testicles from whence they pass through the epididymis and vas, and, in the intervals of coitus are stored in the seminal vesicles. The semen proper is a mixture containing numerous spermatozoa, plus the secretions of the seminal vesicles, the prostate and the urethral glands. The spermatozoa plus the vesicular secretion enter the prostatic urethra through the ejaculatory ducts, where they mix with the prostatic secretion. This mixture during coitus then passes through the entire urethra, mixing with the secretions of the urethral glands, and the entire substance, the semen proper, is ejaculated into the genitals of the female during coitus.

Any factor, therefore, which interferes either with the manufacture of the spermatozoa, or with their vitality, or prevents their expulsion into the female genitals, may cause sterility. We may, therefore, recognize the following etiological factors.

1. *Sterility Caused by Interference with the Manufacture of Spermatozoa.*—Under this heading may be mentioned congenital absence of both testicles; double castration done for various reasons; undevelopment or severe injury to both testicles; atrophy due to mumps or more rarely to typhoid fever and other acute febrile conditions; prolonged exposure to the *x*-ray. Herein may also be mentioned certain severe forms of tuberculosis of both testicles, in which no spermatozoa are manufactured, as well as certain rather unusual cases of syphilis of both testicles.

2. *Sterility Caused by an Interference with the Vitality of the Spermatozoa after They Have Been Manufactured.*—Under this heading may be mentioned severe forms of seminal vesiculitis, especially where both seminal vesicles are the seat of purulent inflammation. Here the spermatozoca which are stored in the seminal vesicles are destroyed. Severe inflammation either of the vasa, the ejaculatory ducts, the epididymides, or the urethra may at times cause sterility by destroying the spermatozoa through the altered chemical action of the secretions. These latter conditions must, however, be very severe in character, and are, moreover, very unusual, as spermatozoa may retain their viability and may cause impregnation while passing through a urethra infected with acute gonorrhea.

3. *Sterility Caused by Conditions which Prevent the Expulsion of the Spermatozoa into the Female Genitals.*—Under this heading we find as the most frequent cause occlusion of both vasa due to double gonorrheal epididymitis. In this condition, although coitus may be absolutely normal including ejaculation, not one spermatozoon is enabled to reach the urethra. In tuberculous and syphilitic epididymitis, the same conditions may obtain. In the prostatic urethra, in rare cases, we find bands of tissue constricting the openings of both ejaculatory ducts causing sterility.[8]

Herein come also those cases of tight stricture of the urethra, in which the semen is prevented from coming out during coitus, although it may dribble out later on when the penis has resumed the flaccid condition. Under this heading come also those cases of impotence in which neither erection nor ejaculation takes place, or in which ejaculation is so rapid that the semen is expelled before the penis has had time to enter the vagina (premature ejaculation). Absence of penis, as well as rudimentary penis, may cause both impotence and sterility. Finally may be mentioned extreme cases of hypospadias and epispadias, in which during coitus, the semen is ejaculated entirely away from the female genitals.

Symptoms.—Strictly speaking there are no symptoms, except the inability to procreate. The man may be perfectly potent and experience all the pleasure of coitus, have normal libido and ejaculation and still be sterile. In some cases the knowledge that he is hopelessly sterile may produce severe psychic symptoms, and even in rare cases lead to suicide.

Diagnosis.—The diagnosis is made from an examination of the semen. Aspermia is that condition in which no semen at all is ejaculated. Oligospermia is the discharge of very little semen. Azoöspermia is that condition in which no spermatozoa at all are found in the semen, while oligozoöspermia means a marked diminution in the number of spermatozoa in the semen. Necrospermia is that condition in which the semen contains only motionless spermatozoa.

But the diagnosis is not complete by merely examining a condom specimen. We must get at the underlying cause of the condition. Aspermia may be due to a complete absence of the testicles, to a tight urethral stricture, to the presence of bands in the neighborhood of the openings of the ejaculatory ducts in the prostatic urethra,[8] or to a paralysis or inhibition of the ejaculatory centers in the spinal cord. In this latter condition, the patient has normal libido and normal erection, but try as hard as he may, he does not have any ejaculation. In some of these cases, the patient may be able to masturbate and bring semen containing lively spermatozoa out of the meatus, and in others he may have nocturnal pollutions containing lively spermatozoa, while in still other cases, massage of the seminal vesicles may bring out fluid containing normal spermatozoa, but during coitus there is no ejaculation. Azoöspermia is generally due to occlusion of both vasa consequent upon a double gonorrheal

epididymitis. It may also be due to tuberculous and less frequently to syphilitic epididymitis or orchitis.

In cases of azoöspermia, we must not be satisfied in merely examining the condom and noting the absence of spermatozoa, but must determine, if possible, if the condition is due to an occlusion of the vasa, or to the fact that the testicles no longer produce spermatozoa. In order to determine these facts, we aspirate one or both testes and examine the fluid for spermatozoa. In necrospermia, we must determine if the spermatozoa are dead before leaving the testicles, or are killed after they have left these organs by the secretions of some portion of the genitourinary tract.

But the diagnosis or responsibility for the sterility in any particular case cannot always be definitely settled by merely examining a condom specimen. As I have pointed out elsewhere[1,2,3] the condom specimen may be absolutely normal, and yet the male be responsible for the sterility. Such is the case in epispadias, hypospadias, tight stricture of the urethra, rapid or premature ejaculation, etc. *As long as live spermatozoa are not found on the os uteri of the female after coitus, the male may be the cause of the sterility*, and conversely, *if live spermatozoa are found on the os after coitus, the husband is absolutely absolved from all responsibility of the sterility.* The technique of looking for spermatozoa in the female genitals is fully described in my book on this subject,[1] to which the reader is referred.

Prognosis.—The prognosis depends upon our ability to relieve the underlying cause. Sterility due to absence or total destruction of both testicles can of course not be relieved. Sterility due to complete absence of penis is also incurable unless artificial impregnation can be resorted to. Sterility due to rudimentary penis can sometimes be relieved by artificial apparatus.[6] Sometimes the penis develops to its normal size after the prolonged use of such apparatus. The outcome of sterility due to impotence depends of course upon our ability to cure the impotence. Sterility due to complete closure of both vasa is absolutely hopeless if the condition has lasted more than three years unless relieved by epididymovasostomy. Sterility due to syphilis, unless very extreme, can generally be relieved by antisyphilitic treatment. The prognosis of sterility due to tuberculous epididymitis or orchitis is generally very bad. Sterility due to prolonged exposure to the *x*-ray is generally good, if further exposure is stopped. As a general rule, however, it takes several years before live spermatozoa are again found in the semen.

Treatment.—A glance at the etiological factors will at once suggest the proper treatment. In those cases in which there is an interference with the manufacture of spermatozoa, all treatment is obviously of no use, except possibly in the syphilitic cases, where active antisyphilitic treatment may be of use.

In cases where spermatozoa are produced but are destroyed after production, appropriate treatment will at times cure the sterility. In seminal vesiculitis, massage and stripping of the seminal vesicles with treatment of the posterior urethra will often affect a cure. In very bad cases, Fuller has effected a cure by his operation of drainage of the seminal vesicles.

In the sterility which has followed a double epididymitis, the treatment should at first be directed toward the posterior urethra, and if no spermatozoa appear in the semen after a few months' treatment, the only thing left is Martin's operation of epididymovasostomy. This is successful in but a small number of cases, but it is the only practical procedure that can be done. I have tried in some of these cases[1] to cure the sterility by injecting the aspirated testicular fluid (if it contains live spermatozoa) both with and without admixture of prostatic fluid, obtained by massaging the husband's prostate into the cervix of the wife, but without any success. This procedure has been successful in animals, but never in human beings.

For sterility due to impotence in the male, the treatment of the impotence described in my previous articles[4,5] should be followed. In severe cases of rapid or premature ejaculation, we may try artificial impregnation by injecting the semen directly from the condom specimen into the female cervix. Tight stricture of the urethra, hypospadias, epispadias, as well as other organic conditions which may be the cause of the sterility, should receive the generally recognized genitourinary treatment for such conditions.

Max Hühner.

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Sterility in Woman.—*Definition.*—Inability on the part of a woman to conceive and produce a living child.

A woman who has carried on normal sexual relations for two years and has not become pregnant may be regarded as sterile. This period of time is arbitrarily chosen because two-thirds of all marriages result in a pregnancy before the end of the second year and unless conception has been voluntarily prevented most of the remaining third will eventually seek professional advice and treatment. Sterility is normal before puberty, during lactation, and after the menopause. It is well known that the birth rate in the United States, especially among the married native born white women, is rapidly decreasing. Engleman in a study of the statistics of lessened fertility of American women estimated that twelve per cent. of sterility is due to disease. He called attention to the fact that the number of children born in each native white family had decreased from four or five at the beginning of the nineteenth century to two at the beginning of the twentieth century.

Statistics indicate that approximately ten per cent. of all marriages are sterile. The fault, however is not always with the female, as in sixteen to twenty-five per cent. of sterile marriages the cause of the sterility can be ascribed directly or indirectly to the male.

Various qualifying terms are used to indicate different types of sterility. In general it is known as primary or secondary, the former indicating that the woman has never conceived, or having conceived has been unable to bear a living child because of defects or lesions either congenital or acquired, and the latter indicating that the woman has borne one child but fails to conceive thereafter. Absolute sterility denotes a condition where impregnation is obviously impossible owing to the absence of certain organs as vagina, uterus, or ovaries.

The factors essential for conception are: (1) a normal ovum; (2) healthy and active spermatozoa; (3) normal tubal, uterine, and vaginal secretions; (4) a healthy endometrium in which the fertilized ovum may lodge and develop. To meet these requirements the male as well as the female must be healthy

and the seminal discharge must contain an abundance of normal active spermatozoa.

Etiology.—The causes of sterility in women are: (1) malformations or congenital anomalies, (2) inflammations and infections, (3) injuries, (4) tumors, (5) constitutional diseases.

Malformations or Congenital Anomalies.—Aside from the comparatively small number of cases of primary sterility due to a total absence of the vagina or uterus or ovaries, there are many instances of sterility in which all the pelvic organs are present but have failed to reach complete maturity in their development. Fortunately this condition of congenital hypoplasia is observed more constantly in the uterus than in any of the other pelvic organs and the lesions therein may be more successfully treated.

Clinical findings here fall usually into one of three groups: (*a*) a small, poorly developed uterus with scanty menstruation; (*b*) a small uterus with anteflexion and a normal period except for dysmenorrhea; (*c*) a uterus normal in size but with a long, conical cervix and a stenosis of the cervical canal, the menstrual period tending to be profuse and prolonged and associated with considerable dysmenorrhea. Any one of these groups may be complicated by a retroversion of the uterus. No cases of secondary sterility occur in this group.

Inflammations and Infections.—The form of inflammation with which one is chiefly concerned as a cause of sterility is the one resulting from infection by the gonococcus during sexual intercourse. This infection may have been of the explosive type, resulting in an acute widespread involvement of all the pelvic organs and a well-marked pelvic peritonitis, or it may have been a slow, chronic insidiously progressive type of infection never incapacitating the individual from active work, but gradually resulting in a low-grade inflammatoy disturbance throughout the endometrium and the uterine tubes and showing itself clinically in an increased or prolonged menstrual flow with some dysmenorrhea, and a yellowish mucopurulent vaginal discharge with no special urinary or bladder discomfort. This chronic form of infection may be present without the patient's knowledge. Gonorrheal infections travel by surface extension and very infrequently by the lymphatic or blood stream; in these chronic cases, therefore, practically the entire lesion may be limited to the endometrium and the mucous membrane of the uterine tubes, with little or no gross change in the organs, so that a bimanual examination gives negative findings and repeated microscopic examinations of smears made from the cervical discharge may fail to show the gonococcus. However, the organism can in many instances be obtained by expressing the secretion from Skene's tubules at the urethral orifice. Any case of sterility associated with a mucopurulent cervical discharge is practically always the result of a gonorrheal infection.

Another group of cases, many of which are of gonorrheal origin, is that associated with chronic endocervicitis evidenced by the presence of a tenacious plug of mucus in the cervical canal and blocking the external os, but without any pus in the discharge. In such cases the women are practically always sterile, the mucous plug in the cervix seeming to present an impassable barrier to the spermatozoa.

A fairly large number of cases of secondary sterility belong to this group as a result of gonorrheal or pyogenic infections in the puerperium or following spontaneous and induced abortions.

The gonococcus traveling by surface extension is more apt to cause an endosalpingitis with destruction of the mucosa and blocking of the lumen of the tubes at various points, whereas the pyogenic germs are more apt to cause a perisalpingitis with closure of the fimbriated ends of the tubes by adhesions and fibrinoplastic exudate.

Conditions leading to hyperacidity of the vaginal secretion are usually due to infection and may be associated with suppuration or a very profuse vaginal discharge. According to Edward Reynolds such alterations in the secretions are most important factors in the destruction of the spermatozoa and in the production of sterility.

Tuberculous inflammation of the endometrium or of the mucous membrane of the Fallopian tubes may prevent conception.

Injuries.—Under this heading may be classified cases of sterility due to acquired malpositions of the uterus; to lacerations of the cervix and pelvic floor; and to the destructive effect of the *x*-ray on the follicles of the ovaries.

Tumors.—Neoplasms of the vulva and vagina may by their size or location mechanically interfere with intercourse and thus lead to sterility. Cancer of the cervix or of the corpus uteri usually inhibits conception. Fibromyomatous growths in the uterus are commonly associated with sterility, especially the one child type, either as a result of endometrial hyperplasia or of accompanying lesions of the tubes. Ovarian tumors do not necessarily lead to sterility.

Constitutional Diseases.—Of these the most common are tuberculosis, chlorosis, Graves' disease, diabetes, obesity, etc. Diseases of the various organs of internal secretion are usually attended with genital atrophy or infantilism and sterility. Hypophyseal diseases, such as acromegaly and gigantism also lead to amenorrhea and sterility.

A certain small number of cases of sterility are dependent apparently upon some other factor than those already mentioned, for a careful examination discloses no congenital defect and no evidence of past or present infection, injury to the pelvic organs, or neoplasm, and yet with an apparently healthy woman conception does not occur. In such cases one will occasionally find the explanation in an increased acidity of the vaginal secretion as a result of excessive decomposition with lactic acid fermentation, and these cases are often cured by using saline or bicarbonate of soda douches at bedtime.

Sometimes apparently healthy women will go for years without a pregnancy, and then at last when they reach the menopause and the symptoms of the climacteric are establishing themselves they will become pregnant. In such cases there may have been abnormal tubal, uterine, or vaginal secretions which, with the lessening physiological activity of the impending climacteric have become more normal.

Treatment.—This is based upon a careful study and proper classification of the etiological factors in each case. Having classified the case, if possible, in one of the above-mentioned groups and ascertained that the husband is not at fault, how shall the condition found be treated?

If the examination is negative and the woman appears perfectly normal she should use a physiological salt douche at bedtime and intercourse should be restricted to the week preceding the menstrual period, as in many of these cases there is too frequent intercourse, with increased ovarian and uterine congestion, resulting in the production of a uterine secretion which inhibits or is detrimental to the activity of the spermatozoa.

In cases of sterility associated with uterine anomalies, groups (*a*) and (*b*) can be greatly benefited by a thorough dilatation of the cervix, a superficial curettage of the endometrium above the cervix, and the use of a stem pessary retained by a suture and left in for about three weeks. Group (*c*) can be helped by a dilatation and curettage and a Dudley operation on the elongated cervix.

A retroversion occurring in any of these groups should be corrected by the use of an appropriate pessary or by an operation.

Sterility due to gonorrheal infection is least satis-

factory to treat. As a rule, the infection is no longer active when the patient comes for advice and one has to deal with end results which vary according to the extent of the primary inflammation. If the bimanual examination does not disclose any lesion of the tubes or ovaries, one is justified in performing a careful dilatation and curettage of the uterus and in ordering only saline douches. Should the patient not become pregnant within a year and there is an undoubted history of previous gonorrheal infection, and an examination of the husband shows plenty of normal, active spermatozoa, then one is justified in assuming that the tubes were probably involved in the inflammatory process and in advising an exploratory celiotomy for the purpose of freeing adhesions and opening the tubes if they are found to be closed.

The acceptance of this advice will depend upon how anxious the patient is to leave nothing undone that may aid her in obtaining a cure, and as a matter of fact the patient has to assume the burden of responsibility in cases of this particular type, for the exploratory celiotomy may not disclose any lesion of the tubes, although in many cases chronic salpingitis with adhesions and blocking of the tubes will be found.

Gonorrheal cases which are quiescent but present a definitely palpable lesion of the tubes and ovaries require not only a curettage of the uterus for the purpose of restoring the endometrium to normal, but must also undergo an abdominal operation to permit of plastic surgery on the tubes, which in all probability will be found closed at their fimbriated ends.

Injuries.—All malpositions should be corrected surgically if necessary. Lacerations of the cervix and pelvic floor should be repaired.

Tumors.—Where the sterility seems to be due to the presence of fibromyomatous tumors in the uterus, one should do a curettage and, if possible, a myomectomy. Organotherapy in the treatment of sterility associated with various disturbances of internal secretions has not been satisfactory. WILLIAM P. HEALY.

Stewart, Sir Thomas Grainger.—Born at Edinburgh, Scotland, Sept. 23, 1837. He studied medicine in Edinburgh, Berlin, Prague, and Vienna, and received his doctor's degree in 1858 from the university of the first-named city. In the following years he held various hospital and teaching positions, to wit: in 1862, Pathologist at the Royal Infirmary; in 1869, an Attending Physician at the same institution; and in 1876, Professor of the Practice of Physic and of Clinical Medicine. The department of internal diseases in which Stewart took special interest was that of renal pathology. He died Feb. 3, 1900. Toward the close of his career the title of Baronet was conferred upon him.

Of Stewart's published writings the following deserve to receive special mention: "A Practical Treatise on Bright's Disease of the Kidneys," second edition, 1871; "Clinical Lectures on Important Symptoms—I. Giddiness (second edition, 1898), II. Albuminuria (1888);" "Introduction to Diseases of the Nervous System," 1884; "Paralysis of Hands and Feet from Diseases of Nerves," 1881; and "Eye Symptoms in Locomotor Ataxia," 1879. "Diseases of the Trachea and Bronchial Tubes," in vol. vi. of the Twentieth Century Practice of Medicine, 1896.

A. H. B.

Stillé, Alfred.—Born in Philadelphia, Pa., Oct. 30, 1813. His ancestors, on the father's side, were Swedish. He studied medicine at the University of Pennsylvania and received the degree of Doctor of Medicine from that institution in 1836. During the following two years he continued his medical studies in Paris and the other European capitals. From 1839 to 1841 he was Resident Physician of the Pennsylvania Hospital. From 1854 to 1859 he was Professor of the Theory and Practice of Medicine in the Pennsylvania Medical College. In 1864 he was chosen to occupy a similar chair in the University of Pennsylvania, and he continued to hold it until 1884. He died Sept. 24, 1900.

Of his published writings the following deserve to receive special mention: "Elements of General Pathology," 1848; "Therapeutics and Materia Medica," 1860 (three later editions: 1864, 1868, 1874); and "Epidemic Meningitis, or Cerebrospinal Meningitis," 1867. In 1860 he published a new edition of "A Treatise on Medical Jurisprudence" by Drs. Francis Wharton and Moreton Stillé (a younger brother of Alfred), 1855; the medical part being revised and corrected, and considerable new text added. In 1879 he was associated with John M. Maisch in the preparation of the National Dispensatory.

A. H. B.

Stillingia.—U. S. P., *Queen's Root.* The dried root of *Stillingia sylvatica* L. (fam. *Euphorbiaceæ*). This is a perennial plant, with a large, tough, spongy root, and erect herbaceous or slightly woody stem, a foot or so in height, growing abundantly in the Southern States, where it has been used for about half a century.

The drug usually occurs in short transverse sections of very long, tapering, slenderly fusiform roots, about 2.5 centimeters (one inch) or less in thickness, very light, tough, and spongy; externally of a deep or occasionally a light reddish brown, finely, shortly, and crookedly longitudinally wrinkled and incompletely annulate, especially the thicker portions, with constrictions which frequently become slight fissures; ends of the sections pinkish, very fuzzy with innumerable partly detached fine bast fibers, the bark very thick, containing scattered fine resin cells and laticiferous ducts; the wood radiate, fibrous, and porous; odor slight, peculiar; taste pungent, bitter, and acrid.

The activity of stillingia depends upon three or four per cent. of a nauseous volatile oil, a large amount of soft resin, and a fixed oil, the composition of which has not been studied, but which apparently holds an acrid substance in solution. There are considerable tannin, starch, and other unimportant constituents. It should not yield more than five per cent. of ash.

Stillingia is an emeticocathartic, like many other plants of its family, and is said to be "alterative." Upon this property depend its principal uses, which are very similar to those of sarsaparilla, in syphilis, rheumatism, gout, etc. That its use is mildly beneficial cannot be doubted. Belonging to the same family with the castor and croton-oil plants (see *Euphorbiaceæ*), it rather actively promotes the excretions, from which result its amelioration of the above-named diseases evidently proceeds. Dose gr. xv. to xxx. (1.0–2.0) two or three times a day. A fluid extract is official (*Fluidextractum Stillingiæ*, U. S. P.), dose ♏xv.–xxx. (1.0–2.0).

HENRY H. RUSBY.

Stokes, William.—Born in Dublin, Ireland, in 1804. He studied medicine in Edinburgh, Scotland, and received his doctor's degree in 1825. In the early part of his professional career he was associated with Graves in introducing genuine clinical instruction and in perfecting the relatively crude methods of physical examination which were in use at that time. Thanks to the efforts made by these two men the knowledge of diseases of the chest was soon materially enlarged. Stokes was chosen President of the British Medical Association in 1867, and of the Royal Irish Academy in 1874. In the following year he resigned his position of Attending Physician at Meath Hospital —a position which he had held since 1826—and he also

retired from private practice. He died January 7, 1878.

Stokes owed much of his reputation to the three classical treatises which he published during the years 1837–74, viz., "Treatise on the Diagnosis and Treatment of Diseases of the Chest," Dublin, 1837; "The Diseases of the Heart and the Aorta," Dublin, 1854; and "Lectures on Fever," Dublin, 1874. Of his other published writings the following also deserve to receive mention here: "An Introduction of the Use of the Stethoscope with its Application to Diagnosis in Diseases of Thoracic Viscera," Dublin, 1825; "Clinical Reports of the Medical Cases in the Meath Hospital," Dublin, 1827 (written conjointly with J. R. Graves); and "Lectures on the Theory and Practice of Physic," Philadelphia, 1837. A. H. B.

Stokes, Sir William.—Son of the foregoing, was born March 10, 1839, and died Aug. 18, 1900. Of his more important contributions to medical literature the following deserve to be mentioned here: "On Supracondyloid Amputation of the Thigh," in *Medico-Chir. Transactions*, 1870; "On a Hundred Cases of Stricture of the Urethra," in *Dublin Journal*, 1871; "On an Extension Apparatus for the Treatment of Certain Injuries and Diseases of the Lower Extremity," in *British Medical Journal*, 1878; and "On Acute Myxedema following Thyreoidectomy," in *Brit. Med. Journal*, 1886. A. H. B.

Stomach, Anatomy of the.—The stomach exhibits the usual four layers found in the alimentary tract, called, from within outward, the tunica mucosa, the tela submucosa, the tunica muscularis, and the tunica serosa.

The tunica mucosa is the glandular lining membrane of the stomach. In the fresh condition it is of fleshy consistence and of a pinkish color. The color of the fresh mucous membrane depends on three factors—the amount and venosity of the blood contained in its vessels, the physiological condition, and the character of the glands. In the dog, in the resting condition, the mucous membrane of the greater curvature of the stomach presents a grayish-pink appearance and is relatively opaque. After digestion has been going on for some hours, the grayishness and opacity disappear and the mucous membrane presents a rose-pink color.

If the veins are engorged the grayish-pink tint is deepened to a chocolate pink, which rapidly brightens on exposure to the air. The mucous membrane of the pyloric portion of the stomach is always more transparent, paler in color, and firmer in consistence than that of the fundus and corpus ventriculi.

The point of contact of the esophageal and gastric mucous membranes at the cardia forms a somewhat zigzag line, the esophageal epithelium extending in the form of irregular conical projections into the stomach (Schaffer) in such a manner that frequently in longitudinal sections engaging the termination of the esophagus and the beginning of the stomach, portions of the epithelium of the former may appear as isolated patches surrounded by gastric epithelium. This irregularity of the gastroesophageal junction is an indication of that tendency of the esophageal epithelium to invade the stomach and displace the glands, which in some of the lower primates, Innus, Semnopithecus, etc., has resulted in the formation of a distinct chamber of the stomach, lined by stratified epithelium. At the summit of the musculus sphincter pylori the gastric mucous membrane is continuous with the tunica mucosa duodeni.

In the contracted stomach the tunica mucosa is thrown up into a series of coarse folds, the plicæ mucosa, mainly longitudinal in direction, but with transverse and oblique connecting folds. These plicæ mucosæ involve the whole thickness of the tunica mucosa and the superficial layer of the tela submucosa. When the stomach is distended to its utmost the folds disappear. A permanent fold at the pyloric end of the stomach, caused by the projection into the cavity of the musculus sphincter pylori, forms the valvula pylori.

The whole surface of the mucous membrane in man is indistinctly marked off by irregular sulci, of varying depths, into small fields a few millimeters in width, the areæ gastricæ, giving the tunica mucosa the so-called mammillated appearance.

If the surface of the mucous membrane be examined with a lens, the close-set depressions, foveolæ gastricæ, into which the gastric glands open, may be seen. These openings are separated from one another by delicate partitions which in the pyloric region are often continued into pointed villus-like processes, projecting into the cavity of the stomach as the plicæ villosæ. Cases have been reported in which the whole inner surface of the stomach was beset with these villus-like processes. The number of foveolæ opening upon the surface of the gastric mucous membrane has been estimated by Toldt to be eighty-seven per millimeter. The total extent of the mucous membrane measured in the same individual by means of the planimeter was 76,300 square millimeters, giving 6,638,100 as the total number of foveolæ in the stomach. It seems probable, however, that the number of foveolæ is subject to considerable variation in different individuals. In a number of pathological cases reported by Einhorn, the number varied from twenty to 160 per square millimeter.

The whole of the surface of the mucous membrane and the walls of the foveolæ gastricæ are covered with a simple cylindrical epithelium, mucigenous in function, uniform in type throughout the stomach, but differing somewhat in structural details in the different regions. The cells of this epithelium are somewhat conical in shape, but vary with the shape of the surface upon which they rest, the conical shape being more pronounced on convex surfaces. The pointed apex of the cells rests against the reticular tissue of the lamina propria mucosa; the broad, slightly convex base of the cell is directed toward the free surface of the tunica mucosa. The adjacent surfaces of the epithelial cells are separated from one another by minute spaces, across which the cells are connected by protoplasmic intercellular bridges. The intercellular spaces are closed internally by lines of cement (*Schlussleisten* of Kohn) which connect the adjacent free edges of the cells. This cement substance is not entirely confined to the intercellular location, but, as shown by Carlier in the newt and by Bensley in man, extends over the free surface of the cell in delicate radiating lines which may easily be mistaken by an inexperienced observer for traces of a striated cuticula. The distal portion of each epithelial cell forms a cup-like cavity, the theca, which contains the specific secretion of the cell; in this case mucin or its antecedent substance. The contents of the theca are in the form of small droplets, which appear in sections of properly fixed material, stained in an alcoholic solution without exposure to water, as fine granules. If the mucin has been allowed to absorb water and go into solution, it precipitates in the form of the coarse spongy network which is usually seen in the theca of these cells. The distal portion of the theca contains very little cytoplasm, but in the proximal portion the granules are separated into groups by threads of cytoplasm which form a coarse network. The conical attached end of the cell is occupied by a homogeneous cytoplasm contains an oval nucleus in which many fine mitochondrial filaments may be seen.

Between the nucleus and the theca the cytoplasm stains less deeply than that in the base of the cell, owing to the presence of the structures which have been interpreted by Holmgren as similar to the canal-

like structures observed by him in the hepatic cells, to which he has applied the name trophospongium.

The so-called replacing cells (*Ersatzzellen* of Ebstein) do not exist in the epithelium of the stomach, the structures which have been described under this name being, as suggested by Stöhr, in all probability, lymphocytes which have invaded the epithelial layer.

The epithelium of the foveolæ gastricæ is, as has been indicated, similar to that of the free surfaces, but on going down the foveolæ, certain changes of a transitional character make their appearance as the bottom

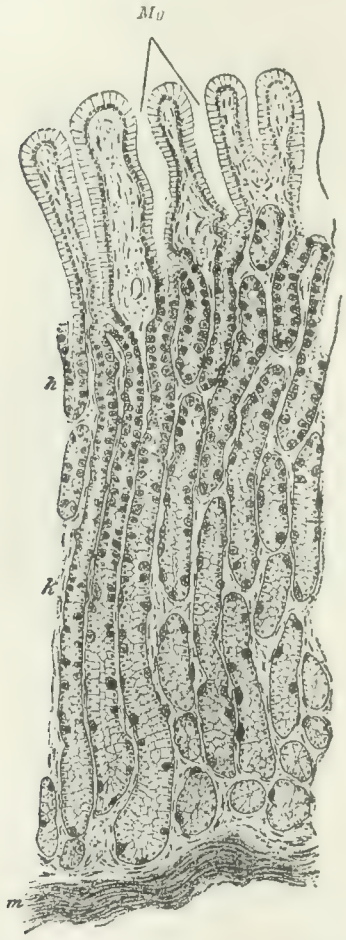


FIG. 4639.—Vertical Section through the Mucous Membrane of the Fundus Gland Region of the Stomach. ×85. *Mg*, Foveolæ gastricæ; *h*, neck of gland; *k*, body of gland; *m*, lamina muscularis mucosæ. (After V. von Ebner, in von Kölliker's "Handbuch der Gewebelehre des Menschen.")

of the depression is approached. Near the mouth of the foveola the cells are slightly imbricated at their attached ends and have a larger theca than those of the free surface. Deeper in the foveola the cells become shorter and more cubical in shape, the nucleus larger, more rounded, and richer in chromatin; the theca tends to become smaller in extent and divided into two more or less distinct masses, a proximal mass near the nucleus and a distal mass near the cavity. These smaller cells of the bottom of the crypt exhibit great activity in division, as is indicated by the presence of numerous mitoses. The cells of the surface, on the other hand, rarely divide. On this fact Bizzozero has based his theory of the mode of regeneration of the surface epithelium, according to which the cells of the bottoms of the crypts are endowed with the property of dividing and producing new cells, which by a gradual process of migrating or displacement finally reach the surface and replace the cells, which for various reasons are being constantly lost there.

A point of some interest is the occasional occurrence in the human stomach, on the surface of the tunica mucosa, or in the foveolæ, of epithelium of the intestinal type, that is to say, composed of cells with a distinct striated cuticula alternating with goblet cells (Schaffer, Boeckelman, Hári). There is still some doubt as to whether these patches of intestinal epithelium occur normally in the human stomach. They appear to occur most frequently in the pyloric region, but have been observed by Schaffer at the very margin of the esophagus in the foveolæ of the cardiac glands.

The great thickness of the gastric mucous membrane is caused by the closely aggregated tubular or tubuloacinous glands. These are of three kinds, occupying three definite regions of the mucous membrane. The *cardiac glands* (glandulæ cardiacæ) form in man a small area around the cardiac orifice of the stomach, which varies in width in different individuals and in different parts of the circumference of the cardia in the same individual, the extremes, so far recorded, being 0.5 centimeter in one of Kupffer's cases, 4.3 centimeters in a case described by the writer. The tunica mucosa of the fundus ventriculi, of the curvaturæ major et minor, and of the parietes anterior et posterior is occupied by the *fundus glands* (glandulæ gastricæ propriæ), that of the antrum pyloricum and the adjacent portions of the stomach, by the *pyloric glands* (glandulæ pyloricæ). The cardiac and pyloric glands are, for the most part, mucous glands of simple structure, the acid and pepsin of the gastric juice being in large measure produced by the complex fundus glands.

At the lines of junction of the various glandular zones a gradual transition from one type of gland to the next may be observed, forming thus between the cardiac and fundus zones on the one hand, and between the fundus and pyloric zones on the other hand, intermediary zones of small extent.

The tunica mucosa in the region occupied by the fundus glands differs in thickness according to the location. In man, according to von Kölliker, the thickness of the tunica mucosa is 0.37 millimeter to 0.56 millimeter at the cardia, 1 millimeter in the middle of the greater curvature. Zimmermann gives the thickness of the mucous membrane as 1.2 millimeters in a piece of mucous membrane from the fundus gland zone. In material examined by the writer, the thickness of the mucous membrane, including the lamina muscularis mucosa, was 0.64 millimeter at the beginning of the fundus glands, 0.82 millimeter in the middle of the fundus ventriculi, 1.2 millimeters to 1.3 millimeters in the middle of the curvatura major.

The fundus glands (glandulæ gastricæ propriæ), physiologically the most important, are slightly wavy, branched tubules, placed vertically in the tunica mucosa, and so closely aggregated throughout the whole of the zone that the interglandular tissue of the lamina propria mucosæ is reduced to a minimum. Each gland is connected with a foveola gastrica by a short collecting duct (*inneres Schaltstück* of Rollett), lined by epithelium of the same type as th at of the deep ends of the foveolæ.

The gland may be divided into two portions, which differ from one another in size and in the character and arrangement of their respective epithelial elements. The more superficial, narrower portion of the gland is called the neck of the gland; the deeper, wider portion, the body of the gland.

The relative lengths of the foveolæ and different sections of the glands is given by Zimmermann as follows:

Thickness of the tunica mucosa....	1.200 mm.
Depth of the foveolæ gastricæ.....	0.256 to 0.325 mm.
Collecting duct (*Drüsenhals* of Zimmermann).....	0.046 to 0.078 mm.
Neck of gland (*Schaltstück* of Zimmermann).....	0.265 to 0.312 mm.
Body of gland..	0.465 to 0.558 mm.

The measurements obtained by the writer correspond very closely with those of Zimmermann as regards the length of the body of the gland, but show relatively longer foveolæ and shorter necks. They are as follows, taken from glands of the middle of the greater curvature of the stomach:

Thickness of tunica mucosa.....	1.200 to 1.320 mm.
Combined length of foveolæ and collecting duct.....	0.358 to 0.539 mm.
Neck of gland.....	0.147 to 0.220 mm.
Body of gland.....	0.414 to 0.526 mm.

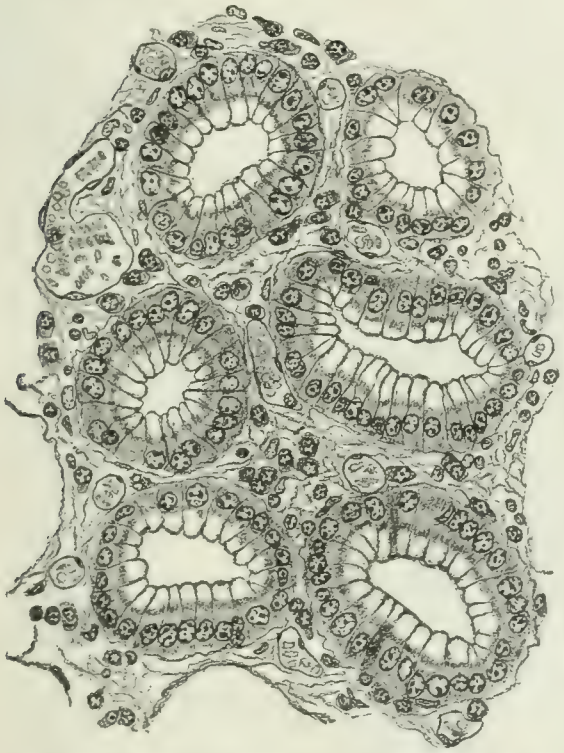


FIG. 4640.—Section Cut Parallel to the Surface of the Mucous Membrane of the Greater Curvature of the Human Stomach, Across Six Foveolæ Gastricæ, showing the Type of the Epithelium and the Tissue of the Lamina Propria Mucosæ. Note the large number of plasma cells in the latter. ×394.

The differences between these two sets of measurements possibly indicate that there is considerable individual variation in the relative lengths of the foveolæ and the necks of the glands.

The fact that the fundus glands of the stomach are composed of several kinds of cells was discovered in 1850 by von Kölliker, who described them as composed of very large mononucleated cells, located immediately beneath the membrana propria, and of smaller rounded cells which formed a complete tube around the very narrow lumen. This discovery, however, attracted little attention from histologists, and even von Kölliker himself failed to mention it in the subsequent editions of his text-book. The two kinds of cells were subsequently rediscovered in 1870, independently of one another, by Heidenhain and Rollett. The former called the chief cells and parietal cells respectively *Hauptzellen* and *Belegzellen*. By Rollett the chief cells were called "*adelomorphe Zellen*," the parietal cells, "*delomorphe Zellen*."

The descriptions of Heidenhain and Rollett differed in some important respects. The former described the neck of the gland as being composed of both chief and parietal cells, and mentioned the occasional occurrence of parietal cells under the cylindrical epithelium. Rollett denied both the existence of chief cells in the neck of the gland, which he supposed to be wholly composed of parietal cells, and the occurrence of the latter in the foveolæ. The researches of subsequent investigators, in particular those of Stöhr, have amply sustained Heidenhain in both these respects. In 1892 Bizzozero called attention to the fact that the chief cells in the neck of the gland differed somewhat from those in the body of the gland. The question as to the nature of these cells has since been investigated by Oppel, Bensley, Zimmermann, Cade, and others, and it has been shown that the transition which Bizzozero supposed to exist between the chief cells of the neck of the gland and those of the body of the gland does not occur, and that the two kinds of chief cells are indeed specifically different.

The fundus gland is composed of cells of three distinct types—the parietal cells, large, ovoidal elements projecting on the outside; the mucous cells of the neck of the gland (*Halshauptzellen* of Oppel); and the pepsin-forming chief cells of the body of the gland (*Grundhauptzellen* of Oppel).

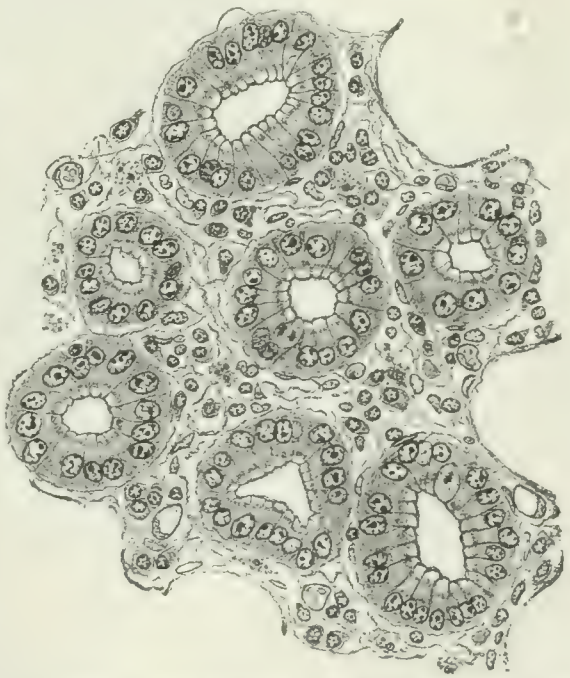


FIG. 4641.—Section Across the Foveolæ Near their Outer Ends. Note the smaller size of the foveolæ as compared with Fig. 4640; the smaller mucigenous border (theca) of the epithelial cells; the mitoses; and the larger amount of interglandular tissue. ×394.

In the body of the gland, the large, wedge-shaped or cuboidal chief cells form an almost continuous lining for the narrow lumen, the large ovoidal parietal cells being displaced to the periphery of the gland away from the lumen, with which they are only connected by narrow ductlets which pass between the adjacent surfaces of the chief cells.

In sections of fresh mucous membrane, mounted in an indifferent fluid (aqueous humor or blood serum), the portions of the chief cells of the body of the gland

which border the lumen are seen to be occupied by closely packed minute refractive granules. These granules have been shown by Langley in a number of mammals and lower vertebrates to diminish in number during secretory activity and to accumulate during rest. Langley has also shown that the amount of pepsin which may be extracted from the mucous membrane is proportional to the extent of this superficial granule-filled zone of the chief cells. The granules are therefore composed of the antecedent substance of the enzyme, and are called zymogen granules. The zymogen granules in the gastric mucosa of man are exceedingly difficult to preserve, and for this reason are usually not visible in stained sections. In material fixed in alcohol or in aqueous solutions of mercuric chloride they have, as a rule, completely disappeared. They may be retained by fixation of the tissue in alcoholic solutions of mercuric chloride or in solutions containing four per cent. of formaldehyde.

In sections of tissue fixed by mercuric chloride in alcohol and stained in hematoxylin, or, better, in toluidine blue, the chief cell of the body of the gland exhibits two well-defined zones—a deeply stained proximal zone containing the nucleus, and a pale distal zone bordering the lumen. The relative sizes of these two zones depend on the physiological condition of the cell, the clear zone being larger in a resting cell, smaller in a cell which has been actively secreting for several hours. The cytoplasm of the basal zone stains intensely in nuclear dyes such as hematoxylin, toluidine-blue, thionin, methylene-blue, etc., and exhibits an indistinct radial striation, which has been interpreted by some observers as due to the presence in the cytoplasm of groups of parallel filaments (the basal filaments of Solger). The intense staining of the basal zone has been shown by the writer to be due to the presence in it of substances chemically similar to the chromatins of the nucleus. This may be shown by the employment of Macallum's microchemical test for iron which gives a distinct positive reaction, quite as intense as that given by the nuclear chromatin. Hence this material is called chromidial substance. The structure which is so frequently observed in this zone is due to the presence of large mitochondrial filaments.

The transparent distal zone of the chief cells of the body of the gland, that is, the zone that is next the lumen of the gland, exhibits a finely reticular structure, the meshes of the network being of wonderful regularity and corresponding in size to the zymogen granules observable in the living cell. This reticular appearance has been interpreted by Théohari and others as due to the presence of a true cytoplasmic reticulum or spongioplasm. The more probable explanation is that the cytoplasm of the portion of the cell nearest the lumen contains innumerable small granules of zymogen, each granule enclosed in a space separated from the neighboring spaces by the continuous cytoplasm. In sections stained in alum hematoxylin and eosin or in toluidine-blue, the granules remain unstained and the spaces they occupy appear as tiny vacuoles, so closely aggregated that the portion of the cell in which they occur appears reticulated. The correspondence between the granules and the meshes of the cytoplasmic network may be demonstrated by staining sections of material fixed fresh in formalin or in alcoholic solution of mercuric chloride, in iron alum hematoxylin, or in neutral gentian. By these methods the zymogen granules are intensely stained, and it may be readily seen that each granule is enclosed in a mesh of the network.

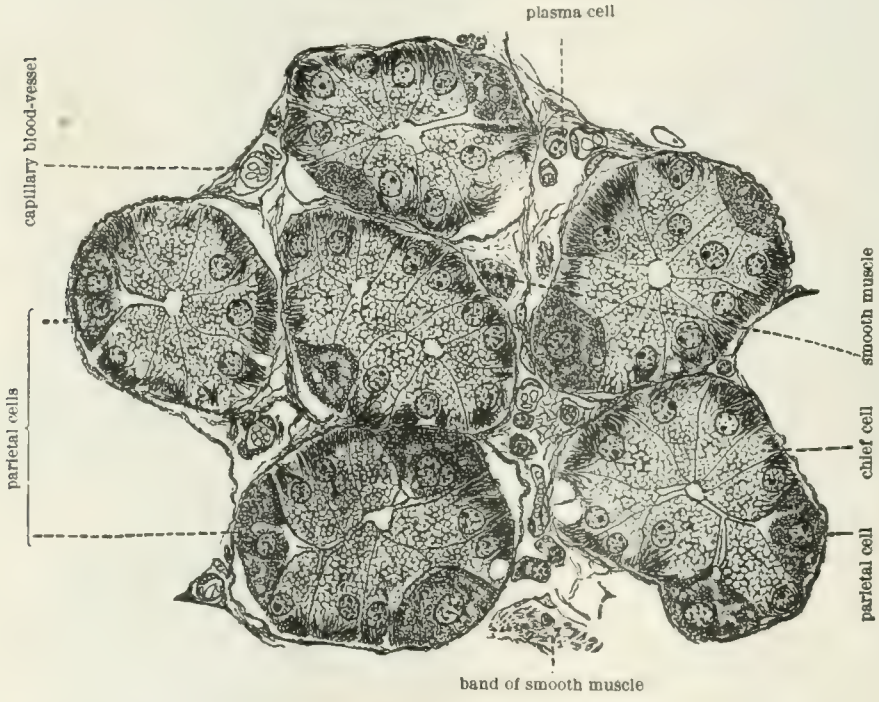


Fig. 4642.—Section Across Six Fundus Glands from the Greater Curvature of the Human Stomach, near the Outer Ends. In the chief cells may be seen the two characteristic zones: the outer zone containing basal filaments of prozymogen; the inner zone a fine network enclosing the spaces in which the zymogen granules are lodged. ×500.

The nucleus of the chief cell of the body of the gland is located at the junction of the two zones, is spherical in outline, and possesses one or two oxyphile nucleoli and a well-defined chromatin network.

It has been shown by the writer and confirmed by Cade that the chief cells of the neck of the gland differ in several important points from those of the body of the gland. These cells lack both chromidial substance (there is no indication of basal filaments in them) and zymogen granules. In the living gland the contrast between the two portions of the gland is very striking, owing to the fact that the zymogen granules are entirely confined to the body of the gland.

The neck chief cells resemble very closely the mucous cells from salivary glands. For the most part they appear triangular when seen in longitudinal sections of the gland, the broad base of the triangle directed toward the lumen, the narrow apex toward the outside, where the cells are crowded by the presence of the parietal cells. The nucleus is located in the proximal attached end of the cell and is spherical, oval, or crescentic in outline, according to the degree of loading of the cell with secretion. The contents of

the cell appear in hematoxylin eosin sections clear and transparent, and exhibit a reticular structure, the large meshes of which are separated by delicate protoplasmic trabeculæ. The meshes or clear spaces in such preparations are the cavities of the cell in which the secretion is stored. Usually there is in these cells a condensation of the cytoplasm in the middle of the cells in the form of a transverse band, incompletely subdividing the secretion into a proximal and a distal mass. The nature of the secretion contained in these cells may be determined by staining in a modified form of P. Mayer's muchematein solution of the following composition: Hematein, 1 gram; aluminum chloride, 0.5 gram; seventy-per-cent. alcohol, 100 c.c. The sections fastened to the slide are stained in this solution under the microscope until the mucin of the surface epithelial cells is a deep blue; the stain is then washed off with ninety-five-per-cent. alcohol, and the sections are dehydrated, cleared, and mounted in xylol balsam. In such preparations the contents of the secretion spaces of the neck chief cells, as well as the mucin of the surface cells, are stained intensely blue. A similar result is obtained by staining sections with Mayer's mucicarmine, freshly prepared and undiluted, the contents of the neck chief cells and of the theca of the epithelial cells of the foveolæ gastricæ staining in this solution intensely red. Thus the impression gained by a study of the structure of these cells that they secrete mucus is confirmed by the staining reactions.

At the junction of the neck and body of the gland for a very short distance the mucous cells and zymogenic cells are mixed with one another, affording at this place a good opportunity to compare their respective cytological characters. In a very few of the glands of the fundus the mucous cells extend right to the bottom of the gland, replacing entirely in this case the ordinary chief cells of the body of the glands. Such mucous glands contain fewer parietal cells and a larger lumen than the ordinary fundus glands. The mucous chief cells of the neck of the fundus gland of man and mammals are the homologues of the large clear cells found in the necks of the gastric glands of reptiles and anurous Batrachians, with which they correspond in position, structure, and staining characters.

The parietal cells occur in all parts of the gland, although they may be found in greatest numbers in the necks of the gland, alternating in this situation with groups of the mucous neck cells. In the body of the gland they are fewer in number, and in the foveolæ only an occasional parietal cell may be seen.

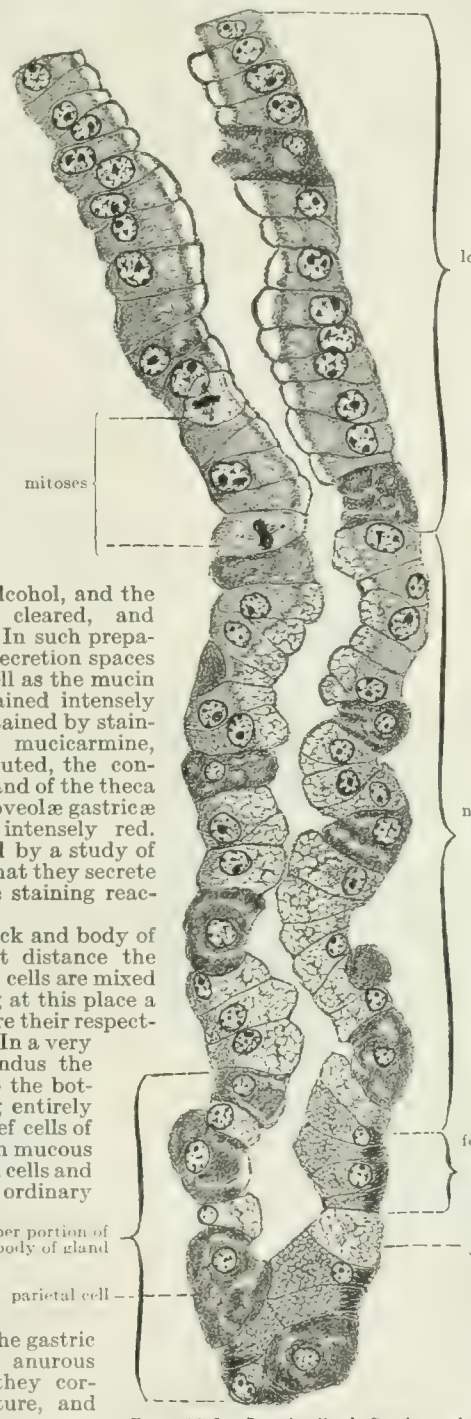

lower end of foveola gastrica
mitoses
neck of gland containing parietal and mucous cells
ferment-forming chief cells of body of gland
mucous chief cell
upper portion of body of gland
parietal cell

Fig. 4643.—Longitudinal Section of Part of a Foveola Gastrica, of the Neck, and of Part of the Body of a Fundus Gland of the Stomach of Man. ×580.

The parietal cells are of ovoidal shape with centrally placed nuclei. In the neck of the gland they have a broad surface of contact with the lumen, but in the body of the gland they are crowded to the outside of the gland, and are connected with the lumen only by narrow ductlets which pass between the adjacent surfaces of the chief cells. In each parietal cell according to Zimmermann, three zones of structure can be made out, a central mass of coarsely granular structure, containing the spherical nucleus or nuclei, for the latter are often multiple, a peripheral zone of similar structure, and an intermediate zone of finely granular structure. The differences between these various zones are best brought to view by staining sections according to Heidenhain's iron hematoxylin method, in which the coarse granules of the middle and outer zones stain deeply. The intermediate zone forms the free surface of the cell on the lumen or on the minute ductlets above described.

For a long time it was thought that the parietal cells in the body of the gland were completely shut off from the lumen by a layer of chief cells. Stöhr was the first to point out that the parietal cells also came into contact with the lumen. According to him this connection was effected by the parietal cell possessing a pointed projection which penetrated between the adjacent surfaces of the chief cells and thus reached the lumen of the gland. It was not, however, until the introduction of the rapid Golgi method for the impregnation of tissue spaces that the real nature of the ductules of these cells was determined. By this means Erik Müller was able to show not only that a minute canal ran from the lumen of the gland to the parietal cell, but that the latter possessed an intricate system of branching and anastomosing secretion canaliculi. These intracellular canaliculi have since been observed by Müller, Zimmermann, and others in ordinary stained preparations, especially in sections stained by the ferric alum hematoxylin method of M. Heidenhain, in which the intracellular and intercellular secretion canaliculi may be readily seen. In Golgi preparations of the gastric glands the fine ductule which connects the parietal cell with the lumen of the gland is seen to divide, on arriving at the cell, into a group of fine branches, most of which penetrate the substance of the cell, in the intermediate zone of which they ramify (intracellular canaliculi); others penetrate a short distance between the parietal cell and the adjacent chief cells (intercellular canaliculi). The true

intercellular character of the latter may be determined, as Zimmermann has shown, by the presence of the intercellular cement lines. The ductules of the intracellular canaliculi frequently contain transparent globules of coagulated secretion, which may also be observed in the lumen of the gland as far as its opening into the foveola gastrica.

The theory of Heidenhain that the parietal cells are the sole source of the hydrochloric acid of the gastric juice has been shown by Harvey and Bensley to be incorrect. By means of neutral red and cyanamin chloride used as indicators these observers have shown that the acid of the gastric glands is not the product of any particular cell of the gland, but that it makes its appearance only when the secretion has reached the foveotal gastricæ. Greenwood, Fitzgerald, and Macallum have shown by microchemical tests that the parietal cells contain more chlorides than the rest of the gland.

FIG. 4644.—Lower End of Fundus Gland, Chief and Parietal Cells. In the latter the intracellular ducts may be seen. (After K. W. Zimmermann, *Arch. f. mikr. Anat.*, Bonn, Bd. lii.)

FIG. 4645.—Fundus Gland of Cat. Golgi preparation, fixed in ammonium sulphide and stained with hematoxylin and eosin; showing intracellular ducts of the parietal cells. (After K. W. Zimmermann, *Arch. f. mikr. Anat.*, Bonn, Bd. lii.)

The mucous membrane of the greater part of the pars pylorica is thinner than that of the greater curvature, although thicker than that of the fundus and cardia. The thickness in material examined by the writer was 0.832 to 0.955 millimeter. Near the sphincter pylori, however, it again increases in thickness to 1.3 millimeters, or in places as much as 1.8 millimeters.

The glands of the pyloric region are much less closely set than in the fundus region, and are separated from one another by a larger amount of tissue belonging to the lamina propria mucosæ.

The foveolæ into which the pyloric glands open are much narrower in man than in most mammals. They rapidly diminish in diameter, to become narrow tubes, which branch as they descend in the mucous membrane, and at about the junction of the middle and outer thirds of the mucous membrane receive the pyloric glands. The long tubular branches of the foveolæ in the pyloric region may be compared to the short collecting ducts of the fundus glands. In view, however, of the fact that they are lined throughout by epithelium similar in character to that of the foveolæ, it seems to me better to consider them as part of the latter.

Into the bottoms of these foveolar branches open the pyloric glands. These are composed of a varying number of branching wavy tubules, into which open short, pear-shaped acini. Both tubules and acini are lined by the characteristic pyloric gland cells. The thickness of the portions of the mucous membrane occupying the foveolæ and glands respectively, I have determined as follows:

Length of foveolæ and branches	0.441 to 0.476 mm.
Width of portion of tunica mucosa occupied by the glands proper	0.283 to 0.301 mm.

In the thicker distal portion of the pyloric mucous membrane they are as follows:

Length of foveolæ and branches	0.735 mm.
Width of mucosa containing glands proper	0.301 mm.

The narrow tubular branches of the foveolæ are lined by cells of the type of those found at the bottoms of the gastric foveolæ and in the short tubules which are intercalated between these and the neck of the glands in the fundus region. They are cylindrical cells, containing an oval nucleus and a considerable amount of cytoplasm. At the end of the cell which borders on the lumen a small theca is seen containing mucus, stainable in mucihematein according to the method already described.

The terminal branches of the pyloric gland are made up of large, cubical cells surrounding an obvious lumen. These cells are usually found filled with secretion which occupies the meshes of a coarse network of cytoplasm. The nucleus is situated at the base of the cell and is spheri-

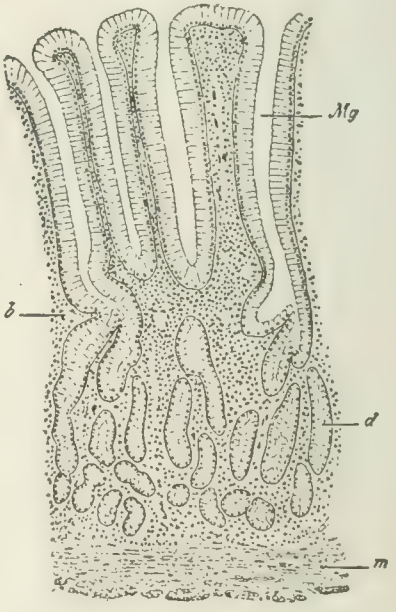


FIG. 4646.—Vertical Section of the Pyloric Mucous Membrane of the Stomach. ×85. *Mg*, Foveolæ gastricæ; *b*, blood-vessels of mucous membrane; *d*, glandular tubules; *m*, lamina muscularis mucosæ. (After V. von Ebner in von Kölliker's, "Handbuch der Gewebelehre.")

cal, flattened, or crescentic in outline, according to the amount of the secretion contained in the cell.

The theory of Heidenhain that the cells of the pyloric glands are pepsin-forming elements similar in character to the chief cells of the body of the fundus gland, has been shown to be incorrect. As has been pointed out, the chief cells contain two characteristic substances, namely, chromidial substance, a deeply staining substance found in the base of the cell, and zymogen, found in the form of coarse granules along its free surface. Neither of these substances occurs in the pyloric gland cells. The absence of the granules explains the greater transparency of the pyloric mucous membrane. On the contrary, the meshes of the coarse network seen in the pyloric gland cells are filled with a substance which stains strongly in muchematein or mucicarmine, when employed according to the methods indicated above. These facts, together with the strong resemblance of the pyloric gland cells to mucous cells from other sources, and the gradual transition in character from the gland cells to the cells of the superficial epithelium, indicate that the bulk of the secretion of the pyloric glands is simply mucus. What other subsidiary substances are secreted along with the mucin is at present unknown.

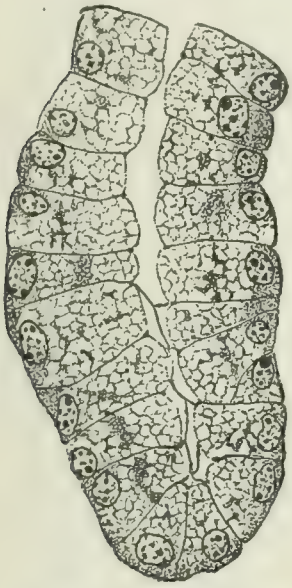


Fig. 4617.—Tubule of Pyloric Gland of Man. (Highly magnified.) Note the thin basal layer of cytoplasm; the reticular cell body containing secretion; the subdivision of the latter in some cells into proximal and distal masses.

Morphologically and physiologically the cells of the pyloric glands are regarded by the writer as the equivalents of the mucous chief cells found in the necks of the fundus glands. The same relation thus obtains between the pyloric glands and the fundus glands of mammals as between the corresponding structures in Reptilia and Anura.

The cardiac glands occupy a zone varying in width from 0.5 centimeter to 4.3 centimeters around the cardiac orifice of the stomach. The glands of the proximal portion of this area are much more richly branched than either the fundus glands or the pyloric glands. They are composed largely of cells similar in character to the pyloric gland cells and the mucous chief cells of the fundus glands, and like them contain a secretion which stains in muchematein and mucicarmine. Some tubules are, however, formed of cells similar in type to the chief cells of the body of the fundus gland, inasmuch as they contain both chromidia and granules of zymogen. A few parietal cells may also be present in the cardiac glands.

Toward the distal part of the zone the glands become less branched, and chief cells make their appearance regularly at their outer ends, a transition being thus gradually accomplished from the cardiac glands to the fundus glands.

The framework of the tunica mucosa is composed of reticulum, which forms a delicate network supporting and separating the glands and containing the blood-vessels, nerves, etc., of the membrane. The delicate fibrils of which this tissue is composed are condensed around the surfaces of the glands to form basement membranes for them. In the dog, according to Mall, the reticulum is especially condensed at two levels in the mucosa, one just above the lamina muscularis mucosæ, corresponding to a rudimentary stratum fibrosum (stratum compactum of Oppel); the other at the level of the necks of the glands. In man the glands reach almost to the muscularis mucosæ, so that here also the stratum fibrosum of Mall is rudimentary.

Here and there in the tunica mucosa branching bands of smooth muscle extend between the glands from the muscularis mucosa in the direction of the free surface. These also receive a delicate investment of reticular fibrils, containing a network of fine elastic fibers.

In the meshes of the reticular framework many wandering cells occur. In the superficial portions of the mucous membrane Unna's plasma cells are especially abundant (Figs. 4640 and 4641). A few polymorphonuclear neutrophile and eosinophile leucocytes, and lymphocytes, are present, and in sections stained in polychrome methylene blue numerous mast cells may be seen among the glands.

Solitary lymph nodules (noduli lymphatici solitarii) occur in varying numbers in the mucous membrane of the stomach. They are particularly abundant in the cardiac and pyloric regions, where they occupy the deeper layers of the mucous membrane. Occasionally they may be found in the superficial tela submucosa, in which case they are often continuous through an opening in the lamina muscularis mucosæ with the reticular tissue of the tunica mucosa.

Fig. 4648.—Section through the Junction of Esophagus and Stomach of Man, showing Cardiac Glands. ×121. *Oe*, Esophagus; *m*, stomach; *cd*, cardiac glands; *wd*, dilated ducts of cardiac glands. (After J. Schaffer, *Sitzungsb. d. k. Akad. d. Wissensch.*, Wien, Bd. cvi, Abth. iii.)

The deepest layer of the tunica mucosa is formed by the lamina muscularis mucosæ, a double layer of unstriated muscle fibers, 50 to 100 μ is thickness. It consists, according to Klein, of an inner circular and an outer longitudinal layer of fibers, which intercross and pass into one another. According to Böhm and

von Davidoff it is composed of three layers. Between the constituent fibers of this layer may be seen a delicate network of reticulum and a rich network of elastic fibers. The fibers of the latter, for the most part, run in a direction parallel to the muscle fibers. From both layers of the lamina come off the groups of muscle fibers referred to above, ascending in the tunica mucosa among the glands.

The tela submucosa is a loose layer of collagenic fibrous tissue, connecting the tunica mucosa with the tunica muscularis, and containing the large blood-vessels and lymphatics and the nerves and ganglia forming the plexus of Meissner. This layer is poor in elastic fibers except in the neighborhood of the tunica muscularis, where the rich network of elastic fibers may be seen. Here and there, in the tela submucosa, are to be seen larger and smaller accumulations of adipose tissue.

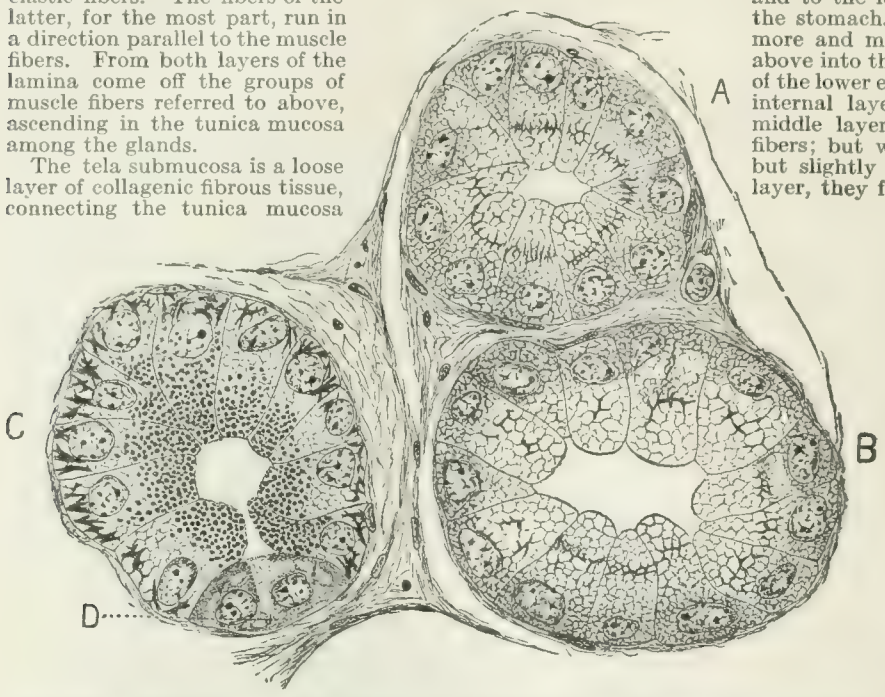


Fig. 4649.—Cross-section of Three Tubules of the Cardiac Glands of Man. ×1,000. *A*, Mucous tubule, showing cells in early stage of mucin formation; *B*, mucous tubule, showing cells in various stages of mucin formation up to complete loading; *C*, tubule composed of cells similar to the chief cells of the body of the fundus glands. These cells contain basal filaments (prozymogen) and zymogen granules; *D*, binucleate parietal cells with intracellular secretion channels. (After R. R. Bensley, '02.)

In the description of the muscular coat, the recent account given by Birmingham will be followed. The tunica muscularis is composed of three layers, the outermost layer (stratum longitudinale) being a continuation of the corresponding layer of the esophagus. The fibers of which it is composed form on each curvature, but particularly on the curvatura minor, a well-marked layer of numerous distinct bundles. On the anterior and posterior surfaces the layer exists as a very thin sheet, the fibers being less distinctly longitudinal in places, particularly near the middle of the surfaces beneath the cardia, than in the neighborhood of the curvature (Fig. 4650). The middle layer (stratum circulare) is best developed at the pylorus, where it forms a thickened muscular ring, musculus sphincter pylori, surrounding this aperture. In the adjacent narrow portion of the stomach the fibers are also well developed, and the resulting rings are numerous and closely placed. As we pass on toward the left the layer becomes thinner and the rings correspondingly fewer, but they still form a distinct and well-defined continuous sheet, the fibers of which can be easily seen even through the peritoneum, forming very symmetrical rings, disposed at right angles to the long axis of the organ. This regular arrangement is continued as far as the region of the esophagus, where it is interrupted. To the left of the cardia the layer is continued for some distance in the form of oblique fibers, which radiate from the right side of the esophageal opening above, downward, and to the left on the two surfaces of the stomach. These fibers, becoming more and more oblique, are continued above into the superficial circular fibers of the lower end of the esophagus. The internal layer is composed, like the middle layer, of circular and oblique fibers; but while the oblique fibers are but slightly developed in the middle layer, they form an important part of the internal layer. Beginning as a series of circles at the summit of the fundus, it extends in the form of a layer of rings, disposed at right angles to the axis of the stomach, as far as the cardia. Beyond this it is continued by a number of fibers—the well-known oblique muscular fibers of the stomach—which radiate from the left side of the esophageal opening, downward, and to the right on both surfaces of the stomach, some of them reaching almost as far as the antrum pylori. These fibers end by turning abruptly toward the greater curvature and passing into the circular fibers of the middle layer. The highest of these oblique fibers pass into the deeper circular fibers of the esophagus.

The tunica muscularis is composed of unstriated muscle fibers bound together in bundles by delicate reticular tissue. All the layers of this coat contain

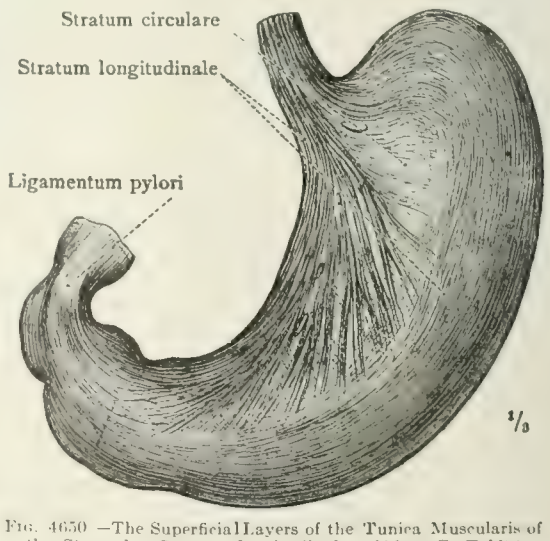


Fig. 4650.—The Superficial Layers of the Tunica Muscularis of the Stomach. Stratum longitudinale. (After C. Toldt.)

many elastic fibers forming networks, the meshes of which are elongated in the direction of the long axis of the fibers.

Between the strata is a thin layer of collagenic con-

nective tissue, containing numerous blood-vessels and the nerves and ganglia of the plexus of Auerbach.

The peritoneal coat of the stomach (tunica serosa)

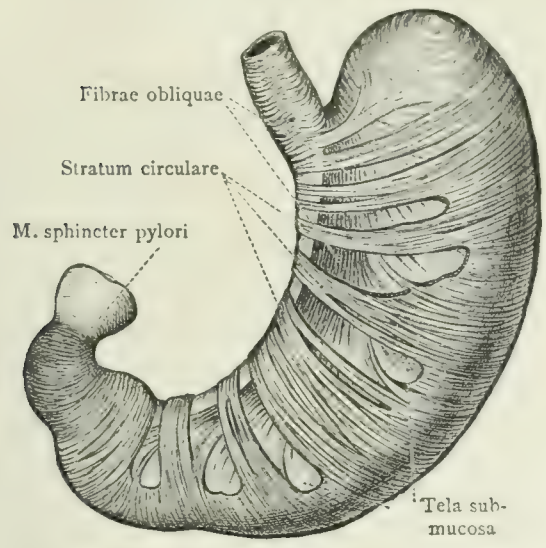


Fig. 4651.—The Middle and Internal Layers of the Tunica Muscularis of the Stomach. Stratum circulare and fibræ obliquæ. The stratum circulare has been removed in places. (Toldt.)

consists of collagenic tissue, composed of crossing and intercrossing fasciculi and containing elastic fibers. The free surface is covered by a layer of flat, irregularly shaped nucleated mesothelial cells, which give to the external surface its smooth, glistening appearance. Under the endothelium is a thin layer of connective tissue, containing in its deeper half a network of fine elastic fibers. The deeper layers of the tunica serosa, formed of connective tissue composed of loosely interlaced fasciculi of collagenic fibrils and a few elastic fibers, contain the blood-vessels and nerve bundles.

The blood-vessels of the stomach are derived from all three branches of the arteria celiaca, which form arterial arches along the curvature minor et major, from which the smaller branches of the organ are derived. That along the lesser curvature is formed by the union of the right gastric branch (arteria gastrica dextra) of the arteria hepatica with the left gastric artery (arteria gastrica sinistra); that of the greater curvature, by the union of the right and left gastroepiploic arteries (arteriæ gastroepiploicæ dextra et sinistra) derived from the hepatic and splenic arteries. In addition, the fundus ventriculi receives a number of short branches (arteria gastricæ breves) from the arteria lienalis. The large vessels formed by these anastomoses may be compared, according to Mall, to the vascular arches of the mesenteric arteries.

From the arches thus formed branches come off which penetrate the tunica muscularis at the curvatures, and are distributed in the tela submucosa of both surfaces of the organ. These branches in the submucosa are, in the dog, according to Mall, of various sizes, being smallest and most numerous in the pyloric region and fundus, largest in the middle zone. They pass in a circular direction around the stomach, branching and anastomosing freely to form a fine plexus of vessels, located at about the middle of the tela submucosa. From this plexus vertical branches arise which pass through the lamina muscularis mucosæ at very regular intervals and supply the mucous membrane. As soon as the bases of the glands are reached, each of these vessels breaks up into radiating branches (the stellate arteries), which in some animals form a second plexus within the deepest portion of the mucous membrane.

From these stellate arteries arise numerous capillaries which form a dense network with elongated meshes, surrounding the gastric glands from the bases to their necks. As the capillaries approach the openings of the glands, they begin to collect into larger vessels, which in turn communicate with a plexus of veins located under the epithelium. Thus the deeper layer of the mucous membrane receives the blood in a more arterial condition than do the superficial layers.

The subepithelial venous plexus is composed of small vessels which form a network of meshes surrounding the foveolae near the openings. From this plexus larger veins pass vertically to join the subglandular plexus at the outer edge of the mucous membrane just internal to the lamina muscularis mucosæ. From this second venous plexus branches pass to the tela submucosa, which join one another and communicate finally with the submucous plexus of large veins. The veins which form the submucous plexus correspond in their distribution very closely to the vessels of the arterial plexus. Each large artery has, as a rule, two accompanying veins, the smaller arteries one. The arteries are, as a rule, more superficial than the veins and smaller in size.

The tunica muscularis is supplied, to a limited

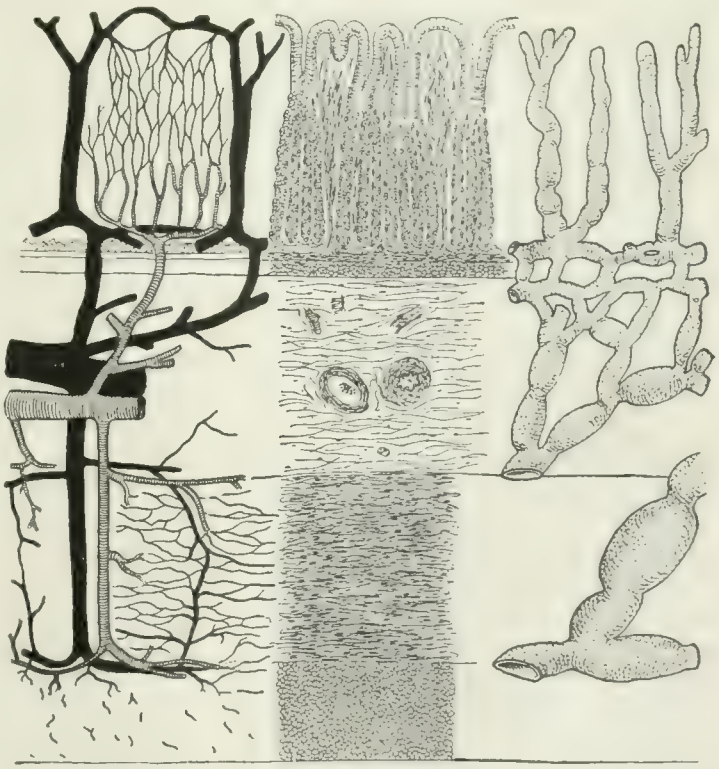


Fig. 4652.—Three Sections of the Stomach Wall of the Dog, Placed Side by Side to show the Situation of the Blood and Lymph Vessels in the Different Tunics. ×70. Veins black; arteries striated; lymphatics dotted. (From A. Oppel, '96, after F. P. Mall.)

extent, along the greater and lesser curvatures by branches which come from the arteries as they pass through to the submucosa. The great bulk of the muscular coat, however, is supplied with blood by means of recurrent branches from the plexus of vessels in the submucosa. These branches pass directly outward from the submucous plexus through the stratum circulare, to the intermuscular layer, where they form a plexus the meshes of which are for the most part elongated in the direction of the fibers of the stratum longitudinale. From this plexus and from the recurrent arteries which form it are given off branches which break up into capillaries in the muscular layers. The circular coat receives, in addition, numerous branches directly from a plexus lying between the tela submucosa and the tunica muscularis.

All the veins leave the stomach in company with the arteries.

The lymphatics of the stomach begin as comparatively wide, blind, capillary tubes beneath the epithelium of the stomach. These pass somewhat irregularly outward and join to form larger trunks, which communicate with a fine network of lymphatic vessels located in the mucous membrane between the lamina muscularis mucosæ and the bases of the glands. This plexus (plexus mucosus) in turn communicates by means of vessels which pass at right angles through the lamina muscularis mucosæ with a second plexus located in the inner part of the tela submucosa. This plexus is composed of large vessels with many valves. From it arise many irregular branches which anastomose and pass through the substance of the submucosa to join the large collecting branches. The latter, in turn, communicate by large branches which pass through the circular muscle with the intermuscular plexus, the large vessels of which run toward the lesser curvature. For further details as to the arrangement of the large lymphatic vessels of the stomach, see the article on the *Lymphatic System*.

The nerve supply of the stomach is derived from the two nervi vagi and from the plexus celiacus. The abdominal portion of the nervus vagus sinister descends as the chorda œsophagea anterior on the anterior surface of the esophagus to the stomach, where it divides into a group of branches located on the anterior face of the viscus, near the vertical portion of the curvatura minor. These branches anastomose freely to form the plexus gastricus anterior. From this plexus come off branches which radiate over the anterior face of the stomach. These branches run in the tunica serosa for a longer or shorter distance, but finally penetrate the muscular coats to terminate in the intrinsic plexuses of the organ. The right vagus goes in large part to the ganglion semilunare dextrum, but contributes some branches to the plexus gastricus posterior, distributed on the posterior face of the organ.

The sympathetic nerve supply is derived from the plexus celiacus by means of fibers which accompany the several branches of the arteria celiaca. The plexus gastricus superior accompanies the arteria gastrica sinistra, but also receives communicating branches from the right vagus, and from the plexus hepaticus, which reach the stomach in company with the arteria gastrica dextra. Some of the branches of the anterior gastric plexus accompany the rami esophagei of the left gastric artery to the cardia; others descend upon the anterior and posterior surfaces of the stomach beneath the peritoneum, anastomosing on the left with the branches of the plexus lienalis which accompany the arteriæ gastricæ breves to the fundus, on the right with the branches of the plexus hepaticus which accompany the arteria gastrica dextra. Additional fibers from the hepatic and splenic plexuses accompany the arteriæ gastroepiploicæ dextra et sinistra respectively and are distributed to the greater curvature. The nerve fibers from all these sources, after a longer or shorter course in the tunica serosa, penetrate the muscular coats and join the intrinsic nerve plexuses of the organ.

The stomach, like the intestine, contains two characteristic nervous plexuses formed of branching and anastomosing bundles of non-medullated nerve fibers, forming a fine network with ganglia at the nodal points. These are the plexus myentericus, located between the strata circulare et longitudinale of the muscular coat, and the plexus submucosus, situated in the tela submucosa. The former plexus furnishes the motor supply to the tunica muscularis, the latter supplies the lamina muscularis mucosæ.

R. R. Bensley.

Stomach, Examination of the Functions of the.—Secretion, motility, absorption, and sensation constitute the functions of the stomach. The determination of the secretory and motor functions is necessary for accurate diagnosis.

Examination of the function of absorption, as will be demonstrated later, is for practical purposes usually unnecessary.

Sensation.—As a rule, under normal conditions, we do not recognize that we have a stomach, unless for example following the rapid ingestion, particularly on an empty stomach, of very hot or cold material such as coffee or ice cream. Even so, gastric sensation is evanescent. On the other hand, with a pathological condition of the organ, subjective sensations such as cramps, pain, burning, etc., may be present or even a combined subjective and objective manifestation of sensation such as tenderness; for the latter may also be an objective manifestation; for example, when there is protective muscular rigidity on palpation over an ulcer. The function of sensation may, therefore, be of considerable assistance to our diagnosis. The material for this article, the writer desires to state is in part from the new Third Edition of his book on Diseases of the Stomach, Intestines and Pancreas, and the illustrations are from the same source through the courtesy of W. B. Saunders Company.

Secretion.—Though gastric secretion may occur under the influence of the pleasant odor or agreeable appearance of the food (psychic secretion) particularly if the subject has been fasting, it chiefly takes place from the time of the entrance of food into the stomach and continues until the chyme has passed into the intestine. Secretion is diminished toward the last. Examination at various periods after taking food, will give different results and it is, therefore, necessary to examine the gastric contents at a definite time during the height of digestion. A definite test-meal should be administered. The writer will recommend those methods which he has found best from personal experience.

Test-meals.—*Test Breakfast of Ewald and Boas.*—This is administered in the morning, in the fasting condition (no food or drink, after awaking, before the meal) and consists of one to two rolls or one and one-half to two slices of bread (35–70 grams) and one large cup of tea (300 to 400 c.c.) or water. Tea is not of stable strength, is irritating to some patients and tends to color the gastric contents. I usually advise 60 grams of bread and 350 to 400 c.c. of water, generally 350 c.c. The average slice of bread from the loaf weighs 30 grams approximately. If the patient is of small physique, the test breakfast must be proportionately reduced. The *stomach should be aspirated one hour after the breakfast and the gastric contents examined.* When hypermotility of the stomach is present, no contents may be secured at this time, in which event, a new test breakfast should be administered on the following morning and aspiration should be performed, part of the contents thirty minutes later and the balance forty-five minutes after the meal.

Usually one directs the patient with empty stomach to arrive at the physician's office at 8.00–8.30 A.M. where the breakfast is administered under personal supervision. The subject should thoroughly masticate a small portion of the bread, then drink a little water and so on, taking about ten minutes for the entire process. When properly weighed and measured, the breakfast may be taken at home.

When the breakfast is aspirated, a residuum of 100 c.c. or more at once suggests motor insufficiency. It is easy to recognize in the test breakfast remnants of food from a previous meal, when motor insufficiency is marked. The writer usually advises a late dinner the night previous, the patient taking as vegetables, boiled spinach and boiled rice, with the addition of six raisins without the seeds. These materials, particularly the spinach, are readily detected the following morning if there is marked motor insufficiency.

The test breakfast will in most cases be sufficient to determine the required information, even to a considerable extent the degree of motor insufficiency. The use of Riegel's test dinner and the other methods for this purpose are described under the section on this subject.

Scientifically speaking, the diagnosis should *preferably not be made from a single examination of the gastric contents.* Practically the patient will often refuse a second test, or the family physician will expect one examination by the specialist to suffice, or one may be called to a distant locality and be obliged to depend on a single examination.

I have frequently been obliged to base my diagnosis on such single aspiration of the gastric contents, taken in connection with the history, physical examination and radiography, when the last was possible. I much prefer to depend on a single gastric analysis plus the *x*-rays, than on numerous analyses without the latter. In cases of suspected nervous affections of the stomach several examinations are preferable, as the results of each gastric analysis may vary in the same subject.

Riegel's Test Dinner.—Riegel's test dinner is the oldest advocated. It consists of a plate of meat broth (about 400 c.c.); a beefsteak weighing from 150 to 200 grams (5 to 7 ounces); 50 grams (1½ ounces) of mashed potatoes; and a roll (35 grams). Aspirate four hours later.

Ewald's Test-meal.—This consists of about 6 ounces (175 grams) of finely chopped meat; stale bread, 35 grams, and butter, to be taken three hours before withdrawal of the stomach contents.

This is practical as regards quantity, as the test meal of Riegel is considered large in amount by many.

Test-meal of Germain Sée.—The patient is given 3 to 5 ounces (100 to 150 grams) of white bread; 2 to 3 ounces (60 to 80 grams) of finely chopped meat, and a large glass (300 c.c.) of water. Aspiration two hours later.

Klemperer's Test-meal.—This consists of 1 pint (500 c.c.) of milk and two rolls (70 grams), given on an empty stomach. Aspiration two hours later.

Dry Test-meal.—Boas has suggested a dry test breakfast, consisting of a roll without water, as giving a more accurate index of gastric secretion. In cases of disordered motility the dry method may be accurate, but from a practical standpoint there is no advantage in it. Some prefer it in differentiating between hyperacidity and hypersecretion.

Boas' Special Test Breakfast Containing no Lactic Acid.—1 ounce of rolled oats boiled in 1 pint of water, with salt to taste. Boas advocates this, as it contains no lactic acid, and that it is valuable when an accurate test for this acid is desired.

Two shredded wheat biscuits with water (300 c.c.) or a pint bowl of granose are recommended as a convenient substitute. Sahli, Jaworski, Friedman, Roberts and others have suggested modifications, but there are no advantages.

The test-meals that are in chief use are the Riegel test dinner and Ewald-Boas test breakfast.

One, when possible, should make several tests and take a general average. In some patients it would be probably preferable to employ the test dinner as well as test breakfast. The gastric secretion (appetite juice) is undoubtedly greater after a dinner of a character agreeable to the patient than following an unattractive meal, consisting of bread and water. All these factors must be considered.

Rehfuss, Hawks, Bergheims, and Fowler have reported interesting results from Rehfuss' so-called "fractional method of examination." The patient swallows a soft collapsible weighted stomach tube, shortly after the test breakfast and the gastric contents are aspirated and examined at brief intervals during the entire course of gastric digestion, the tube remaining *in situ* during this period. The method is disagreeable for the patient, long and complicated for the operator, there is often considerable irritation from the tube and careful investigation fails to convince me that a correct diagnosis cannot be as readily made by the older and much simpler method.

Precautions before the Test-meal.—Internal medication should be stopped several days before the test-meal so as not to influence the result. This is particularly true if acids or alkalis are being administered. If the patient is very nervous, it is preferable not to inform her ahead of time that the stomach tube is to be passed, as the nervous element might influence the secretions.

Contraindications to Aspiration.—Among the chief contraindications are recent gastric, intestinal, pulmonary, renal or bladder hemorrhage, high blood pressure particularly in elderly persons, angina pectoris, severe endocarditis and thoracic aneurysm. At least two weeks should elapse after hemorrhage, before the attempt is made to pass the tube. High arterial pressure should be reduced somewhat before aspiration is attempted. In a patient subject to attacks of angina pectoris, in my early career, I precipitated a severe but fortunately not fatal attack by passing a stomach tube. This was a sufficient lesson. In patients in whom passage of the tube is inadvisable, one should arrive at the diagnosis by testing the digestive system by the Schmidt-Strassburger diet and then examining the stool; by the history of the case and by physical examination. There is also no contraindication to radiography. In order to avoid misunderstanding, I would state that there are no contraindications to the passage of the stomach tube in poison cases where lavage takes preeminence over everything.

Method of Aspiration of the Gastric Contents.—The selection of the proper type of tube is of great importance. It should be moderately soft and quite flexible, of a caliber 28–30–32 French. There should be an opening at the tip and preferably two lateral openings as in Fig. 4653. One should have at hand in the office all three sizes as noted above for adults, and as small as 16–18 (French) for children. Select the size

Fig. 4653.—Best Tube for Aspiration.

tube to suit the dimensions of the patient. One would not employ a 32 tube on a small woman. An exception to this is when esophageal spasm occurs, in which event a large tube can often be the more readily passed. It is more difficult to aspirate with a tube with a closed tip, particularly when the gastric contents are small in quantity, nor is it as easy to empty the stomach with a tube of this description.

Position of the Patient and Operator,—As a rule, the

patient sits upright on a chair and is protected by a rubber sheet or large towel. Tight collars should be loosened. False teeth should be removed. The patient holds a basin in her lap in which is a glass container for the gastric contents. Expectoration into the basin is thus made possible without contaminating the aspirated contents. The operator stands as depicted in Fig. 4654, the left arm about and firmly supporting the patient's head and neck, the little finger of the left hand resting on the chin of the subject. The tube, held close to the end, is passed along the roof of the mouth with the right hand, aided

Fig. 4654.—Aspiration. Position, and bulb attached to tube

by the thumb and index-finger of the left hand. The patient's confidence should be gained and the impression given that there is no danger. She should swallow as the tube enters the esophagus and if there is respiratory difficulty, long deep inspirations should be taken. If the tube coils in the mouth or esophagus, it should be at once withdrawn and a fresh attempt made. If the pharynx or esophagus is irritable a preliminary spray or four per cent. cocaine or five per cent. eucaine may be employed, or the tube may be placed on ice before its passage, as the cold lessens irritation. The patient's hands should be occupied in supporting the basin on her lap, so not to interfere with the operator. The tube should be introduced about twenty inches or preferably until resistance is felt from the wall of the stomach, when it should be slightly withdrawn. With gastroptosis or dilatation of the stomach it would be necessary to introduce the tube to a much greater depth before contents could be secured, which in itself would suggest one of these conditions. At times gentle manipulation of the tube (forcing it in and out) may be advisable in order to start muscular contraction of the stomach and thus aid in the expulsion of its contents.

If aspiration is performed with the patient in bed, the subject should lie on her right side thus gravitating the contents into the narrowest part of the stomach (the pars pylorica). By this means, one can secure gastric contents even if very little be present, and it is also of service to completely empty the stomach and thus determine the quantity of contents at a definite time, *i.e.* "the motility of the organ."

A Politzer bulb can be employed for aspiration.

Boas' Method.—The Boas aspirator, consisting of a rubber bulb with two soft rubber ends and provided at the distal end with a clamp, is attached by the proximal end to the stomach tube by a piece of glass tubing.

The clamp is fixed, the bulb compressed and then gradually released and thus filled with gastric contents; the clamp is then opened and the contents by compression of the bulb forced into a glass, bottle, or some other receptacle. Other complicated devices for aspiration have been suggested but they possess no advantages.

Ewald-Boas Expression Method.—This consists in having the patient exert pressure on his stomach by means of his abdominal muscles. He should first inspire deeply and then compress the abdominal walls in the same manner as during defecation. The pressure expels the gastric contents through the stomach tube into a receptacle. This method is considerably employed and excellent when successful. In cases of atony of the stomach or when the abdominal walls are relaxed, with dilatation of the stomach or with gastroptosis and often from plugging of the stomach tube, the expression method is a failure. Moreover complete emptying of the organ will not occur so that correct determination of the motility may not be possible, *i.e.* there may be motor insufficiency and yet it may not be in evidence.

Author's Method.—It is my custom to attach to the stomach tube a rather stiff white aspirating bulb (Tiemann's) without valves such as depicted in Fig. 4655. Expression of the gastric contents may first be attempted. If the tube becomes stopped by food fragments, the thumb is placed over the open end, the

Fig. 4655.—Aspirating Bulb.

bulb is squeezed and the obstruction is immediately relieved. This obviates blowing through or removing the tube.

Whether expression is successful or fails, aspiration is then further resorted to, in order to thoroughly empty the stomach. The stomach tube is pinched near the teeth and the bulb is then squeezed to empty it of air. While the bulb is flat from compression, the thumb is placed over the free end, the stomach tube is then released and the bulb is gradually allowed to fill with gastric contents. When it has partially or completely filled, the stomach tube is again pinched near the teeth, the thumb removed from the free end of the bulb, and by gradual compression of the latter, the contents are expressed into the receiving vessel. This process is repeated until no more contents enter the bulb. It is advisable to move the tube about during the procedure and to finally aspirate with the patient lying on the right side, thus gravitating the remaining contents into the narrow pars pylorica. This insures removal of all the gastric contents and hence a quite accurate determination of the motility of the stomach.

Examination of the Ingesta.—Before examination of

the gastric contents is begun, the quantity aspirated should be carefully measured. After the Ewald-Boas test breakfast of sixty grams bread plus 350 c.c. water, one would expect to secure on aspiration one hour later an average of 40 to 75 c.c. of contents. If 100 c.c. residuum or more is present, this would be diagnostic of motor insufficiency. This might occur with an atonic stomach in normal position, or with atonic dilatation of the stomach, with dilatation of the stomach from pyloric or duodenal stenosis, or with gastroptosis particularly in a stomach of the water-trap or fish-hook type. Physical examination would be necessary to determine which of these is responsible for motor insufficiency. Regarding the diagnosis of motor insufficiency by means of the *x*-rays, I desire to record an interesting fact. Radiologists hold that if the stomach is free from barium at the end of six hours after the barium meal, that the motor power of the stomach is good. The presence of barium at this time, of course, shows a deficient emptying of the organ. On the other hand, I desire to state with great positiveness that I have, on a number of occasions, aspirated 140 to 150 c.c. of contents one hour after the test breakfast and positively determined that motor insufficiency was a factor in the production of symptoms, while the radiologist finding an empty stomach six hours after the barium meal stated in the same patients that motility was normal.

There are, therefore, minor degrees of motor insufficiency which may be thus overlooked, if reliance be placed on the radiologist alone. With marked cases of motor insufficiency considerable residuum, 200 to 300 c.c. or more, will be aspirated an hour after the test breakfast and at times there may even be food present, ingested at a previous meal.

Macroscopic Inspection.—Macroscopic inspection of the aspirated gastric contents after the test breakfast often gives considerable information. In some cases, there will be large undigested pieces of bread, at once suggestive of deficiency of gastric digestion (insufficient hydrochloric acid). Coarse particles with very little liquid, no mucus, no odor, no evidence of fermentation, and in small amount, often with increased motility suggest achylia gastrica, which would be confirmed by the subsequent determination of very low acidity and by the absence of the ferments.

Partially digested bread or pultaceous material with which mucus is well mixed, or to which it is adherent would be significant of chronic gastritis. If in doubt, microscopic examination would differentiate between mucus from the pharynx, lungs, or stomach by determination of the type of epithelial cells mingled with the mucus.

A fine fluid mushy mass suggests good digestion, while fine starchy material settling in small amount, with most of the contents fluid and digested, occurs with hyperchlorhydria.

Bread coarsely divided, incorporated with thin mucus, the aspirated contents of a light orange or yellow tinge and small in amount would be significant of achlorhydria hemorrhagica gastrica which would be confirmed by the subsequent determination of a very low acidity, the absence of hydrochloric acid, the presence of occult blood and numerous bacteria.

With Riegel's test-meal the differences are even more pronounced.

The mass may be fine, uniform, and mushy, containing no coarse elements showing good digestion, or there may be coarsely divided bread, and undigested meat fibers, etc., significant of the opposite condition and so on.

Mucus, blood, and bile are often readily visible in the aspirated contents. Blood, however, may be invisible (occult) or of coffee-ground appearance, and for these the test must be made. Red mould may occasionally look like blood and green mould like bile, so that microscopic examination may be required to differentiate.

In some cases the gastric contents, when placed in a glass, forms three layers, at the bottom fine starchy material, next cloudy fluid and on top a foamy layer, which last is an evidence of gaseous fermentation. There may be a floating layer of food, saliva, and mucus and even some residue from a previous meal. This condition suggests benign stenosis of the pylorus. The quantity aspirated is in large amount, at times more than the test breakfast administered, due in part to retention of a previous meal or to hypersecretion. Further examination should show the presence of hyperchlorhydria, sarcinæ and yeast cells; while by Reichmann's test one can determine whether or not hypersecretion is a factor. This test is as follows: the stomach is thoroughly washed out at bedtime, on the following morning—ten to twelve hours later, no food or drink meanwhile being ingested, the stomach is aspirated. If more than 20 to 30 c.c. pure gastric juice of rather high acid content is secured, hypersecretion is present. This is particularly true if the patient have the symptoms pointing to hypersecretion. Frequently as much as 75 to 125 c.c. of contents are secured in this event.

When malignant stenosis of the pylorus is present, there is a considerable amount of retention of gastric contents (motor insufficiency) and the material is usually more offensive than with benign stenosis. Meat fibers are present, if previously ingested with the test-meal. Subsequent tests demonstrate the absence of free hydrochloric acid, the presence of lactic acid, absence of sarcinæ, few or no yeast cells, the presence of occult blood, microscopic pus, at times mucus, and in the later stages the Boas-Oppler bacilli.

Chemical Examination.—Having measured the aspirated gastric contents to determine motility of the organ, and having obtained as much information as possible from macroscopic examination, the material should then be filtered. Filter-paper or absorbent cotton may be employed, but filtration through several layers of cheese-cloth placed in a funnel is a convenient method.

From a practical standpoint the most important feature is the determination of the hydrochloric acid during the height of digestion. If this is present, it is then necessary to determine whether it is normal in amount, or whether increased or deficient. (Quantitative test.) If hydrochloric acid is deficient in amount or absent, the digestive power of the stomach is deficient.

When free hydrochloric acid is present, the determination of pepsin is practically unnecessary; in fact, it is often present even in the absence of free hydrochloric acid. In the last event, if the gastric contents are acidified with sufficient HCl and digestion of albumin then occurs, this is evidence of sufficient pepsin formation. Even in the absence of free hydrochloric acid, when combined hydrochloric acid is present, pepsin and rennet are usually found also, even though in small amount. On the other hand, with cases of very low total acidity 2–4–6 with absence of free hydrochloric acid, and absence of combined hydrochloric acid, pepsin and rennet are absent (achylia gastrica). To avoid possibility of error, when free hydrochloric acid is absent, it is preferable to test for pepsin and rennet, as we can thus positively differentiate between achlorhydria and achylia gastrica. The greater the excess of free hydrochloric acid, the greater is the interference with the starch digestion, so practically determination of changes in the starch are usually unnecessary. Lactic acid determination is not required except in the presence of a low hydrochloric acid content, or in the event of its absence, while the chemical determination of occult blood is only necessary in cases of suspected ulceration. Chemical examination for practical diagnosis can be thus much simplified, comprising total acidity, free HCl, and combined HCl; and further tests when these are low or absent.

For a complete chemic analysis the following tests should be performed, reaction of contents; total acidity; free hydrochloric acid; combined hydrochloric acid, total hydrochloric acid; lactic acid; inorganic acids; propetone, peptone; pepsin; rennet; dextrin; erythrodextrin; achroodextrin; sugar; occult blood; bile and intestinal juices. As a basis of comparison, it is necessary to remember the findings of the normal gastric juice after a test breakfast, normal gastric juice is of acid reaction, total acidity 40–60 (0.15–0.21) free HCl 25–50 (0.1–0.2 per cent.); combined HCl present, propeptone small amount, peptone more, pepsin and rennet present, sugar and achroodextrin present, erythrodextrin present in small amount or absent, dextrin absent. Some patients may have free HCl within the above normal limits or near or at 60 (the border line) and yet suffer from the symptoms of hyperacidity, while others have free HCl as high as 100 and yet present no symptoms at all.

Individual peculiarities must therefore be considered.

Reaction.—This is determined by means of blue and red litmus-paper. If the filtrate is acid, it turns the blue paper red; and if alkaline the red turns to blue; neutral gastric contents cause no change.

Test for Free Hydrochloric Acid.—Numerous coloring matters when exposed to the action of weak solutions of hydrochloric acid undergo changes, and have been employed as tests for its presence.

There has been considerable dispute as to the respective superiority of these tests. Though organic acids, when present in considerable quantities, may give these color changes, yet they are not as sensitive to organic acids as to mineral acids. I agree with Riegel that this danger is practically negligible. As a precaution one can employ one of the following qualitative check tests, which react only to free mineral acids and not to the organic acids. The writer, however, depends on Töpfer's method.

In addition, the test for lactic acid should be performed.

The Phloroglucin-vanillin Test (Günzburg's).—This reagent consists of two grams of phloroglucin and one gram of vanillin dissolved in thirty grams of absolute alcohol. An equal number of drops, one or two each, of this and the gastric juice are placed on a porcelain dish and mixed with a glass rod. The dish is then held over an alcohol lamp flame and the fluid allowed to evaporate slowly. A cherry-red color appears if free hydrochloric acid is present. (See Plate LVII.) If there are only traces, then there is a rose tint at the margin. If hydrochloric acid is absent, the color varies from yellow to brown.

This test responds to free hydrochloric acid and not to organic acids. The solution is unstable, and should be preserved in a dark glass bottle. It is advisable to make a fresh solution frequently.

The Resorcin-sugar Test (Boas).—Five grams of resorcin and three grams of cane-sugar are dissolved in 100 c.c. of alcohol. Equal drops of this reagent and gastric juice are slowly evaporated to dryness, without burning, in a porcelain dish or a butter-dish over an alcohol flame. If free hydrochloric acid be present, a rose-red color appears, which fades on cooling (Plate LVII). It responds to hydrochloric acid only. It is nearly as delicate, more easily obtained, less expensive, and more stable than Günzburg's test. After performing one of these check tests it is preferable in all cases to test quantitatively for acidity; and for this purpose I prefer Töpfer's method. The qualitative method gives no basis for scientific accuracy.

Töpfer's Method.—This method determines quantitatively: Total acidity; free hydrochloric acid; combined hydrochloric acid; total hydrochloric acid, and acid salts quite accurately for clinical purposes. In routine examinations it is rarely necessary to determine more than total acidity and free and combined hydrochloric acid. If free acid is absent, then the pepsin and rennet tests should be made. Occult blood tests are necessary when erosions or an ulcerated condition are suspected. We know that starch digestion is disturbed when HCl is in excess and that pepsin is present when HCl is in evidence.

Solutions Required.—(1) One per cent. alcoholic solution of phenolphthalein (colorless). (2) One per cent. aqueous solution of sodium alizarin sulphonate (opaque brownish yellow). (3) Five-tenths per cent. alcoholic solution of dimethyl-amido-azobenzol (yellowish red). (4) Decinormal solution of NaOH to titrate the gastric juice; 1 c.c. of tenth-normal NaOH neutralizes 0.00365 hydrochloric acid.

Töpfer's method depends upon the different sensitiveness of three-color end-reagents to the various constituents of the gastric juice.

Though 10 c.c. of the filtrate are usually employed, I have illustrated the method on the basis of 5 c.c., as it is often practically found impossible to carry out all the tests when using larger quantities. The methods are equally correct.

In each of the three beakers (*A*, *B*, and *C*, Plate LVII, Fig. 5) are placed 5 c.c. of the filtered gastric contents.

To beaker *A* are added one or two drops of the phenolphthalein solution, as an indicator of the total acidity. This body turns red-pink or red as soon as the fluid becomes slightly alkaline, after the addition of the sodium hydroxid.

To beaker *C* we add one to two drops of the dimethyl-amido-azobenzol solution. A reddish-pink or cherry-red color develops if free hydrochloric acid is present, depending on the amount of acidity. After titration with sodium hydroxide the end-reaction is a pale orange yellow.

To beaker *B* is added one or two drops of the sodium-alizarin-sulphonate solution. After sufficient sodium hydroxide is added, a violet color (the end-reaction) appears.

The titration with sodium hydroxide is performed from a graduated pipet or buret, supported on a stand. The latter should be graduated to $\frac{1}{5}$ or, by preference, to $\frac{1}{10}$ c.c.

The elements combining the total acidity in beaker *A* are free hydrochloric acid, acid salts, combined hydrochloric acid, and organic acids, which respond to the phenolphthalein test. In beaker *B* are free hydrochloric acid, acid salts, and organic acids, responding to the alizarin test. Hence, as Töpfer claims, to find the combined hydrochloric acid, one must subtract the acidity of *B* from the total acidity of *A*. In beaker *C* we have free hydrochloric acid alone, which responds to the dimethyl-amido-azobenzol test. In the absence of organic acids, the acidity of *C* subtracted from the acidity of *B* will give the acid salts.

Total Acidity.—The beakers being thus prepared, titration of beaker *A* (total acidity) is begun with the sodium hydroxide solution. As this is added, the reddish color appears, but it disappears as the fluid is agitated. The procedure should be continued until a permanent red-pink or reddish color is present, as in end-reaction (Plate LVII). As the degree of acidity is expressed by the number of cubic centimeters of a decinormal solution of sodium hydroxide required to saturate or make slightly alkaline 100 c.c. of the gastric contents, and as only 5 c.c. of the latter was employed (which is $\frac{1}{20}$ of the total quantity), the number of centimeters of the sodium hydroxide necessary to produce the end-reaction must be multiplied by 20. Thus if 3 c.c. sodium hydroxide produced the end-reaction in 5 c.c. of the filtrate, the total acidity would be 3×20, or $60 +$. Multiply this figure of acidity by 0.00365, and we have the percentage of total hydrochloric acid, or $60 \times 0.00365 = 0.219$ per cent.

Free Hydrochloric Acid.—Commence titration of beaker *C*, to which the dimethyl-amino-azobenzol solution has been added, and continue titration until

Fig. 1.—Phloroglucin-vanillin test. Color reaction.

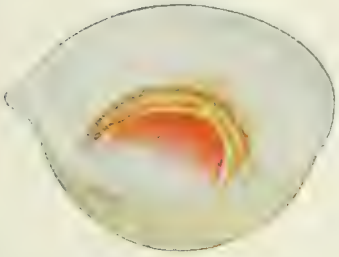


Fig. 2.—Resorcin test. Color reaction.

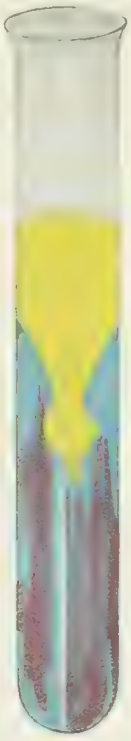


Fig. 3.—Uffelmann's test.

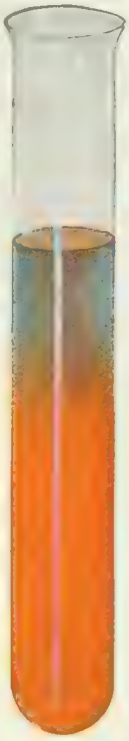


Fig. 4.—Congo red test.

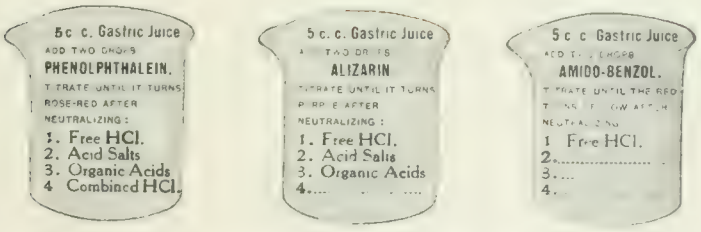


Fig. 5.—Topfer's tests; see end-reactions below.

Fig. 6.—Phenolphthalein end-reaction. Total acidity.

Fig. 7.—Sodium alizarin sulphonate end-reaction.

Fig. 8.—Dimethyl-amido-azobenzol end-reaction.

COLOR REACTIONS OF GASTRIC CONTENTS

(From Kemp's Diseases of the Stomach, Intestines, and Pancreas, W. B. Saunders Company.

the solution becomes a pale lemon yellow, as in Plate LVII. As saturation with the decinormal sodium hydroxide solution was computed on the basis of 100 c.c. of gastric contents, and only 5 c.c. or $\frac{1}{20}$ were tested, the number of cubic centimeters of sodium hydroxid solution required to produce the end-reaction must be multiplied by 20. Thus, if 2 c.c. of this alkaline solution will produce this result, we must multiply it by 20, and we say the free hydrochloric acid is 40 +. To compute free hydrochloric acid in percentage, multiply 40 × 0.00365 = 0.146 per cent.

Combined Hydrochloric Acid.—Commence titration of beaker *B*, to which the sodium-alizarin-sulphonate has been added, and continue the process until the end-reaction, the violet color, occurs. As only 5 c.c. of gastric contents are employed, and again the computation is based on 100 c.c., the number of cubic centimeters of decinormal sodium hydroxide employed must be multiplied by 20. If, for example, 2.2 c.c. were required, 2.2 × 20 = 44 + acidity. Töpfer has shown that alizarin is sensitive for all the elements comprising acidity, except for the combined hydrochloric acid. The acidity 44, therefore, secured by this reaction must be subtracted from 60, the total acidity; and this gives 16 acidity as the combined hydrochloric acid. In percentage 16 × 0.00365 = 0.06 per cent. combined hydrochloric acid. The total acidity, free and combined hydrochloric acid, are important to examine for as a matter of routine.

Fractions of a centimeter must often also be computed. If 10 c.c. of gastric juice be employed in the tests, then the number of cubic centimeters of sodium hydroxide required to produce the end-reaction must be multiplied by 10. If 2 c.c. of gastric juice is used, the multiple is 50, and so on.

Author's Method.—Simple Technique for Töpfer's Method.—In place of the buret or pipet for titration, the author employs a small measuring glass of 10 c.c. capacity—marked each cubic centimeter up to ten. With slight practice, one can easily estimate within $\frac{1}{8}$ c.c.—sufficiently near for diagnostic purposes. One can also employ a centrifuge glass marked in cubic centimeters and $\frac{1}{10}$ c.c. The gastric filtrate 5 c.c. each is placed in three small test-tubes, Töpfer's reagents added to each as usual and titration is carried with the decinormal sodium hydrate from the small measuring glass—drop by drop. It enables the consultant to carry his reagents in small compass and make chemical tests on the spot. *When there is a scanty amount of gastric filtrate,* after determination of the free hydrochloric acid, add to the *same solution,* one to two drops of the phenolphthalein solution, no change of color is produced. Then titrate with decinormal sodium hydrate until the red end-reaction is reached. The sum of the free HCl already determined plus the amount of sodium hydrate required to produce the end-reaction, will give the total acidity.

Lactic Acid.—Uffelmann's Test.—This reagent is sufficiently accurate, if necessary precautions are observed. It should be freshly prepared before each test. It can be prepared as follows: 10 c.c. of a four per cent. carbolic acid solution is mixed with 20 c.c. of distilled water, and to this is added 1 drop of sesquichloride of iron. A watery solution of carbolic acid (two per cent.), to which is added 1 drop of liquor ferri sesquichloride, is another method of preparation. These solutions have an amethyst-blue color. A simple method is to place a few drops (4 or 5) of carbolic acid in a test-tube and fill about two-thirds with water. If the carbolic is not in perfect solution, decant a little, and add sufficient water to secure such. Then add a few drops of liquor ferri sesquichloride, or tincture iron chloride sufficient to give a clear amethyst color when shaken. As about five per cent. is the maximum solubility of carbolic, the above method about corresponds to the per cent. methods described above.

Other methods of preparation are recommended by Riegel: 20 c.c. of distilled water, 10 c.c. of a four per cent. carbolic acid solution, and 0.1 c.c.of neutral ten per cent. iron chloride solution; or, dilute the officinal rion chloride solution with distilled water until the solution is about colorless, and then add a two to four per cent. solution of carbolic until the amethyst-blue color appears. A very dilute iron chloride solution will also give the reaction, but the blue color acts as a contrast. The lactic acid reaction has been described as a canary-yellow or, more often, a canary-green color (Plate LVII). Fatty acids produce an ash-gray and inorganic acids decolorize the blue solution. As at times the phosphates may be present in the gastric contents and they give the same reaction, a modification has been recommended, which is practical for general use.

Modified Uffelmann.—Take 5 c.c. of the filtrate plus 10 c.c. of ether, and shake in a test-tube for a few minutes; then allow it to stand until the ethereal solution has separated from watery solution. Pour the ethereal part into another test-tube and place it in a glass of hot water to evaporate. Add 1 c.c. of distilled water to the remaining drops, and test for lactic acid with the Uffelmann solution. If the canary color occurs, lactic acid is present. A larger quantity of the filtrate can be employed with two or three times the quantity of ether. Fleiner does not evaporate the ether, but adds Uffelmann's solution directly to it. The solution will appear yellow at the bottom of the tube if lactic acid be present.

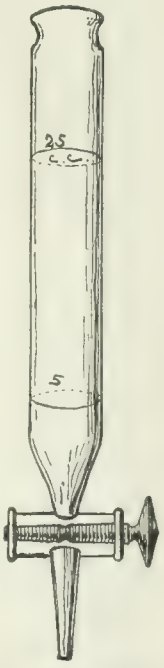


Fig. 4656.—Strauss Mixing Funnel.

Strauss employs a mixing funnel with two markings, one at 5 c.c. and the second at 25 c.c. (Fig. 4656). Fill to 5 c.c. with the stomach filtrate. Pour on ether (Squibbs') up to 25 c.c. and shake the mixture well. Open the lower stop-cock and allow the fluid to run off until it reaches 5 c.c., and then pour in distilled water to 25 c.c. To this mixture add 2 drops of iron chloride solution (1 : 9 distilled water), and shake the whole. Investigations by Strauss show that if one cubic millimeter of lactic acid be present, an intense green color occurs; if less lactic acid, the color is light green.

Arnold's Test.—(1) A solution of gentian violet (0.2 c.c. saturated alcoholic solution in 500 c.c. distilled water), and (2) Tinctura ferri perchloridi, 5 c.c. (U.S.P.), diluted with distilled water (20 c.c.). A drop of the iron solution gives a blue color with 1 c.c. of the gentian violet, which changes to yellowish green when gastric contents which contain lactic acid are added.

Other methods have been suggested, notably that of Boas, which is rather complicated. It is based on the oxidation of lactic acid into acetaldehyde and formic acid. The presence of aldehyde is demonstrated by the iodoform reaction with alkaline iodine solution or of aldehyde of mercury with Nessler's reagent.

Boas' Method.—Take 10 to 20 c.c. of the gastric filtrate and evaporate it into a syrupy consistency over the water-bath. If free hydrochloric acid is present, an excess of barium carbonate is added. A few drops of phosphoric acid are then mixed in, and the carbonic acid is expelled by boiling. The fluid is then cooled and extracted two or three times with 50 c.c. of ether. After half an hour pour off the clear ethereal layer. The ether is now evaporated, and the residue washed in a flask with 45 c.c. of water, well shaken and filtered. Concentrated sulphuric acid, 5 c.c. (sp. gr. 1.89), and a pinch of manganese dioxide are added to

the filtrate. The mixture is then distilled over a small flame, and the vapor conducted into a narrow cylinder containing 5 to 10 c.c. of an alkaline iodine solution. This consists of equal parts of a decinormal iodine solution and the standard potassium hydroxide solution. The vapor may be conducted into the same quantity of Nessler's reagent. If lactic acid is present, it gives rise to the iodoform reaction (clouding and odor of iodoform) with the iodine mixture. If Nessler's reagent is used, yellowish-red aldehyde of mercury appears. This procedure is further elaborated for the quantitative estimation of lactic acid, but it is extremely complicated and clinically unnecessary.

We may say that when a test breakfast or test dinner is taken under proper conditions, only traces of lactic acid are introduced, and finding it in appreciable quantities in the gastric contents is of pathological significance, showing subacidity and stagnation. It is not pathognomonic of cancer, but these conditions frequently exist in such cases.

Quantitative Estimation of Lactic Acid.—The acidity of the filtrate is first determined; 10 c.c. of the filtrate are shaken up with ether in excess. The ether is then separated and the degree of acidity computed therein. Subtract this figure from the total acidity and multiply by 0.09, which gives the percentage. Volatile acids must be first tested for and eliminated by boiling. This method is only approximate.

Volatile Acids.—Fatty or volatile acids are recognized by boiling a few cubic centimeters of the filtrate in a test-tube. A strip of moistened blue litmus-paper is held over the escaping vapors. The paper will turn red if they are present. Quantitative determination is hardly necessary.

Acetic Acid.—In large quantities acetic acid can be detected by its characteristic odor. For the detection of small quantities, Einhorn neutralizes the watery residue of the ethereal extract of the gastric filtrate with carbonate of soda, and then adds neutral chloride of iron solution, when a red color is developed.

Propeptone.—Add to the gastric filtrate of 5 c.c., an equal quantity of a saturated solution of sodium chloride. Propeptone, if present, is precipitated. If none is formed, then add one or two drops of acetic acid, and precipitation will occur if propeptone is present. On heating, the solution clears up, but again becomes turbid on cooling.

Peptone.—After filtering out the propeptone, take 2 c.c. of the gastric filtrate and make strongly alkaline by adding sodium hydroxide solution and then add a few drops of a weak one per cent. copper solution. Peptone gives a purple or violet-red color (biuret reaction).

Pepsin.—A thin disc of the white of a hard-boiled egg, weight of about one gram (one centimeter in diameter and one millimeter thick), is placed in a test-tube containing 5 c.c. of the gastric filtrate and kept at blood temperature. The tube can be placed in water at blood temperature in a Thermos bottle. If free hydrochloric acid is not present in the filtrate, add two drops of dilute hydrochloric acid. The presence of pepsin will cause disappearance of the albumin in from two to six hours.

The methods for the quantitative determination of pepsin that have been recognized as practical for clinical purposes are those of Hammerschlag and Mett. Henry Illoway has devised a simple method for determining the relative quantity of pepsin, which seems to the author of value: 10 cgm., exact weight, egg-albumin (white of hen's egg) is coagulated in the following manner: The egg is placed in a small pot of cold water, which is then covered with a lid and put on to boil. It is allowed to cook for ten minutes after the water has begun to boil—in all, heating twenty minutes from the time it has been put on. The egg is then taken out and allowed to cool, either by setting it in a saucer or by putting it in cold water.

To imitate the usual way, food is ingested, the segment of albumin is divided into 2 parts, so that the gastric juice can act upon it more quickly. The coagulated albumin is put into 10 c.c. of the gastric filtrate (from stomach-contents, extracted one hour after an Ewald-Boas test-breakfast), and this is then placed in the thermostat, which is kept at 38° C. The time in which the 10 cgm. are digested, entirely, partially, or not at all, will give a correct idea as to the pepsin secretion. Illoway shows that normal digestion of the albumin requires from five to five and one-half hours.

He classifies as follows: *Hyperpepsinia.* Digestion requiring from three to four hours indicates a secretion of pepsin greater than usual, which may, however, be the normal for that case. *Normal Pepsinia.* Digestion requiring from five to five and one-half hours. *Hypopepsinia.* Digestion requiring more than the usual time. The degree indicated by the number of hours required beyond the standard of time. *Apepsinia.* No digestion at all.

Jacoby-Solms Method.—Ricin Test. Dissolve one gram of ricin, 100 c.c. of a five per cent. solution of sodium chlorid and filter. Mix 2 c.c. of this filtrate with 0.5 c.c. decinormal HCl solution; 1 c.c. of diluted stomach-contents is added, and allowed to remain at blood temperature for three hours. Ferments clear up the ricin deposit. The quantity of pepsin is determined from the amount of dilution in which the stomach-contents will cause the ricin deposit to disappear.

Solms designates the amount of gastric juice which is sufficient to clear up the 2 c.c. of a two per cent. ricin solution in three hours, kept at the blood temperature, as one pepsin unit. The normal stomach contents contain about 100 pepsin units to the cubic centimeter. Witte has modified the above methods. Fuld employs a solution of edestin instead of ricin.

An ordinary thermos bottle partially filled with water at a temperature of about 100° F. can be employed in place of a thermostat, test-tubes containing the solutions being tightly corked and placed therein. Einhorn employs a thermos bottle with metal framework to hold the tubes. These last are graduated in millimeters, so as to dispense with a measuring glass.

Casein Test.—Gross mixes a 1:1000 solution of casein containing 16 c.c. of a twenty-five per cent. HCl to the liter with the filtrate or its dilutions, and leaves it for a quarter of an hour in the thermostat. He then adds a few drops of the concentrated solution of sodium acetate, which results in a precipitate if the casein has not been digested; otherwise the solution remains clear.

W. C. Rose, has devised a test to be employed as a substitute for the "ricin test," employing a globulin preparation derived from the ordinary garden pea (*Pisum sativum*).

Mett's Method.—This consists in sucking fresh egg-albumen into capillary tubes of one or two millimeters diameter, coagulating the albumin by boiling, and then cutting off portions three to five centimeters long of the filled tube and adding these pieces to the gastric contents. This should be kept at body temperature for ten hours in the incubator. At the end of this period each end of the tube will show a lack of solid albumin, owing to digestion, while some will remain in the central portion. Both the empty portions and the portion that is full are measured, and the activity of the pepsin digestion is thus determined. The relative amount of pepsin varies according to the square of the length of the empty portion of the tube, the figures of the latter being expressed in millimeters; thus, three millimeters of digestion equals nine parts of pepsin; two millimeters, four parts of pepsin, etc.

Rennet.—Add five drops of the filtered gastric contents, preferably neutralized with decinormal sodium hydroxide solution, to 10 c.c. of fresh neutral milk in a test-tube. Place this in a glass of warm water at a temperature of about 100° F., or in a thermostat. A

thermos bottle containing warm water is extremely convenient.

Normal Rennet.—In about five to fifteen minutes coagulation will occur if the rennet be normal. If the same quantity of filtrate (five drops) be added to 20 c.c. of milk, Illoway finds, under normal conditions, coagulation will occur within fifteen to thirty minutes. He suggests a simple quantitative method.

Deficient Rennet.—Add 1 c.c. of gastric filtrate to 10 c.c. and 20 c.c. of milk if the smaller quantity of filtrate (five drops) gives no result. If reaction occurs within the same period, rennet is deficient. Deficiency is more marked when no result is obtained with 1 c.c. of gastric filtrate, but is obtained within the half hour with 5 c.c. of filtrate.

Absence of Rennet.—When no reaction is obtained within half an hour with 5 c.c. of gastric juice and 10 c.c. of filtrate, no reaction will occur. It has been demonstrated by Illoway that rennet may be present in nearly normal amount, even if pepsin is markedly deficient; it may be present even if pepsin is absent. Rennet is usually the last one of the elements of gastric digestion to disappear.

Rennet Zymogen (Chymosinogen).—Add to the same specimen of milk three to five drops of a one per cent. solution of calcium chloride and place in an incubator. Coagulation shows the presence of the enzyme; otherwise it is absent.

Examination of Starch Digestion.—The salivary ferment continues its action on starch in the stomach while the amount of hydrochloric acid is not too great. As soon as the total hydrochloric acid reaches 0.12, the action ceases. If the secretion of hydrochloric acid is abnormally great, starch digestion is soon stopped, and there is either no digestion of starch, or the end products are not formed. The reverse is the case in subacidity. To determine the intermediary stages, a dilute iodine-potassium solution (Lugol's) is employed. It consists of iodine, 0.1; potassium iodide, 0.2; distilled water, 200.0. A few drops of the filtered gastric juice are placed on a porcelain dish, and to it is added a drop or two of Lugol's solution. The reactions are as follows: Dextrin turns the fluid blue; erythrodextrin, a red purple; achroodextrin discolors slightly the yellow tincture of the Lugol; maltose does not change the color. For sugar or maltose, Fehling's or Trommer's test must be employed. In normal cases, sugar and achroodextrin are present; erythrodextrin absent or present in small amount; dextrin absent. If blue, or blue-violet color appear, saccharification is deficient.

Other Methods of Testing the Gastric Secretion.—There are several ingenious methods for testing the gastric secretion in order to obviate the unpleasant procedure of aspiration, or because some patients absolutely refuse the tube, or there is danger incurred from its passage, such as in cases of aneurysm, angina, severe endocarditis, or after a recent hemorrhage from the stomach or lungs, or in the very debilitated.

Sahli's Desmoid Test.—This consists in placing methylene blue or iodoform in a small rubber bag and tying it tightly with thin raw catgut. The bag is swallowed after a large meal, and the urine is examined for methylene blue, or the saliva for iodine. Methylene blue colors the urine green or greenish blue. The iodine is tested for in the saliva by starch paper and fuming nitric acid, giving a bluish or violet color. It is based on the fact that raw connective tissue, including catgut, is, according to Schmidt, digested only by the gastric juice and not by the pancreas. The reaction occurs in healthy persons usually six to eight hours after swallowing the bag. If it takes place later, or not at all, the secretory function is insufficient. An early reaction shows hyperacidity. Einhorn, in some cases of achylia gastrica and cancer, has demonstrated that catgut is also digested in the bowel, and considers that the method is unsuitable.

Günzburg's Method.—This is based on the same principle as Sahli's. The patient swallows 0.2 gram potassium iodide, inclosed in a small rubber bag, which is tied with fibrin threads. After the fibrin is digested, the potassium iodide is set free and absorbed. The test of the saliva is made with starch paper and fuming nitric acid, giving a violet or bluish color. This necessitates frequent examinations of the saliva, or the bag may escape and the fibrin be digested in the intestine. The objections are the same as to Sahli's test.

Gas Fermentation.—The presence of free hydrochloric acid does not prevent the development of gas. It may occur in a soil that is non-acid, together with lactic acid fermentation. Stagnation is the chief factor favoring fermentation. Various gases may be formed, but from a practical point of view the determination of its occurrence, quantity, and the time necessary for its development are sufficient. The unfiltered gastric contents should fill a tube such as is employed for the determination of sugar in the urine (the Fiebig tube). It should be placed in an incubator at 37° C. (98.6° F.), or if this is not at hand, in a uniform warm place. One can employ a test-tube, as suggested by Moritz, closed by a rubber cork through which is passed a bent glass tube. The test-tube is filled with gastric contents and then closed with the cork, thus forcing some of them into the curved tube and preventing the entrance of air. The apparatus is inverted in a beaker. As as times the sugar may already be destroyed by fermentation, it is well to prepare a control tube of gastric contents to which a small quantity of powdered dextrose has been added, or it may be added at once. If no development of gas is noted after twenty-four hours, the tube should be allowed to stand for three or four days.

Carbon dioxide may be identified by allowing a small amount of KOH to flow through a pipette to the bottom of the gas column. The carbonic acid is absorbed by it and the fluid moves up to take the place of the absorbed gas. The expressed test-meal, or test breakfast, os vomitus can be employed. If fermentation is excessive, one can assume motor insufficiency. If rapid fermentation occurs within a few hours, pyloric stenosis should be suspected, as this produces the most severe degree of motor insufficiency. If the stomach contains a large amount of lactic acid and no free hydrochloric acid, carcinoma of the pylorus is probably the cause of this stenosis.

Gaseous fermentation is usually more intense in cases of motor insufficiency in which free hydrochloric acid is present. It can occur in any form of stomach disease in which there is a disturbance of gastric secretion. Lactic acid fermentation only occurs markedly in subacid conditions. Alcohol, various hydrocarbons, and sulphureted hydrogen have been found as products of fermentation. Boas finds H_2S chiefly in benign ectasia.

Examination of the Vomit.—The same methods that are employed in examination after the test-meal apply to investigation of the vomitus. The information, however, is not as positive, as the admixture of bile, saliva, etc., obscures the result. Important information is secured, but the physician should inspect the vomitus in person. If the vomiting consists chiefly of food, it should be learned when the last meal was taken and of what it consisted. If coarse morsels are found six or seven hours after a meal, the conclusions are naturally different than if they were found directly after eating; and by this means we can often determine the digestive and motor powers of the patient. If food is vomited that was ingested the day before, marked motor insufficiency is present. With gastric ulcer, vomiting often occurs at the height of digestion. In some nervous diseases it usually takes place immediately after eating. With ectasia, vomiting occurs late in digestion and often in great quantity. In dilatation with hypersecretion the fluid

is abundant, and there are fine remnants of amylaceous material; while with carcinoma of the pylorus undigested morsels of meat are present. In the former case free hydrochloric acid is present, and Congo paper will turn blue; in the latter case, no color change occurs. The presence of blood is important, and its appearance depends on the presence or absence of hydrochloric acid, on the rapidity with which it is poured forth, and on the length of time it has remained in the stomach. It may, therefore, appear chocolate brown, like coffee grounds, or as fresh blood. Mucus is also readily discovered. Pus is rarely found, unless from perforation in phlegmonous gastritis, or from some neighboring focus into the stomach, or unless it has been swallowed. Microscopic pus occurs with ulceration. During violent vomiting bile is frequently in evidence, or when vomiting occurs on an empty stomach. It may occur with pyloric stenosis, when the opening is kept slightly patent. With persistent vomiting of bile one would suspect some obstruction of the duodenum, such as carcinoma, torsion, gallstones, etc. Parasites, such as ascarides or the oxyuris vermicularis, are occasionally found in the vomit, and very rarely a piece of gastric tumor.

Examination of the Contents of the Fasting Stomach.—It may be necessary to investigate the contents of the fasting stomach, especially when disturbance of the motor function is present or when hypersecretion is suspected. Under normal conditions one might expect to find from 5 to even 15 c.c. of gastric contents in the normal stomach. Anything to 30 c.c. over 20 c.c. in association with gastric symptoms is considered pathological. The examination should be made in all cases where one suspects an abnormal quantity of gastric contents will be found in the morning after fasting; also in all cases of suspected ectasia or atony of the stomach. The best method is to wash the stomach thoroughly the night before, both in the sitting and reclining posture, and then administer a test supper. The contents are aspirated, measured, and examined the following morning before breakfast. The chief purpose is to test the motor function of the organ, especially to determine whether motor insufficiency of a high degree is present.

Reichmann's Method.—When hypersecretion is suspected, the procedure is slightly different. The stomach is thoroughly washed at about 10 P.M. and care taken that all the water is removed. No food or drink is allowed thereafter, and in the morning before breakfast the contents are aspirated and examined. A quantity over 20 c.c. found repeatedly taken in association with symptoms, I would consider pathologic (hypersecretion). When there is permanent regurgitation of bile into the stomach, Riegel has shown that this method of examination is important. If bile and pancreatic juice enter the stomach, digestive processes are arrested. Bile, pancreatic, and probably intestinal juice are occasionally found in the empty stomach (duodenal juice, Boas). This material is grass green or yellowish, containing bile constituents, and converts starch into maltose and dextrose, proteins into peptones, and splits fats. If it is aspirated occasionally, it is probably not significant; but if there is constant regurgitation, it is suggestive of obstruction in the duodenum. When there is obstruction to the flow of the intestinal contents, or a communication between the stomach and intestine, intestinal contents are found in the stomach.

Abnormal Constituents of the Stomach Contents.—Abnormal products which are of importance for our diagnosis are quite frequently found in the gastric contents. They may contain mucus, blood, bile, intestinal juice, and pus.

Mucus when present in considerable quantity is easily recognized. It generally occupies the upper part of the fluid, appearing in swollen, glassy lumps or in flakes and shreds. It is also intimately mixed with the food. It can be readily lifted with a glass rod. If in small amount, a few drops of dilute acetic acid are added, it will be revealed by the characteristic precipitate.

Bile and Intestinal Juice.—Small quantities of bile and intestinal juice may occasionally be met with normally. Their frequent occurrence is due either to relaxation of the pylorus or stenosis of the duodenum below the mouth of the bile duct. Pure bile is golden yellow, but green if mixed with gastric juice. I believe that too often the diagnosis is made by simple inspection. Mould may produce a greenish color, and I have found it on several occasions. For accuracy, the tests should be made—Gmelin's for bile pigment, and Pettenkofer's for bile acids.

Einhorn suggests the following for the intestinal juice, which is recognized by its ferments, trypsin, amylopsin, and steapsin:

Trypsin.—Mix the filtrate with one per cent. solution of sodium carbonate until the reaction is decidedly alkaline; add a flake of fibrin and keep in a warm place for several hours. Trypsin will dissolve the fibrin.

Amylopsin.—Starch is changed into maltose.

Steapsin.—Add one drop of blue litmus tincture and a few cubic centimeters of the neutralized filtrate to a small portion of milk and keep at blood temperature. Steapsin changes the blue color, and the milk becomes slightly reddish from decomposition of the fat into fatty acids.

Blood.—Blood in large quantities is easily recognized, as is fresh blood, even if in small amounts. Fresh blood mixed with gastric contents presents a reddish appearance, while old blood is brownish or of a coffee-ground color. It may even appear blackish. When the blood cannot be detected microscopically and gastric hemorrhage is suspected, occult blood must be examined for.

It is advisable to make the same examination of the stool.

Benzidin Test.—This is a test devised by O. and R. Adler. They first applied it to test the feces. Schlesinger and Holst advise boiling the gastric filtrate and testing in the same manner as for feces: *Solution* 1. Knifepointful of benzidin (Merck's) is added to 2 c.c. of glacial acetic acid and allowed to stand and dissolve. *Solution* 2. Ten to twelve drops of the benzidin solution are added to 2½ or 3 c.c. of a three per cent. peroxide of hydrogen solution. Three or four drops of the gastric filtrate, which has been boiled for about half a minute, are added to Solution 2. In the presence of blood, a green or blue color results in from a few seconds to a minute.

Stool.—A small piece of feces about the size of a pea is mixed with 2 c.c. of water and boiled in a test-tube closed with cotton for half a minute; three or four drops of the boiled fecal solution are added to Solution 2. A green or blue color results if blood be present.

For making this test Paul Cohnheim has devised a slight modification. Place a little benzidin (Merck) in a dry test-tube and shake it with about ½ c.c. of glacial acetic acid; add 2 c.c. of H_2O_2 and then carefully place on its surface a little of the fluid which is to be examined. The last should be previously boiled. A green-tinted ring results. The intensity of the green or bluish ring affords one conclusions as to the quality of the occult blood.

Benzidin Test Paper.—Einhorn has devised a benzidin testing paper as follows: Take a saturated solution of benzidin and glacial acetic acid; moisten filter-paper therein and dry it. Both in preparing the paper and making the test avoid contact with the fingers, as a drop of perspiration causes the reaction. When handling the paper, employ ivory-tipped forceps or protect the hand by a towel. A piece of benzidin paper is first immersed in the gastric filtrate, and then a few drops of hydrogen peroxide are added. The paper is then placed on a piece of white porcelain and examined for the development of a blue color. If

blood is present, a blue or green color occurs in a few seconds to a minute. Einhorn shows that if we wait longer periods, other substances may cause the reaction, also in time the paper moistened with peroxide will become blue.

Feces.—In testing for occult blood with the paper, a small piece the size of a pea is rubbed up with 2 c.c. of water, the benzidin paper immersed therein, a drop of hydrogen peroxide added, and the blue color then examined for. The benzidin paper Einhorn recommends as a preliminary, and if there is immediately a strong reaction or none at all, he regards the result as reliable. If at the end of a minute only a trace of reaction occurs, then the aloin-ether extract method may be employed as a check. In the fecal examination, ether extract of feces, as employed in the aloin test, makes the benzidin test more reliable.

In examination of the gastric contents no meat products or iron preparations should be taken for at least twenty-four hours before the test, and in testing the stool the same rule must be observed; but, preferably, for a longer period if possible—at least two or three days as a precautionary measure. It has been demonstrated that prunes give the typical reaction and that rice, milk, and potatoes react to it.

Phenolphthalein Test.—The reagent is made as follows: Dissolve one gram of phenolphthalein and twenty-five grams of potassium hydroxide in 100 c.c. of water, and reducing with ten grams of pulverized zinc. The resulting red fluid is stirred or shaken over a small flame until it is entirely decolored, the phenolphthalein being reduced to phenolphthalin. The solution is then filtered, when it is ready for use. It keeps indefinitely. A small amount of the stool, about 5 c.c., is rubbed up in water until it forms a thin fluid. Into this a little glacial acetic acid is stirred to acidify, ether is then added in equal volume, and the containing glass is slowly moved to and fro until the contents are well mixed. The ethereal solution is then decanted into another reagent glass and twenty drops of the phenolphthalin reagent are added. This last is shaken, and then three or four drops of hydrogen dioxide are added. In the presence of blood the phenolphthalin is oxidized into phenolphthalein, and as it is in alkaline medium, the fluid turns pink. With considerable blood the pink tint persists for some time; with little blood, it soon fades. With much blood, the reaction is pronounced, even without the hydrogen dioxide. To test stomach contents, a few drops of glacial acetic acid are added to a few cubic centimeters of gastric filtrate and the same methods followed.

Weber's Modification of Van Deen's Test for Occult Blood.—Dilute the stomach-contents or, preferably, the filtrate thereof, with one-third volume of glacial acetic acid, and extract with about 10 c.c. of ether. A few cubic centimeters of this acid ether extract are mixed with ten drops of tincture of guaiac and twenty to thirty drops of ozonized oil of turpentine (old turpentine exposed to air). If blood is present, the mixture turns a blue or blue violet; if absent, it turns a reddish brown with a green tinge. The reaction is more distinct if a little water is added and the blue pigment extracted with chloroform. Many authors insist that the tincture of guaiac should be freshly prepared on each occasion. Soper demonstrates that this is unnecessary. He reduces the guaiac resin in a mortar to a fine powder, slowly adding ninety-five per cent. alcohol, leaving a residuum of guaiac in the mortar to insure a strong tincture. This is filtered and kept in a glass-stoppered bottle as a stock preparation. Dilute a portion of this stock tincture with ninety-five per cent. alcohol (tincture, one part; alcohol, five parts), and keep in a smaller glass-stoppered bottle for daily use.

KLÜNGE'S ALOIN TEST.—*Feces.*—In this test freshly prepared aloin is employed. Dissolve as much aloin as can be placed on the tip of a knife-blade in 10 c.c. of seventy per cent. alcohol; add 2 c.c. of the aloin solution to 2 c.c. of the ethereal extract of feces, prepared as above, and then the oil of turpentine or dioxide of hydrogen as described. A cherry-red color appears in the fluid if blood be present.

Gastric Contents.—Ethereal extract of the filtrate is prepared as in Weber's test. The rest of the test is the same as the aloin test of feces. Einhorn at times employs aloin paper prepared with filter-paper saturated with a solution of aloin in seventy per cent. alcohol, the paper being then dried for future use.

Iron Test.—This is useful if the patient is not taking iron. Place a small amount of unfiltered gastric contents in a porcelain dish. Add to it a pinch of potassium chlorid and a few drops of concentrated hydrochloric acid. Mix these thoroughly. Then heat over a small alcohol flame until a dry residue is secured. Add to this a few drops of a weak solution of potassium ferrocyanide. If blood is present, a Prussian blue color results.

The spectroscopic test, Heller's, Schönbein's, Korcznski's, the hemin test, etc., have been suggested, but the ones described are the most practical.

Hemin Crystals.—Hematin combines with one molecule of hydrochloric acid to form hemin. This last substance crystallizes in brown plates or columns, and when produced by the addition of glacial acetic acid, may be of considerable size. Star or rosette-shaped crystals may also be present. The formation of hemin may occur from mere traces of blood. Negative results are not conclusive. The test is as follows: Evaporate a small sample of gastric filtrate on a watch-crystal over a small alcohol flame. Scratch the residue free, and mix with it a grain or two of finely powdered salt. Transfer this to a microscopic slide, and add a drop or two of glacial acetic acid. Gently heat the slide for a minute or two until bubbles begin to form, then cool it off and examine under the microscope with a one-sixth or one-seventh objective. The crystals will be seen as in Fig. 4657.

FIG. 4657.—Teichmann's Hemin Crystals (Jakob).

Gross employs Stozyzowski's modification of the above (Teichmann's) method. He recommends it particularly in the determination of blood in suspected duodenal ulcer, first obtaining the duodenal contents by his aspirator. He notes small apparent blood points in the contents, and placing one of these on a slide, drying it slightly, then covers it with a cover-glass. At the margin he places one or two drops of the following mixture: alcohol, water, glacial acetic acid, of each, 1 c.c., and three drops of hydriodic acid (undecomposed, if possible, and of a specific gravity of 1.5). The specimen surrounded by this solution is boiled for about ten seconds over a small spirit lamp. The loss sustained by evaporation should be constantly replaced. Objective 7, ocular 3, should be employed in the microscope. If the specimen is blood, there will be rhomboid prismatic crystals of a black color (hydriodic hematin ester).

Pus is seldom found in the gastric contents, and is recognized readily under the microscope. Excluding ingested pus and phlegmonous gastritis, pus shows ulceration of the gastric mucosa.

Microscopic Examination of the Gastric Contents.—The relative value of the microscopic examination of the gastric contents after the test-meal, of the vomitus, and of the fasting stomach-contents, as

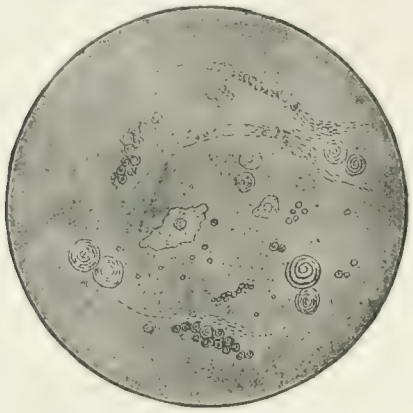


Fig. 4658.—Fasting Gastric Juice Containing Mucus, Snail Forms, Epithelial Cells, and Amorphous Material.

compared with gastric analysis, is still a matter of dispute. Some of the ardent advocates of the microscope go so far as to claim that their method is alone necessary. Undoubtedly, in many cases the clinical symptoms, gastric analysis, the test of the motor function, and macroscopic inspection of the contents afford sufficient information for diagnosis. I do not wish, however, to depreciate the value of the microscope, as in some cases it is of fundamental importance.

Gastric Secretion.—When fasting, the gastric secretion shows normally under the microscope epithelial cells, cell nuclei, some mucus, amorphous material, and microorganisms. (Fig. 4658.) Jaworski describes spiral

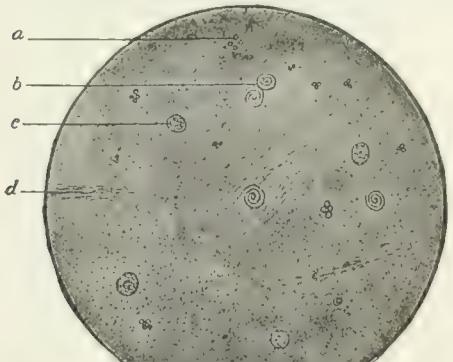


Fig. 4659.—*a*, Nuclei of Leucocytes; *b*, spiral bodies; *c*, nuclei of epithelial cells; *d*, striated mucus.

or snail-like bodies in cases of hyperchlorhydria, but Boas believes they are quite common and that they are developed from the mucus by the action of the gastric juice. Einhorn has found them in patients with normal secretion.

Mucus from the bronchi and lungs is characterized by the presence of alveolar cells and myelin drops; while the occurrence of a great many columnar epithelial cells is evidence of its origin from the gastric mucous membrane. In doubtful cases the microscope will thus determine the source of the mucus, either by examination of the fasting contents or after a test-meal. The clinical symptoms and macroscopic appearance of the contents, as described under Chronic Gastritis, will, however, generally give sufficient information.

Paul Cohnheim holds that the presence of free nuclei of leucocytes and epithelial cells is a positive evidence of hydrochloric acid and pepsin. (Fig. 4659.)

I believe that gastric analysis is much preferable for such determination. Importance has been attached to the presence of two varieties of infusoria, the *Trichomonas hominis* and *Megastoma entericum*, notably by Cohnheim (Fig. 4660). He believes that their presence is pathognomonic of carcinoma, not affecting the motility of the stomach. Amebæ are often associated with them.

The development of these infusoria requires the absence of hydrochloric acid, an alkaline medium, and the existence of deep folds in the mucosa. Previous to aspiration, the stomach-tube and receptacle should be warmed. To differentiate between cancer and achylia gastrica in the suspected cases with emaciation, gastric distress, and achylia, special examination for these infusoria is advocated by Cohnheim. The presence of pus, especially if associated

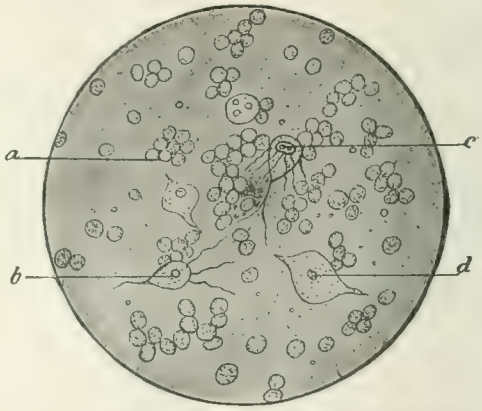


Fig. 4660.—*a*, Pus Cells; *b*, Trichomonas; *c*, Megastoma; *d*, pavement epithelium.

with blood in the non-fetid gastric contents, he also believes aids in the early diagnosis before the tumor is palpable. Microscopic pus in the gastric contents shows ulceration, but not necessarily malignant in type. Phlegmonous gastritis and the ingestion of pus from above must be excluded. Sarcinæ and the Boas-Oppler bacillus can be examined for, both in the fasting stomach and after the test-meal. The same is true as regards epithelial cells and pieces of the gastric mucosa. I will refer to them shortly.

Gastric Contents.—The microscopic examination of the gastric contents after the test breakfast or dinner shows, under normal conditions, a few starch granules, many of which no longer appear in spiral form. The muscular fibers do not show their diagonal stripes; globules of fat, plant cells, and microorganisms are present in small numbers. Many unchanged starch granules are found in hyperchlorhydria and hypersecretion, and the muscle fibers are well digested; while with hypochlorhydria (deficient secretion) unchanged muscle fibers are present. The granules of starch are brought out clearly by the addition of one drop of tincture of iodine, giving a blue reaction. The microscopic findings are here confirmatory of macroscopic inspection.

The varieties of microorganisms have been thoroughly studied by DeBary, Nencki, Boas, and others. It has been demonstrated that they may be present

even in hyperchlorhydria, showing that the hydrochloric acid does not always prevent fermentation.

J. Kaufmann has described a case of hyperchlorhydria in which the motor function of the stomach was not markedly disturbed, but which showed fermentative processes. He isolated eight varieties of microorganisms in a specimen of the gastric contents.

Boas has also described the development of sulphureted hydrogen in a case of hyperchlorhydria. In general, we may say that fermentation develops in cases when the motility of the stomach is reduced.

Mikowski has shown that if free hydrochloric acid be abundant, yeast and thread fungi may be found; while if it is absent, numerous mould organisms are present. This last corresponds to the findings of A. Rose and myself.

Yeast.—A few isolated yeast cells are found in the normal stomach. In ectasia or atony of marked degree the yeast cells are numerous, arranged in colonies, and are in active process of germination (Fig. 4661).

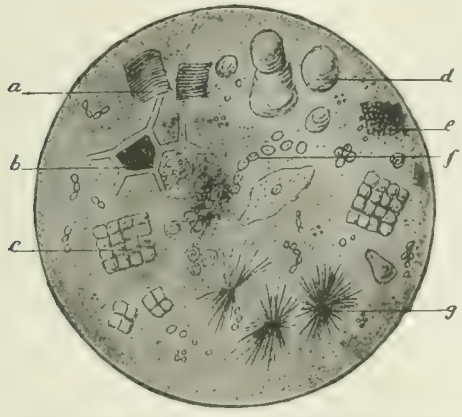


Fig. 4661.—Benign Ectasia. Yeast-cells and sarcinæ are prominent: *a*, Muscle-fiber; *b*, plant-cells; *c*, sarcinæ; *d*, starch granules; *e*, degenerated sarcinæ; *f*, yeast-cells; *g*, fat crystals.

Sarcinæ.—These occur usually in cubes or bales, and are only pathologic if present in large numbers, as in benign ectasia or atony in the presence of hydrochloric acid. They are rare in ectasia from cancer, and, if present, occur usually in cancer developed on an ulcer. Their presence in large numbers is an aid to diagnosis.

Boas-Oppler Bacilli.—They are unusually long, nonmotile bacteria, and are characterized by their large size and end-to-end arrangement (Fig. 4662). They must be differentiated from the Leptothrix buccalis by Gram's solution, with which they stain brown, the leptothrix, blue. Kaufmann's investigations prove the Boas-Oppler bacillus has the power of generating lactic acid from different sugars. Stagnation with lactic acid fermentation is not specific of pyloric carcinoma, but depends on the absence of hydrochloric acid and the presence of stagnation. These conditions exist in stenotic gastritis. These bacilli have been found occasionally in stomach contents that contain free hydrochloric acid (Rosenheim). Kaufmann has demonstrated them in nineteen out of twenty cases of carcinoma. The presence of these bacilli, with pronounced lactic acid fermentation and taken in connection with clinical symptoms, is very significant.

Epithelial Cells, Particles of Tumor, and Fragments of Gastric Mucosa.—Single cells cannot be diagnosed as cancer cells, but cell nests must be found. These are rarely discoverable. Occasionally, after aspiration of the fasting stomach or test-meal, or after lavage, or in the vomitus, small particles of tissue may be found, which on staining may reveal the nature of a tumor. Hemmeter recommends in suspected cases, first, thorough lavage and rectal feeding for a day; then passing the tube, moving it about actively, and subsequent aspiration of the fasting stomach. This is to be followed by lavage. All tissue fragments are to be examined. Einhorn finds, especially after lavage, or at times after aspiration, small pieces of mucous membrane which he stains and examines. Some point to erosions, others to other affections. The fragment may be normal mucosa, or there may be proliferation of the connective tissue, or of the glands, or atrophy (partial or complete), or vacuolization. These conditions are illustrated in their appropriate chapters. A positive judgment cannot be given from this examination, as only a small area may be actually involved and no changes observed in the gastric secretion. On the other hand, a bit of normal mucosa may be aspirated from a diseased organ.

Mould.—Mould in the stomach has been little referred to in literature as a pathological condition except by Talma, A. Rose, Naunyn, Einhorn, and Knapp. I referred to it in an article on "Dilatation

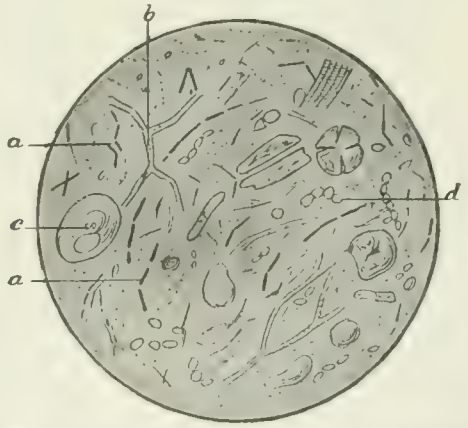


Fig. 4662.—*a*, Boas-Oppler Bacilli; *b*, Leptothrix; *c*, potato-cell; *d*, yeast-cells.

of the Stomach" published in 1904. Einhorn has found it in the wash-water of the empty stomach as blackish-gray or brownish-green flakes of varying number; while Knapp describes it as coloring the chyme a yellowish green or dark red, and states that it has been mistaken respectively for bile or blood from its macroscopic appearance. He emphasizes the necessity for appropriate tests for bile and blood, and not the diagnosis from appearances. I can substantiate this in one case at least, in which the reddish-brown material proved to be mould. The mould flocculi consist of clusters of spores and mycelia, sometimes mixed with mucus and epithelial cells. Crystals are also found, which Knapp considers to be segments of mould filaments.

The mould generally found has been identified by E. K. Dunham as *Penicillium glaucum*, though Knapp reports in addition *Oïdium albicans* and the aspergillus groups. These fungi probably adhere quite closely to the mucosa and may involve considerable areas (Fig. 4663). *Streptothrix foersteri* has been recovered from the gastric contents by Stanley. Knapp holds that the presence of organic acids in the stomach has a decided bearing, and that succinic acid and mould go hand in hand, the presence of the former being conclusive. His test for succinic acid is as follows:

Determination of the Motor Function of the Stomach.—By the motor function of the stomach we mean the peristaltic action of the *stomach which expels* its contents into the intestines. The impairment of the motor power is fully as, and in many cases *more important* than disturbance of its secretory functions. One may have for example an acute impairment of its motility, an acute atony, which if unrecognized,

may result in acute dilatation of the stomach, a dangerous condition; or the disturbance of motility may be of a chronic type, chronic atony, which if untreated may eventually result in chronic atonic dilatation of the organ; while with pyloric stenosis, the motor power may be for a time increased, while the stomach in endeavoring to force its contents past the obstacle, while actually there is some food retention—a "relative motor insufficiency"—which finally becomes a marked motor insufficiency with great dilatation of the organ. Motor insufficiency may be one of the first suspicious symptoms pointing toward malignancy

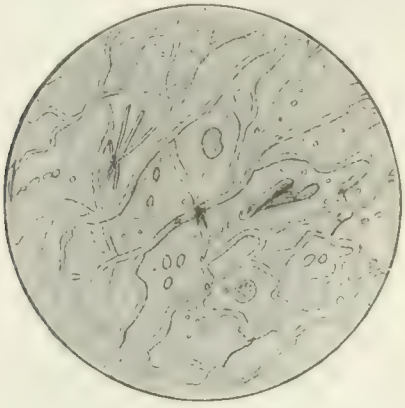


Fig. 4663.—Green Mould Pellicle, Mycelia, Spores, and Crystals.

at the pylorus. It may also occur with hyperaeidity from pyloric spasm or gastric or duodenal ulcer or from spasm of the pylorus occurring as a reflex from other conditions such as chronic appendicitis or gall-bladder disease. With gastroptosis we may have quite good motility of the stomach, while on the other hand it may be impaired, particularly with a prolapsed stomach of the drain-trap, or fish-hook type or when dilatation is associated with the gastroptosis. Hypermotility on the other hand may occur with hyperacidity, achylia gastrica, fissure or superficial ulcer of the pars pylorica or duodenum, or even with early carcinoma not involving the pyloric ring.

Most of our radiologists hold that if six hours after the administration of the barium or bismuth meal, the stomach is empty, that its motility is good. Though true in many cases, in some it is certainly an erroneous deduction. On many occasions, I have aspirated 100 to 125 c.c. and several times as much as 140 to 150 c.c. of contents an hour after the test breakfast, the patients suffering from fermentation, distention, belching, intestinal disturbances, indicanuria, etc., all due to a minor degree of motor insufficiency. The radiographs showed the stomachs of these patients to be empty at the end of six hours and motility had been pronounced normal by the radiologists.

Test Breakfast Method.—This possesses the method of simplicity and affords practical information. The average amount of food ingested should be sixty gm. bread plus 350 c.c. of water; aspiration in fifty minutes to an hour. If just before aspiration the splashing sound is obtained, this suggests motor insufficiency (*i.e.* the stomach does not contract properly about its contents). On aspiration there should be less than 100 c.c. of contents removed, usually from 40 to 75 c.c.; if the residuum is 100 c.c. more, the motility of the stomach is impaired—the degree of impairment being in proportion to the excess over 100 c.c. Varying quantities at the end of two hours also show different degrees of motor insufficiency. With the tube and aspirating bulb described, if one aspirates not only in the sitting posture, but also with the patient lying on the right side, so to pocket all the remaining material in the narrower pars pylorica, usually quite complete emptying can be secured, so that further lavage is generally unnecessary. I generally order the addition of chopped spinach, boiled rice and six raisins without seeds to the dinner or late supper the night previous and note whether any such material is found mixed with the test breakfast. Some perform lavage before the late supper and then aspirate seven to eight hours later before the test breakfast is administered, while others wash the stomach after aspiration of the breakfast. By this last means, more residuum is sometimes secured, as well as material which may be adherent to the stomach wall which otherwise might not be secured. I have generally found it unnecessary however.

Leube's Test-meal.—This is the oldest method of determining gastric motility. He administers a plate of soup, a beefsteak and a roll. If the stomach is found empty six to seven hours later and nothing can be washed out, it indicates that the motor power is sufficiently active, but if food remains longer in the stomach, the motility is reduced. If undigested food is found (300 to 600 c.c. or more), motor insufficiency is present to a degree indicated by the amount of the residuum.

Boas recommends cold meat with rolls and butter and a large cup of tea, usually five hours after the test-meal only a small amount of chyme should be aspirated, while at the end of six hours the stomach should be empty. If contents are present, as heretofore noted, the impairment of motility is in proportion to the residue aspirated.

To test for still greater degrees of motor insufficiency, lavage is performed and a test supper administered at about 10 P.M., a little soup, a slice of bread, a slice of beef, a little chopped spinach, boiled rice and a few raisins without seeds or a fig. The stomach should be aspirated at 7 to 8 A.M. In some there will be a marked residuum after seven hours, but none after nine to twelve hours, in others considerable after twelve hours. Many prefer in every case to wash the stomach before administering the test-meal.

If hypersecretion is suspected as a factor in the production of the large residuum, its presence should be determined by *Reichmann's method.* Lavage the stomach at bed time, and allow subsequently no food and no drink. Aspirate the stomach twelve hours later and if over 20 to 30 c.c. gastric juice is secured, this is an evidence of hypersecretion. In the latter event as much as 75 to 125 c.c. may often be obtained.

Determination of the Quantity of Chyme within the Stomach.—Usually the quantity of chyme can be determined by emptying the patient's stomach by the expression method, especially with the addition of the aspirating bulb that I have described. Air can be forced into the stomach by covering the free end of the bulb and squeezing the latter. If no bubbling sound is heard, the organ may be considered empty. With marked dilatation from pyloric stenosis, it is at times difficult to completely empty the organ.

Mathieu-Rémond Method.—Mathieu and Rémond suggest the following method of determining the total quantity: After removal of the contents a funnel is attached to the tube and 200 c.c. of water poured into the stomach. The funnel is moved up and down several times, and the patient shakes the abdomen so that complete mixture of the water and contents occurs. They are then removed by a combination of siphonage and expression. The quantity of liquid originally contained in the stomach is equal to the number of cubic centimeters of water poured into the stomach multiplied by the degree of acidity of the second portion removed, divided by the figure resulting by deducting the degree of acidity of the second portion from that of the first plus the portion previously withdrawn.

The diagnosis of a case of motor insufficiency due to advanced pyloric stenosis is quite easy but to differentiate between retention from atonic dilatation of the stomach and retention due to an early stage

of pyloric stenosis, or stenosis of the cap—before the typic symptoms occur is not so easy, and can only be determined by the demonstration of deformity through use of the *x*-rays. It is therefore a wise plan to employ radiography when motor insufficiency has been demonstrated, since all cases of stenosis should be treated surgically. If this rule were followed, there would be fewer inoperable cases of cancer. The following tests have been suggested but I do not recommend them.

Salol Test (Ewald and Siever's Method).—Salol is not decomposed in the stomach, but in the alkaline medium of the intestine. Here it is split up, and the salicylic acid is absorbed and eliminated in the urine as salicyluric acid. The latter is recognized by testing the urine with neutral ferric chloride solution, which gives a violet color with this acid. The patient takes salol fifteen grains (1.0) in two gelatin capsules half an hour after a light meal. The bladder is first emptied. Thereafter he urinates every half hour for about two hours, and the different specimens of urine are tested with the iron solution. Under normal conditions the reaction appears in from thirty to seventy-five minutes. In retarded motility it takes two hours or more. Ewald treats the urine with ether and examines the ethereal residue; while Einhorn moistens a piece of filter-paper with the urine and touches the middle of it with the iron solution. Huber suggests to determine the time required for the complete disappearance of the reaction in the urine. The longer the time required for the salol to be absorbed and entirely eliminated through the urine, the longer it has remained within the stomach. He found that normally the excretion of the salicyluric acid after salol was administered lasted twenty-four hours; in patients with diminished motor function it lasted forty-eight hours or more.

Iodipin Test.—Iodipin is decomposed in the intestine. Heichelheim gives 1.6 grams iodipin in gelatin capsules at breakfast. The saliva is then examined every fifteen minutes for iodin by starch paper and fuming nitric acid. In normal cases the reaction appears within an hour.

Klemperer's Oil Test.—Oil is not absorbed in the stomach. After washing the stomach, 100 c.c. of pure olive oil are poured into the empty organ. Two hours later the stomach is thoroughly aspirated. The difference between the original quantity of oil and that withdrawn indicates the condition of the motor function. Normally at this time only 20 to 40 c.c. of oil should be aspirated.

Determination of the Absorptive Function of the Stomach.—The absorptive function of the stomach is usually tested by the method of Penzoldt and Faber, as follows: 0.2 of potassium iodide is administered in a gelatin capsule, and the saliva or urine examined every minute or two with starch paper and fuming nitric acid. The strip of paper is moistened with saliva or urine and then touched with a drop of the acid. A violet or blue color is the reaction. It takes six and one-half to fifteen minutes before the reaction appears in normal conditions. In pathological cases it is retarded. The test should be made on an empty stomach, as with the full organ it is retarded. It is self-evident that the gastric digestion of proteins—and hence their absorption—is delayed in cases of subacidity or anacidity, while these conditions are not so important for the digestion of carbohydrates.

In some cases the absorption of iodide is normal, though we know protein digestion is interfered with, so that I do not consider the test in every case reliable. Hershell gives a capsule containing two decigrams of powdered rhubarb. Under normal conditions the urine gives a red color with liquor potassæ. They are the best tests so far known. The writer, however, considers them unnecessary for practical purposes.

Robert Coleman Kemp.

Stomach, Inflammation of the (The Gastritides, Acute and Chronic).—Inflammatory conditions of the stomach, denominated gastritides, are manifested in a number of ways, depending upon the causation, condition of the stomach, condition of the patient, and course of the pathological process. The different forms of gastritis may be divided as follows: Simple acute, infectious, toxic, phlegmonous; and chronic forms, being chronic with excessive acid, with deficient or no acid (achylic gastritis), and alcoholic gastritis.

Acute Gastritis.—This is a most frequent affection, no age or condition in life being exempt. It may be occasioned by errors in diet, mechanical or thermic irritants, foods too highly seasoned, unripe or overripe fruits, poorly cooked or spoiled food, cold or carbonated drinks, excessive use of alcohol, or any other cause that lays a sudden stress upon the stomach. Some individuals seem peculiarly susceptible to acute inflammation of the stomach, while others are able to eat with seeming impunity articles of food that would ordinarily set up a most acute gastritis in average persons.

Toxic gastritis brought on by spoiled food (a phase of cholera nostras) may be included, and also infectious gastritis caused by microorganisms or parasites that may find their way into the stomach.

Diagnosis.—The patient first complains of loss of appetite, discomfort in the epigastrium, fulness which may be relieved by belching, and occasional nausea. There is seldom a rise of temperature. In the more severe cases the pains are acute, there is headache, nausea, and vomiting which is prolonged, excessive and painful, the vomitus consisting first of food, then chiefly of mucus, at times streaked with blood and admixed with bile which regurgitates into the stomach with the continuous retching. There may be chilly sensations, the pulse may become rapid and thready, the tongue coated and swollen. Constipation or diarrhea may be present, and the early vomitus often has quite a disagreeable odor. Occasionally a duodenitis with jaundice is associated, and herpes of the lips is frequently observed.

Acute gastritis must be differentiated from biliary colic, in which the pain radiates to the right side or shoulder, while pain over the gall-bladder is present; from cholecystitis with or without calculi, in which previous history, tenderness over the gall-bladder, and the presence of a leucocytosis must be taken into account; from hyperchlorhydria, in which the previous history must be considered; from peritonitis, in which there is muscular rigidity, marked abdominal tenderness and distention; and from nervous gastralgia, in which the vomitus is usually very acid but containing little if any mucus, the neurotic history being suggestive. Acute gastritis must also be differentiated from the early stages of typhoid fever, and from the gastric crises of locomotor ataxia.

Treatment.—Patients who are easily upset (with "delicate stomachs") should sedulously avoid those articles of food which have proved irritating in the past, and should empty the stomach with copious draughts of warm water upon the slightest premonitions of trouble.

The symptoms of gastritis having developed, the stomach should be cleared, as well as the intestinal tract, and the patient put to bed. In mild cases, rest to the stomach and quietude to the body will suffice, but in more severe cases, the therapy must be energetic.

For the nausea and pyrosis, alkalies should be freely administered, either in the dry form as bismuth or calcined magnesia, or bismuth with some carminative flavoring agent. The presence of nausea requires external counterirritation. For nausea and acidity the following prescription has often proved helpful in my hands:

℞ Spts. amygdalæ amaræ . . 3ii.
Resorcinolis . . . gr. x
Lac-magnesiæ . . . . q. s. ad 3ii.
Sig. One teaspoonful every two or three hours.

Among other antiemetics, which may be used from time to time, are oxalate of cerium, one-minim doses of Fowler's solution or tincture of iodine, or small pellets of ice given sparingly. The use of cocaine or carbolic acid is not satisfactory. Occasionally a hypodermic of morphine may be required to control the extreme pain and nausea, but it will be generally found that the secondary effects are not good.

Occasionally the patient will prefer an ice-bag over the epigastrium, but the majority are more comfortable under the application of heat, which should be employed perseveringly.

Lavage is occasionally of service when there is distressing nausea with ineffectual attempts to expel the glairy mucus, but unless the lavage can be administered by an expert, it had best be omitted.

Diet.—Entire abstinence from food for twenty-four hours in ordinary cases, and for two or three days in severe ones, is advisable. Rectal feeding in acute gastritis is not satisfactory, as a rule. Einhorn has used duodenal alimentation in several cases with good results.

After the symptoms begin to subside, very light nourishment may be given, though caution must be observed. Egg-albumen, ice-cold; barley-water, alone or with a little milk, and rice gruel with milk, are eligible foods to begin with. Later there may be cautiously added soft-boiled eggs, scraped beef, bouillon, zwieback, broths, and a gradual resumption of the full diet. The patient, however, should be careful for quite a while, as dietetic indiscretions will be liable to result in other acute attacks.

Acute Infectious Gastritis.—This form of acute gastritis is generally precipitated by microorganisms introduced into the stomach with decomposed food, especially meat or fruit, bad milk, or infected water.

Diagnosis.—This disorder presents much the same picture as simple acute gastritis, plus excessive prostration. The temperature, which is normal or even subnormal in mild gastritis, is considerably elevated in this form. This condition does not necessarily follow dietetic errors, but is generally the result of pure infection. With the fever are noted violent headache, thirst, quick pulse, and a marked diminution of gastric juice. The acute symptoms may merge into a semi-chronic character, keeping the patient ill and uncomfortable for one or more weeks.

This is the form of gastritis sometimes rightly, and sometimes wrongly, denominated "ptomaine poisoning," and questions involved often possess a medicolegal significance.

Occasionally death occurs from infectious gastritis, but usually after a brief but stormy illness, the patient recovers.

Treatment.—The treatment is based upon the same principles as obtain in simple acute gastritis, except it is advisable to thoroughly empty and cleanse the stomach by an alkaline antiseptic lavage. A solution of boric acid, or a 1:3,000 permanganate of potassium in physiological salt solution, or a 1:20 of the alkaline antiseptic liquid (N. F.) will be suitable.

No food should be allowed in the stomach for several days, though it may be necessary to administer diffusible stimulants in small quantities. Wine or brandy is sometimes advisable in weak or debilitated subjects.

The physician should be cautious in resuming stomach feeding, and should be specially cautious in passing from liquid to solid food; and, should nausea or vomiting seem imminent, should resort to nutrient enemas.

Drug Therapy.—This comprises the remedies employed in the milder forms of acute gastritis, with the addition generally of small doses of dilute hydrochloric acid, well diluted. A most useful combination to quiet the stomach and abate the nausea consists of the following:

℞ Hydrarg. chlor. mitis,
Phenolphthalein . . . . . ää gr. i.
Sacch. lactis . . . . . gr. v.
Ft. chartulæ No. 10.
Sig. One powder dry on the tongue every hour until five are taken.

The extreme thirst may be quenched by pellets of ice or high saline enemas.

Toxic Gastritis.—This most intense form of inflammation of the stomach is caused by the swallowing of concentrated mineral acids, strong alkalies, or poisons, such as phosphorus or arsenic. Among the extremely irritant acids are nitric, sulphuric, hydrochloric, oxalic, and carbolic; the caustic alkalies, including caustic potash or soda, soap lees, and strong ammonia; and other irritants as alcohol, potassium cyanide, corrosive sublimate, and potassium chlorate. The effects of all these poisons are more intense when taken on an empty stomach. When such agents are swallowed, the acids and alkalies destroy the integrity of the parts with which they come in contact, causing various degrees of sloughing of the mucosa and submucosa, sometimes followed by penetration of the stomach wall and perforative peritonitis.

Diagnosis.—The symptoms are of a fulminating character, as seen in acute intoxication, modified by the nature of the poison ingested. The sudden appearance of violent gastric symptoms in a perfectly healthy individual should excite suspicion. Inspection of the lips, mouth, and tongue will show the effects of corrosive poison, if such has been taken, and examination of the vomitus and odor of the breath may afford additional information. Sometimes it is possible to find the receptacle or bottle from which the poison was taken, or the patient may give the desired history.

Treatment.—There are certain general principles in the treatment of toxic gastritis; first administer fluid to dilute the poison, and at the same time give an antidote; empty the stomach as rapidly as can be done by lavage; if the poison is corrosive, administer demulcents; stimulate the patient, if the vital powers are weak, and, if any of the poison has passed beyond the stomach, give a cathartic. Lavage by siphonage or, that failing, by aspiration, is indicated in practically all cases of poisoning, and any fancied danger of puncturing the stomach by the tube is immeasurably overbalanced by the potential benefits of the lavage. Should no stomach tube be at hand, one can be improvised from a fountain syringe by removing the tip and clip, rounding the edges of the end of the rubber tube, and using a kitchen funnel.

Apomorphine—one-tenth of a grain hypodermatically, or zinc sulphate or alum in warm water may be given to promote emesis. Among useful demulcents which are generally at hand, are whites of raw eggs, milk, olive or cotton-seed oil, flour boiled with water, starch- or gum-arabic-water.

The later treatment, after the toxic symptoms are controlled, are similar to other forms of acute gastritis.

Phlegmonous Gastritis.—This rare condition is also called acute interstitial gastritis, and is used to characterize those cases of inflammation of the stomach in which the gastric submucosa, and to a lesser extent, the mucous and serous coats are uniformly or focally filled with pus (Lockwood). Up to the present only about 100 cases have been reported. Men are more frequently affected than women in the proportion of about three to one. Among the reported cases, about one-half have oc-

curred among day laborers, who were addicted to alcoholic and dietetic excesses. Alcohol is thought to be an etiological factor, though a goodly proportion of the cases has been among non-alcoholics. The disease is not limited to any particular age. The primary cause is always microbic, especially the streptococcus, which probably enters through some solution of continuity in the mucous membrane; or secondary, due to pyemia, puerperal infection, or the exanthemata.

Diagnosis.—The diagnosis is exceedingly difficult during life, but few, if any, having been correctly made in advance of necropsy. The patient presents all the aspects of an acute infection, with delirium and coma preceding death. The blood examination shows leucocytosis with increase in the polynuclears. There is muscular rigidity in the upper portion of the abdomen, due to peritoneal irritation even before perforation takes place. When this occurs there are the usual manifestations of general peritonitis. In the cases of circumscribed abscess the tenderness is more localized, the symptoms not so fulminating, and the duration more prolonged. The duration may be from three or four days to several weeks.

The high temperature, chills, and early muscular rigidity, with exquisitely tender epigastrium point to an acute suppurative process of the stomach. Differentiation of localized gastric phlegmon from a localized peritoneal abscess following perforation of the stomach wall by ulcer or cancer is practically impossible. Abscess of the liver, acute pancreatitis, and acute cholecystitis can be differentiated by their history and other significant diagnostic points.

The *prognosis* is very unfavorable, the mortality rate being about ninety-five to ninety-eight per cent. All cases of recovery reported have been of the circumscribed form.

Treatment.—Realizing the difficulties in diagnosis, and the unfavorable terminations of this disease, treatment holds out but little encouragement. Laparotomy may be resorted to in the vague hope of affording some relief. Should this not be attempted, an ice-bag may be kept over the epigastrium, energetic rectal feeding may be used, enteroclysis may be administered to relieve tympanites, injections of the mixed vaccines resorted to, and the pain assuaged with opiates. By using a supportive and stimulating treatment with vigor, the patient has a slender chance for recovery.

Chronic Catarrhal Gastritis.—Up to the time that more exact methods of examination came into vogue the diagnoses of chronic gastritis, chronic catarrh of the stomach, and chronic dyspepsia were made in those cases of digestive disturbance characterized by long-continued nausea and indigestion, unless the symptoms of ulcer or cancer stood out predominantly. Since the refinements of diagnosis have enabled the gastric diseases to be more intelligently discriminated, this diagnosis is not made so frequently as formerly, though even now about eight or ten per cent. of chronic indigestions may be placed in this class.

This disease occurs more frequently in men than in women, and the same irritating causes that produce acute gastritis can produce the chronic type when exerted for a long period of time; such as hasty eating with imperfect mastication, gastronomic excesses, highly spiced foods and condiments, overindulgence in tea, coffee, or alcohol, excessive use of tobacco, especially chewing strong, black tobacco, habitual use of certain drugs, and a septic condition of the teeth, as pyorrhea alveolaris, in which constant swallowing of pus and other products of decomposition sets up inflammation. Though smoking is ascribed as a cause by some writers, I have never seen a case of chronic gastritis that could be honestly traced to that habit. (Let this not be considered a defense of smoking, for many forms of neurotic indigestion or even atony may follow in the wake of excessive indulgence in this use of tobacco.) Probably the commonest cause is found in the abuse of alcoholic drinks, though some stomachs seem to bear without injury quantities of alcohol that would acutely inflame others. I have seen a few individuals who suffered from chronic gastritis for two or more weeks after the ingestion of less than four ounces of rye whiskey.

Acute gastritis does not generally merge into the chronic form, except where there are a number of recurrences at short intervals from similar causative factors. It may be secondary to acute infectious diseases, as typhoid fever, and is frequently associated with cancer of the stomach. It may be secondary to cirrhosis of the liver, pulmonary or cardiac disease, and chronic nephritis and syphilis.

There are several forms of chronic gastritis, as follows: (1) The form is which there is excess acid—acid gastritis, hyperesthetic gastritis, or acid catarrh of the stomach. (2) The form in which, while there is chronic catarrh, there is practically normal acidity. (3) The form in which there is a diminution or absence of acid, denominated asthenic gastritis, subacid gastritis, achylic gastritis, or atrophic gastritis. To this may be added a rather specific form —alcoholic gastritis.

Symptoms.—These are much like those of other gastric disturbance. The disease, as a rule, develops slowly, changing in its aspect from time to time. The appetite is variable, sometimes being quite good, or even ravenous, then for a time the patient may have absolutely none. A disagreeable taste in the mouth is often mentioned, there is a thirst and dryness of the mouth with frequent food remnants. Pressure and fullness after eating is complained of, with palpitation of the heart during the digestion of meals. For a while the eructations seem to relieve most of the distressing symptoms, but as the disease progresses, there is almost constant uneasiness in the epigastric region during waking hours. The sleep, however, is troubled and the patient often awakes with headache followed by vertigo on arising. The bowels are usually constipated, with perhaps an occasional attack of diarrhea.

When vomiting occurs, it is usually in the morning, and consists chiefly of slimy mucus, with occasional remnants of the previously ingested food. The tongue is sometimes covered with a thick gray fur, though this is by no means characteristic. Odor of the breath is offensive, especially when there is atony of the stomach with fermentation, or the teeth are in poor condition.

Nearly all of these patients are low spirited and pessimistic. It appears that the complex of symptoms embraced in chronic catarrhal gastritis exercises a peculiarly depressing effect on the mentality, and seldom have I seen any individual suffering from this disorder, who did not feel his spirits dampened and his mental horizon beclouded.

The patient's appearance may be quite good, and he may preserve his weight remarkably well. In severe cases he looks badly, shows black rings under his eyes and chills easily. Where the anorexia is prolonged much weight may be lost, and an extremely emaciated state may supervene.

Upon physical examination the epigastrium may appear bloated. Tympanites is sometimes present, but the stomach is usually in the normal position. The gastric region is sensitive to pressure, with rather diffuse tenderness. There is seldom any real sense of resistance or rigidity there.

A splashing sound that is found when the stomach should be empty signifies atony. When the stomach contains food liquid or gas, this splashing sound possesses little diagnostic importance.

The urine is generally scanty, with increased

specific gravity. It is frequently loaded with phosphates and urates.

Diagnosis.—The diagnosis of chronic catarrh of the stomach *cannot* be positively and intelligently made without employment of the stomach tube. By gastric analysis many suspected cases prove to have normal gastric contents, and are to be considered neuroses; while in other cases, evident gastric catarrh is discovered when some other condition was thought more probable.

Lockwood insists that: (1) Gastric analyses should always be made in every case of dyspepsia, no matter whether these symptoms be apparently gastric or intestinal, unless passage of the tube is contraindicated. (2) Gastric analyses should always be made in all cases of intestinal toxemia, of recurring headache of toxic origin, and in patients who complain of the symptom-complex which is spoken of by the laity as "biliousness." (3) Gastric analyses should be made in all cases of chronic diarrhea that is not due to evident disease of the colon or rectum. (4) Gastric analyses should be made in all cases of anemia and general physical wretchedness without known cause and which are rebellious to treatment.

The presence of *gastric mucus* in *excessive quantities* in the stomach contents is the chief diagnostic point in chronic catarrhal gastritis.

My usual procedure is as follows: One hour after an Ewald-Boas test-meal has been taken (two slices of bread without butter and a glass and a half of water) a sufficiency of the stomach contents are aspirated for an examination. In chronic catarrhal gastritis these conditions are usually found present: the total acidity is often diminished; free hydrochloric acid is small in amount, or absent; pepsin and rennin are present but diminished; erythrodextrin present in small quantities; achroodextrin and sugar abundant. Should the gastric contents swell up into the tube in great quantity, hypersecretion may be suspected.

The particles of bread are not as fine as normally, but larger and coarser. Mucus is intimately mixed with food remnants and is adherent to the larger particles. Upon passing a wire up through the contents, thick, tenacious ropes of glairy mucus hang to it, presenting a characteristic appearance. Should rhere appear but little mucus when the symptoms would indicate its presence, the patient should be seen the following morning with an empty stomach, and lavage performed, in which event, the mucus will be easily discovered in the wash-water.

Microscopically mucus, round cells, and epithelial cells are found to be present. In doubtful cases the microscope may enable the physician to differentiate the types of mucus. If squamous epithelium is mixed with it, this probably comes from the mouth or pharynx; if pigmented alveolar epithelia, probably from the air passages. Columnar epithelium mixed with mucus shows its gastric origin.

Chemical Findings.—With acid gastritis we find the free hydrochloric and total acidity somewhat or greatly increased, though this reaction bears but little comparative relation to the amount of mucus present. The observant physician may find cases of marked catarrhal gastritis in which the acidity remains practically normal, notwithstanding gastric disturbance, anorexia, and malaise.

In subacid gastritis there may appear all gradations from a slightly reduced acidity to a complete absence of gastric juice, or achylic gastritis.

Einhorn has carefully examined the washings of many cases, finding small shreds of the mucosa present, which he believes to be due to erosions.

Motility is generally good in acid cases, in fact the tendency is toward an increased evacuation of the stomach. Should atony or dilatation be present, there is naturally motor insufficiency, and, in the absence of acid, fermentation.

Absorption.—While physiological absorption in the stomach is but slight, even that small amount is interfered with when the mucosa is coated with thick glairy mucus.

Course.—The tendency of all chronic gastritides is toward a long duration, and, like some cases of postnasal catarrh, may extend over many years without incapacitating the patient for the ordinary duties of life. Even where there seems to be decided improvement, relapses are frequent, and no one can be considered permanently cured until many months have elapsed without gastric disturbance.

Differential Diagnosis.—The following differential points are succinctly stated by Kemp:

Chronic Gastritis.—No severe pain; no circumscribed spot painful to pressure; no hematemesis; no cachexia; no marked emaciation, except in severe cases of long duration; free hydrochloric diminished or absent; gastric mucus present; slow course.

Ulcer of the Stomach.—Hyperchlorhydria present, but not invariably so; severe pain in the epigastrium with intervals free from pain when stomach is empty; local tenderness which is circumscribed; dorsal pain; hematemesis, or occult blood in the stool or gastric contents; microscopic pus; *no mucus;* patient has appearance of suffering; no true cachexia.

Cancer of the Stomach.—Age usually over forty-five; rapid course; free hydrochloric acid usually markedly diminished or absent; lactic acid present; mucus sometimes present; pain generally continuous, but not so acute as in ulcer; Boas-Oppler bacillus; cachexia; tumor on physical examination; small amount of visible or occult blood present in gastric contents; microscopic pus; hematemesis much less than ulcer; foul odor to vomitus at times present.

Achylia Gastrica.—Slow course; scarcely any gastric juice; acidity very low or entirely absent; absence of pepsin and rennin; usually no mucus nor lactic acid.

These differential considerations apply to typical cases, and the observer must be on the *qui vive* for various gradations and modifications of these clinical pictures.

Treatment.—The main features of treatment will be discussed, attempting to note the various modifications incident to the presence of increased, diminished, or deficient acid and other gastric juices.

Treatment may be divided into: (1) Prophylaxis. (2) Hygiene. (3) Local treatment of the stomach. (4) Diet. (5) Medication, and perhaps (6) Mineral springs.

In border-line cases the general principles applying to hyperchlorhydria may be applied with safety until a definite diagnosis is arrived at.

Prophylaxis.—This is probably the most important, and consists in the correction of all causes contributory or aggravating, that may be apparent in connection with the gastric catarrh. Dietetic errors must be inquired into, and both regularity and uniformity of the meals enjoined. Some patients claim that their dietetic and other habits are already correct, but if the physician will have them keep for several days a written memorandum of every article eaten and every daily act, there will generally be found some information which can be acted upon with advantage. Deliberate eating, adequate mastication, and thorough insalivation should be insisted upon, and it is well that the physician should personally see to it that the teeth are in such condition so that good mastication may be performed without discomfort. Should Riggs' disease, or pyorrhea alveolaris, be present, the physician should be slow to promise much improvement until this very important contributory irritation is abated. Catarrhal states of the postnasal cavities should also be investigated and cared for, and tonsillar or pharyngeal disease should receive appropriate attention. Pathologic conditions of the tonsils with their potency for evil

are just now beginning to be accepted at their true value.

Cardiac disease, especially with failing compensation, should be properly treated; likewise diseases of the liver and kidneys, so as to lessen the liability to secondary gastritis.

Moderate smoking is not injurious as a general rule, but chewing tobacco, especially black tobacco, or that which is sweetened, is quite harmful, and should be prohibited. Should the "cathartic habit" be indulged in to an inordinate extent, this too, should be regulated, and evacuations of the bowels be accomplished by harmless means.

Hygiene.—A favorable mental attitude should be sought during mealtimes, so as to promote the benign and helpful influences of the psychic aids to digestion. If practicable, a rest, or a brief season of bodily and mental quietude should be enjoyed directly after meals, and the body should be strengthened by properly directed exercise. The ventilation of both the living and sleeping rooms is worth investigating, and, when convenient, a change of climate, environment, or even occupation may be of assistance in the treatment.

Local Measures.—The removal of excessive mucus and the soothing of the irritated gastric mucosa are of equal importance.

One or more glasses of hot water, drunk upon arising, dissolves and washes into the intestine some of this mucus. Alkaline medicines, also, dissolve the mucus to a certain extent, though not as much as some enthusiastic writers have claimed.

Lavage.—In no pathological condition will more satisfactory results be obtained than by the proper and careful use of lavage in chronic catarrhal gastritis. Indiscriminately employed, it becomes harmful, and by its unskilled and injudicious application, lavage has been made the object of criticism in many quarters.

The chief indication for lavage in gastritis is the presence of mucus in such excess that it envelopes the food, prevents its saturation by the gastric juices, and impedes the orderly evacuation of the stomach. The custom of washing every stomach in which small amounts of mucus are found, is rapidly passing away. It should be remembered that a thin mucous coating of the lining of the stomach is a protection against irritating food and gastric juice of heightened acidity, and with all this washed away, the stomach is more suceptible to pathologic influences.

Lavage once daily is sufficient, unless there are also stagnation and fermentation, in which event the mucus may be washed out in the morning, and the fermenting mass be washed out again as near as possible to the hour for retiring. Daily lavage should not be kept up long, and where this procedure must be continued for several months, two or three times weekly is ample sufficiency. So far as practicable, the lavage should be performed with the stomach free from food, and, if required to clean that viscus, the patient should assume both the standing and sitting positions while the operation proceeds.

The solutions employed are various, depending on the condition of the stomach and the sensations of the patient. It is well to first wash out the stomach with plain warm water, and then follow with the medicament. The following may be used: one-grain tablets of potassium permanganate dissolved in one p nt of water, sodium bicarbonate, sodium chloride, silver nitrate, five grains to the pint of water, calcined magnesia, ichthynol, or boric acid. In those of a constipated habit, I sometimes leave a small amount of water containing a heaping teaspoonful of the calcined magnesia in the stomach.

Electricity.—Except in cases with marked atony or dilatation, electricity exerts but little if any tangible benefit. In nervous individuals, however, it may possess some psychic effect. The same may be said concerning vibratory massage.

Diet.—This is a most important adjunct to the management, and the patient need not expect permanent improvement unless the dietetic injunctions are obeyed. Let me also caution the physician not to so limit the food, if possible, that the patient will become undernourished and with it depressed and emotional. The stomach is capable of doing only part of its work, while an extra burden is imposed upon the small intestine. The diet, therefore, must be so arranged that both divisions of the alimentary tract are protected. A diet rich in carbohydrate with a minimum of protein is indicated. In chronic gastritis, especially among those who necessarily perform manual labor, solid foods may be permitted. In achylic states spices and condiments may be permitted within bounds, and the diet should be as varied as possible.

Medicinal Treatment.—This must be governed by circumstances, remembering that, except for the management of symptoms, it is not well to institute a medical regimen that may extend over many months. In hyperacid conditions gentle alkalies may be administered, and gentle laxatives may be combined with them. The ordinary alkaline and carminative prescriptions indicated in hyperchlorhydria are often most efficacious and comforting to the patient. For the occasional sensitiveness of the gastric mucosa there may be given olive oil, oil of sweet almonds, or liquid paraffin, in teaspoonful doses, a short while before meals.

In subacid or achylic conditions, small doses of dilute hydrochloric acid (six to ten drops) may be given after meals; and if desired, this acid may be combined with pepsin, or nux vomica. The administration of huge doses of hydrochloric acid (sixty drops), as advocated by some, is not endorsed by me. Before meals, there may be given with propriety and benefit the bitter stomachics, as condurango, quassia, or cinchona. Three-grain doses of orexin, given one and a half or two hours before meals often exercise a stimulating effect upon achylic stomachs.

Mineral Waters.—The treatment of chronic gastritis by the employment of mineral waters, or balneological measures, is much more in vogue in Europe than in this country, though under proper advise and supervision excellent results are sometimes attained.

The reason that sojourners at foreign spas or at mineral springs in this country improve so markedly in so many instances, is not so much because of any great virtue in the water, as because of the freedom from business cares and worries, the exercise in the open air, the change of environment, and the diversion of the mind to outward interests. It should not be forgotten that the daily ingestion of copious draughts of water causes a steady washing out of the stomach and emunctories of the whole body, so that the sufferer is greatly benefited thereby.

Alcoholic Gastritis.—This form manifests itself somewhat differently from the other forms, and requires somewhat different treatment. It is generally brought on by indulgence in alcoholic debauches more than in regular use of the different forms of alcohol as a beverage, and is especially prone to appear when cheap brands or but slightly diluted forms of whiskey are consumed.

In this form of gastritis nausea and vomiting predominate, appearing soon after meals, and depending to an extent upon what is eaten. This nausea is less when liquids or bland articles are taken. With this nausea is a decided repugnance for food, the patient generally desiring whiskey alone, and he finds that while in the undiluted form it hurts him more,

it is more easily retained. The stomach does not always become quiet when empty, but distressing retching keeps up, in which strings of ropy mucus are gotten up with difficulty. Another rather characteristic symptom is the "morning sickness," which seems relieved only by whiskey. Thus the wretched patient is constantly impelled to drink that which injures him most and keeps alive the fire of gastric distress.

The test-meal does not disclose any special signs, and occasionally fairly normal test-meals may be obtained from alcoholic patients in whom severe clinical symptoms are manifest. Long-continued cases, however, with many exacerbations, may result in complete achylia. Achylia, too, is generally present when the liver is cirrhosed.

Treatment.—The outlook naturally depends upon the patient's habits, for, if complete abstention from all forms of alcoholic intoxicants may be secured, the chances for recovery are bright, although the deep pathologic changes will of course persist.

In some cases it seems impossible to stop the stimulant at once, though this is always theoretically indicated. I have found in many instances, that the following prescription given in but little water, will to some extent relieve the craving for whiskey:

℞. Tr. capsici,
Tr. gentianæ co..... āā ʒi.
Sig. One teaspoonful in water every three hours.

Also may be given:

℞. Spts. ammoniæ aromat ..... ʒii.
Sig. One teaspoonful in water every one to three hours.

Should there be threatened delirium tremens with occasional spasmodic twitching of the muscles, the hypodermic use of one-fiftieth grain of apomorphia every two hours will bring both quiet and relaxation. This should not be continued if nausea is increased. For the nervousness and tremor, I have found this helpful:

℞. Conc. tr. passifloræ incarnatæ,
Elix ammoniæ valerianatis ..... āā ʒi.
Sig. One teaspoonful in water every one or two hours.

The diet should be bland and liquid at first, though, if the food is retained with difficulty, hot soup or oyster stew, to which is added plenty of black pepper, will more probably be kept. It appears that these overstimulated stomachs require highly seasoned foods to stimulate the juices, and alcoholic habitues have sometimes learned this fact by experience.

The unirritating hypnotics may be required for a brief period, but should be promptly discontinued upon convalescence, or another pernicious habit may be formed.

Gentle salines may be employed to empty the bowels, and several glasses of warm water may be taken on arising, when the retching is ineffectual.

In addition, all the resources of psychotherapy should be brought into play, in order that a weakened will power may assert itself, that complete and lasting abstention from alcoholic drinks may be achieved, and with bodily and nervous strength may also be gained digestive peace and health.

George M. Niles.

Stomach, Neuroses of the.—Theoretically, and to some degree practically, neuroses of the stomach may be classified as depressions, exaltations, and perversions of any one or more of its functions—sensation, motion, and secretion—or of any subdivision of these functions. Absorption can scarcely be considered as a gastric function, the thick glandular lining membrane not being strictly a mucous membrane and not being adapted to afferent currents. While some degree of absorption occurs, especially of crystalloids including foreign, more or less toxic substances, in a liquid or soluble state, this is so far exceeded by efferent secretory currents and by passage through the pylorus, that no clinical test of absorption is available. The stomach, like many other organs, has some eliminating and some direct antitoxic power but this is manifested mainly under abnormal conditions.

Neuroses of Sensation.—*Hypesthesia.*—The stomach normally gives somewhat vague sensations of heat and cold, tension and fullness, discomfort even amounting to pain from thermic and chemic insults and, less often, from those of a mechanic nature, resulting from the presence of dense foreign particles, or from surgical or accidental traumatisms. It is uncertain how far the stomach itself participates in the general sensations of hunger, thirst, appetite, and special cravings. With this normal low level of sensibility and the further habitual blunting of sensibility from the dietetic habits of taking cold and hot ingesta alternately and of using condiments, it is only in extreme cases of lack of response to irritation, that the term hypesthesia can be employed. So far as appetites are concerned, general depressive states and stoic habits with prolonged self-repression, may almost entirely eliminate them, although, in the latter case, persons may eat and drink sufficiently.

Hyperesthesia.—On the other hand, the individual may have abnormally distinct sensations of heat and cold, tension and reaction to chemic irritation, not necessarily though usually amounting to discomfort or pain. Some describe muscular and tactile sensibility approaching that of the surface of the body, and not necessarily uncomfortable. These phenomena are not especially characteristic of neurotic individuals.

Gastralgia is commonly considered a gastric neurosis but a sharp distinction should be made between a phenomenon which is itself not physiologic and one which indicates a departure from physiologic circumstances. In the great majority of cases included under the term gastralgia, the pain is a perfectly normal response and although the cause of the pain is abnormal, it is not an abnormality of the sensory apparatus. By analogy with other words ending in -algia, gastralgia should indicate a functional disturbance of peripheral nerves, with due allowance for the fact that it is difficult to discriminate between a pure neuralgia and a neuritis. The gastric crises of tabes and similar conditions occurring in other degenerative nervous diseases are clearly organic but do not affect the stomach intrinsically. As commonly used, the term gastralgia does not imply either a strict neuralgia, a neuritis, or the symptomatic extension of another form of nervous disease but rather the following: (1) discomfort or pain due to increased tension or weight of stomach contents, to excessive motility, especially against resistance at the pylorus, or chemical irritation, especially by great increase of secreted HCl or fermentation acidity, or to some foreign substance; (2) pain referred to the epigastrium but due to a great variety of conditions, as gallstones pancreatic calculus, appendicitis, etc. Obviously, therefore, gastralgia in the great majority of instances either indicates a condition not affecting the stomach or a perfectly normal response to a condition which is abnormal in quite a different sense from that implied by the word hyperesthesia.

Dysesthesia referred to the stomach occurs mainly in neurotics and takes the most bizarre forms, as itching, tickling, sensation of heat from cold ingesta and *vice versa*, vermicular movements, etc., sensations of a foreign body, etc. But it should be remembered that certain persons, as noted, have remarkably acute muscular and tactile sensibility of the stomach and may correctly describe vermicular and other peristaltic movements, an obstruction, perhaps one of such consistency that it is not appreciable by sounding,

as hemorrhoidal veins at the cardia, the presence of an unsuspected foreign body, etc.

Neuroses of Motion.—*Submotility, hypokinesis,* or *atony,* usually corresponds to depression of secretion, at least of HCl, hence justifying the term atonic dyspepsia, though the correspondence is not absolute and hypesthesia is not usually characteristic; on the contrary, the disturbances of motion and secretion are rather apt to cause gastralgia.

On the other hand, *supermotility* or *hyperkinesis* is apt to be accompanied with hyperchlorhydria, with more or less symptomatic gastralgia. Somewhat after the analogy of the heart, gastric motility does not necessarily correspond with the actual movement of gastric contents. While, *a priori,* we should expect an atonic stomach to empty itself slowly and a hyperkinetic stomach rapidly, various paradoxes may occur. The muscle may lack tone without any organic atrophy which would result in dilatation or ptosis, including such obstacles to passage of contents as the development of a prepyloric pouch or a deviation of the major axis from its normal, approximately forty-five-degree obliquity. If there is either essential weakness or lack of tonicity of the pylorus or associated deficiency of HCl, contents especially the bland and soft ingredients of the usual test-meal, slip through readily, in spite of the relative weakness of the muscular action. On the other hand, hyperkinesis, subjectively felt, audible by stethoscope, sometimes palpable or even visible, may act against an obstacle at or shortly beyond the pylorus; or, reflexly from the irritation of an excess of HCl, hyperkinesis may act against a pyloric spasm so that ischochymia exists in spite of relatively increased gastric motility. These two opposite paradoxic conditions are rather the rule than the exception.

As in the case of the heart, an obstacle to the passage of current onward, tends reflexly to produce hyperkinesis, this purely functional response tends to develop a compensatory muscular hypertrophy and later, atrophy, dilatation and lowering of motor function result. Or, in asthenic cases, perhaps on account of a primary departure of the major gastric axis from its normal forty-five-degree obliquity so that the stomach is either upright with a prepyloric dependent pouch or nearly horizontal, the tendency to diminished power, atrophy and dilatation occurs without the intervening stage of hyperkinesis and hypertrophy.

A few words of caution may be introduced regarding *x*-ray pictures. The retention of bismuth in the stomach may be due to some factor favoring adhesion rather than to actual interference with propulsion of contents. Neither this test nor any other bearing directly on time of emptying, depends solely upon muscular function but upon the correlation of various mechanic factors, as already described. A radiogram is correct absolutely, like any other instantaneous photograph, but often gives a false conception of average contour and position of the stomach. Normally, unless the stomach is distended and deficient in peristaltic power, the bismuth rides on the extreme inner surface of the rugæ of the mucosa or may, with other contents, actually be thrown further toward the interior and away from the gastric wall. Thus a single radiogram may apparently demonstrate an hour-glass contraction when none is present, a series of radiograms or, better yet, fluoroscopic examination, revealing the true condition of a marked peristaltic wave.

The sphincters introduce somewhat perplexing problems into the study of gastric motility, because their functional state does not necessarily correspond to that of the stomach as a whole nor to that of each other and because increase of functional power is apt to manifest itself in tonic rather than in clonic form as for the gastric muscle generally.

Cardiospasm may occur as a neurosis and present symptoms practically identical with spasm of the esophagus itself. It may or may not lead to esophageal dilatation. It may be due to irritation at the site of a local fissure or ulcer or bunch of hemorrhoidal veins due to hepatic sclerosis, even to a beginning cancer. In general, a spasm of any part of the alimentary canal may be due to organic lesion at some other site. Cardiospasm may be the first symptom of cancerous or other organic stricture of the esophagus at a different level, possibly of still more remote lesions to be mentioned under pylorospasm. Cardiospasm is the initial symptom of globus hystericus and may develop no further. The writer regards globus hystericus, not as a hallucination but as a genuine, though neurotic, spasm involving successively, the cardia and ascending segments of the esophagus. If any of these spasms are merely neurotic, they will probably yield to suggestion, self-control, general hygiene, sedative drugs such as cannabis indica, valerian, sumbul and asafetida. Careful mastication and slow deglutition, with water or mineral oil to expedite the passage of the bolus, may be useful. Massage with the bougie, or galvanic or high-frequency currents within the esophagus have both a direct and a suggestive effect. Organic silver preparations introduced by some form of esophageal applicator, emulsions of bismuth salicylate in mineral oil, etc., may heal simple ulcerations. Instrumentation of any kind is apt to rupture esophageal varices, although otherwise indicated. A spasm at the cardia or of the esophagus, including ascending globus, if reflex from some organic lesion, will usually persist till obstruction from this lesion predominates or until it is relieved, the prognosis, thus differing as widely as the treatment, for such contrasted conditions as syphilis, cancer, and cicatricial contraction.

The normal standard of competency of the cardia varies greatly in individuals, some being almost unable to vomit or even expel gas and thus being liable to chemic and mechanic results of retention of irritating or distending gastric contents. In this respect, they are liable to the more serious consequences of minor indiscretions of diet characteristic of the horse, though the statement that this animal never vomits is not quite correct. On the other hand, some persons regurgitate gas with annoying frequency, and even liquid and pultaceous contents, especially soon after a meal when in the prone or stooping posture. Such persons may maintain, throughout life, the ability to empty the stomach more or less completely, without nausea—puking rather than vomiting.

Functional relaxation of the cardia is, therefore, somewhat difficult of diagnosis as an acquired neurosis and distinct from idiosyncratic and congenital failure of development of this sphincter, except as indicated by the history of the case. Strychnine and analogous drugs theoretically strengthen the function of the cardia but are apt to antagonize this local effect by a similar action upon the pylorus and general gastric muscle. Massage with the tube or bougie or the use of an esophageal electrode to transmit a faradic current is, on the whole, the best direct means of treating relaxation of the cardia.

Pyloric spasm is apparently less apt to be a pure neurosis than cardiospasm; more apt to be due to local fissures and ulcer; more apt to be a reflex from lesions of the lower alimentary canal and its appendages, as the gall-bladder (cholecystitis and gallstones), appendicitis, hernial and other types of ileus, peritonitis, etc. Especially in the new-born it is with difficulty differentiated from hypertrophy and, on account of its more inaccessible position, from organic obstruction of any form, at or near its site. There are, however, two exciting causes of pylorospasm that are quite readily removable; (1) more or less foreign bodies, including dense and hard inclusions of indigestible matter in food, as fruit pits and bits of bone; also theoretically

digestible masses, imperfectly cooked or masticated, such as lumps of potato, large pieces of meat, unchewed peas and the like. These reflexly produce contraction of the pylorus or may even act in a purely mechanic way as ball valves. (2) An excess of acidity, especially that due to excess of HCl secretion, strong spices, alcohol, etc., produces spasm of the pylorus by a chemical reflex. While the weight of authority, physiologically, is to the effect that HCl produces rhythmic relaxation of the pylorus, exactly the opposite is true from the clinical standpoint. (See Ischochymia.)

Relaxation of the pylorus is noted mainly in conditions of subacidity and hence due to lack of stimulation of reflex muscular contraction.

With special regard to general lines of therapeutics, it is urged that stethoscopic auscultation of the gastric area be practised for several minutes, as a routine. Palpation gives an idea of the resistance of the gastric wall and, hence, indirectly of muscular development. In connection with tests of emptying power, secretion, etc., a general diagnosis may thus be made of the motor strength of the stomach and the results of contractions.

Neuroses of Secretion.—Waiving, for the present, the question as to the ultimate functional or organic cause of these conditions, the following facts may be stated. The stomach secretes mucus with its included organic and inorganic chemicals, as well as certain foreign substances adventitiously present, *e.g.* certain poisons eliminated to some degree by this route. Alterations in mucus secretion of any organ are admittedly due to organic changes usually broadly included under the term inflammation, or possibly to fluctuations in blood volume and pressure and other local and general factors determining differences in osmotic tension, not directly constituting a functional state of the organ itself.

The secretions of the stomach more or less strictly digestive, include HCl, pepsin, rennin, invertin, and steapsin. The last four unorganized ferments are probably not absolutely definite substances but each term represents a group acting respectively on proteid, on milk caseinogen, on double hexoses and on fats, the respective actions being peptonization, precipitation of casein, breaking up of the double into single hexoses, splitting of fat into glyceryl and fatty acid radicles. Fat splitting in the stomach is always slight and is probably due to entrance of minute quantities of pancreatic secretion and hence not strictly a gastric function. It is practically of no importance and not subject to clinical consideration. Normally, ptyalin of the saliva forms more or less maltose from cooked starch, this action taking place mainly in the stomach unless mastication is unduly prolonged. Lactose and saccharose are commonly present in the ingesta and other double hexoses may be. Double hexoses may be absorbed as such but are then largely eliminated, either by the urine or into the intestine where they are probably changed into single hexoses, and reabsorbed and utilized by the body. There is some dispute as to whether invertin is secreted by the stomach itself, and whether gastric invertin, if an entity, is specifically limited to maltose or acts on other double hexoses. Some authorities deny the existence of such an invert ferment altogether and ascribe the change in maltose, saccharose, etc., as well as the convertion of inulin—a variety of starch—into levulorotary fructose sugar, to HCl. No extensive study of carbohydrate digestion in the stomach, on a quantitative basis has been made.

The general statement may be made that any proteolytic ferment, such as pepsin, trypsin, or those occurring in plants, either produces a coagulation of raw milk or is accompanied by a ferment that does so; also that there is no other analogous coagulation of a raw protein by a ferment. Thus, for practical purposes, pepsin and rennin may be considered identical although it is disputed whether this is scientifically correct. It may further be stated that when free HCl is present in the gastric juice, mature proteolytic and milk-coagulating ferments are present and that if any HCl has been secreted at all, even if no trace remains in the stomach contents, pepsinogen exists and may be converted into the mature ferment, capable of peptonizing proteid, by the addition of HCl. In the great majority of instances, the gastric filtrate is capable both of peptonizing proteid and of coagulating milk, in a still greater majority, of doing so if HCl is added; it is only rarely that ferment action is entirely absent (achylia); and the instances in which pepsin or rennin—or let us say, the corresponding peptonization and milk coagulation—occur singly, that is, one being present without the other are so extremely rare as to be open to question on the ground of some error of technique. For example, a sample of milk may fail to coagulate because the process of pasteurization has been carried to too high a temperature or for some other reason; or lack of peptonizing power may be reported because too large and dense a mass of coagulated albumin has failed to dissolve entirely, whereas considerable has really passed into soluble albumoses and peptones. The writer would not absolutely deny that pepsin and rennin are distinct ferments nor that one action may be present without the other but he has encountered only a few such cases, many years ago, before the necessity of checking milk coagulation and proteid solution was realized.

It may further be stated that, with proper care to maintain sufficient HCl, a proper temperature and occasional agitation, quantitative tests of peptonization do not show marked differences; nor can milk be considered a sufficiently accurate reagent to mark differences in coagulating power. Our knowledge of the exact steps in peptonization is not accurate enough to make the distinction of qualitative differences in peptic power practical. Thus, so far as secretion of ferments by the stomach is concerned, we can rule out perversion and excess of function and can recognize deficiency of function only to the degree of complete absence or of presence of proenzymes requiring HCl for their development. Obviously, therefore, the clinical classification of secretory abnormalities of the stomach is limited to HCl and to the direct results or inevitable accompaniments of its absence and it is scarcely necessary to state further that the classification is purely quantitative and cannot recognize a perversion.

The practical classification of secretory abnormalities of the stomach is: *A.* Hyperchlorhydria [*B.* Euchlorhydria, the normal mean]; *C.* Hypochlorhydria; *D.* Achlorhydria in the sense of absence of free HCl; *E.* Achylia gastrica, absence of HCl and of ferments.

Standards of Definition.—Normal human gastric juice contains about 2 : 1,000 of HCl corresponding to a decinormal strength of about fifty per cent.

(Note.—As the atomic weight of H is 1 and of Cl 35.5, a normal solution of HCl contains 36.5 grams of the gaseous acid per liter. A decinormal solution contains 3.65 grams per liter and each per cent. or degree of acidity represents 0.0365 : 1,000. An easy way to make computations is to multiply degrees of acidity by the number of days in a year and point off without regard to decimals, remembering that the full normal acidity of fifty degrees corresponds to an absolute proportion of a little less than 2 : 1,000 [1.825].)

As an approximate average, gastric contents consist of about half gastric juice during the period of full digestion one to two hours after a test-meal. Hence, 25 degrees may be taken as the average full standard of euchlorhydria. Some hold that euchlorhydria exists so long as any free HCl is present and after an ex-

ceptionally hearty meal, rich in proteins, this statement is practically correct. But, for the ordinary test-meals, 15 to 25 degrees of free HCl may be considered normal. Some use the term hyperchlorhydria even for 25 degrees and it is obvious that no arbitrary line may be drawn. It is suggested that the term be used as follows: Any contents showing 40 degrees or more of free HCl are hyperchlorhydric. If the total bulk of chyme obtainable by thorough extraction exceeds 100 c.c. (after a test-meal of total volume of 250 c.c.) and especially if the chyme exceeds in volume the test-meal, an acidity down to 25 degrees may be considered hyperchlorhydric according to the development of symptoms. Hypochlorhydria may be diagnosed for any degree of free HCl acidity below 15. Achlorhydria applies to cases with ferments, showing no free HCl, but with ferment action present on adding HCl to the normal standard. Achylia is reserved for cases in which neither HCl nor ferments are present. Occasionally a case will be found with no free HCl, that shows no notable peptonizing power nor milk coagulation even on adding small quantities of HCl but in which the biuret test shows a trace of peptone. Such cases may be termed hypochylia. The biuret test should not be confused with a somewhat similar color due to phenolphthalein administered therapeutically or accidentally conveyed in the laboratory. If, as customary, dimethylamidoazobenzol is used as an indicator for free HCl, readings should be taken at the point of disappearance of the cherry or cerise tint and the occurrence of an orange, not at the final straw yellow which exaggerates the reading of free HCl by 5 to 10 degrees. This is an extremely practical caution for apparently many clinicians have assumed 25 degrees as the limit between eu- and hyperchlorhydria, have titrated to the final discharge of color of dimethyl and have thus classified as hyperchlorhydria, cases at the upper limit of hypochlorhydria.

Recurring to the significance of the term functional, it may be assumed that this term may be applied to an occasional and transient hyperchlorhydria following anger, irritation, worry, etc.; to hypochlorhydria, achlorhydria or even achylia, transient and due to fever, general depression, chill, a paroxysm of asthma, etc. Generally speaking, a depressive functional disturbance may be of longer duration than one of exaltation. On the other hand, persistent states are more apt to be due to inflammatory, degenerative or other organic disease, although the stomach itself may react functionally to an organic disease elsewhere, as the achylia of Addison's disease.

Hyperchlorhydria.—In many cases, this presents a close analogy to hyperhyroidism and is probably due to actual hypertrophy of acid secreting cells though it is not certain that the distinction of acid and peptic cells is histologically correct. It may, indeed, coexist with hyperthyroidism. It is apt to manifest itself as an underlying tendency with attacks or exacerbations due to nervous strain, indiscretions in diet, etc. It is frequent in young adults, without such difference as to sex. In middle life, it is more frequent in males, probably on account of their greater liability to stress and less liability to chronic states of exhaustion. It is especially frequent in well-to-do brain-workers.

Protein and especially meat stimulates the secretion of HCl, while fats and carbohydrates, which do not require it for digestion, rather retard its secretion. But, on the one hand, protein also fixes HCl and thus tends to counteract the excess of free acid while temporary overeating of rich fatty foods, candy, etc., may cause an attack. Obviously, NaCl is the chief source of HCl in the system but as the chlorine is, successively, secreted as HCl, combined with protein, liberated in inorganic combination and resecreted as HCl, enough is usually retained in the system to allow a hyperchlorhydria to persist, even if pretty rigorous attempts are made toward Cl starvation. Conversely, the direct effect of an excess of NaCl in the stomach —more than three per cent.—is to reduce HCl secretion. Condiments, small dense particles such as seeds, and sapid methods of cooking stimulate HCl secretion.

The classic symptomatology includes gastralgia coming on one to two hours after a meal, especially after the heartier and more stimulating meals, but often coming on several hours after the evening dinner and persisting for several hours about the middle of the night. The pain, as stated, bears no direct relation to the degree of acidity. It is usually relieved by taking food or drink, both by dilution and by affording protein with which the HCl may combine. Gastric ulcer, on the other hand, is said to suffer exacerbation of pain if food is taken. This classic rule of differential diagnosis is liable to occasional exception in either direction. The pain may be localized at a point in the epigastrium or at the eleventh rib posteriorly in hyperchlorhydria when repeated tests show no bleeding, or these pain points may be absent in ulcer. Acid eructations may or may not occur. Hyperchlorhydric patients usually complain of gas but, on close questioning, admit that it cannot be raised in large amount. As a matter of fact unless under extraordinary conditions of impregnation of food with saprophytes and ischochymia, very little gas is formed in the stomach from fermentation, incubated contents showing only one percent. or thereabouts after twenty-four hours. Occasionally, however, very large amounts of gas are belched, not on account of fermentation but of effervescence between highly acid chyme and carbonates in the pancreatic, hepatic and intrinsic intestinal juices, the gas being admitted to the stomach by more or less relaxation of the pylorus. Ischochymia is characteristic of hyperchlorhydria but not invariable. The most typical cases of hyperchlorhydria from the symptomatic standpoint are due to gallstones, appendicitis, and various other abdominal conditions. In some of these cases, a reflex hyperchlorhydria actually develops but in others, equally typic symptomatically, HCl is reduced, even absent.

Diagnosis, therefore, depends on chemical tests. The writer's effervescence test by auscultation after administering $NaHCO_3$, distinguishes between conditions with little acidity and those with great acidity, and hence is of some tentative value. Also, after establishing the fact of hyperchlorhydria, it is convenient to determine the state of acidity at any given time. But neither this test nor qualitative tests nor attempts at approximate quantitation on small samples obtained by buckets and the like, can supplant titration of massive contents after thorough evacuation by the tube.

Treatment.—Simple dilution by drafts of water is palliative and especially if the water is cold, more or less therapeutic. The still alkalies, especially magnesium oxide or hydroxide and ammonia water are the best immediate treatment. If the acidity is excessive or if there is much tendency toward looseness of the bowels, sodium bicarbonate is the only alkali practically available. The dietetic treatment is obvious from the etiology. Mineral oil, bismuth, kaolin, mucilaginous preparations are, in different ways, locally soothing. Cannabis indica—other drugs of the group being usually contraindicated as too strongly mydriatic—orthoform, anesthesin, and even cocaine both relieve pain and tend to prevent further secretion. The more local anodynes are also useful diagnostically to distinguish between pain actually located in the gastric nerves and that referred from a distant organ. Rather protracted lavage exhausts the acid secretion temporarily and astringents, such as tannin, and still better, organic silver compounds, reduce the tendency to excessive secretion. Postures should be employed to get the solution in contact with all parts of the stomach for periods of two or three

minutes for each part and the stomach should then be drained and washed, to prevent argyria.

Prognosis.—A single attack of hyperchlorhydria, obviously due to some neurotic strain, while apt to recur from the same or an analogous cause, is not especially apt to establish a chronic condition. Any given attack is easily controlled but many cases give a history of recurrences which undoubtedly indicate some organic change in the secreting cells and such cases will usually require occasional repeated attention, until senility or some other depressing condition or an entire change of habits and nervous susceptibility produces relief. But, as with hyperthyroidism, this period is likely to give place to one of secretory exhaustion.

The danger of ulcer from corrosion by HCl, or rather by peptic digestion by HCl and pepsin of a part whose vital resistance is diminished by some trophic change or local ischemia is not very great. Preliminary necrosis by organic circulatory obstruction of any kind is still rarer and occurs in patients not likely to show an excess of secretion. Neither is hyperchlorhydria especially symptomatic of gastric ulcer. C. A. Ewald, in a large series, found the acidity about equally divided between normal and abnormal and the latter about equally divided between hyperchlorhydria and hypochlorhydria. More recently, it has been claimed that hyperchlorhydria is symptomatic of duodenal ulcer but this is true only as almost any abdominal lesion may imitate the symptomatology of hyperchlorhydria or occasionally cause hyperchlorhydria reflexly. For instance, one case of hyperchlorhydria occurred in a patient with an old tubal abscess following a distinct history of gonorrhea. Gonococcic vaccine not only relieved the pelvic symptoms but the hyperchlorhydria. It is probable that most cases of typic peptic ulcer in young persons are really due to the digestion of a part of lowered vitality, but this may occur without any excess of HCl. On the one hand, a series of cases of peptic ulcer, does not indicate by history or previous examinations, preceding hyperchlorhydria, to any significant degree; on the other hand, a series of cases of hyperchlorhydria does not subsequently yield ulcer cases in significant number.

Ischochymia, in the general sense, refers to any stagnation of food in the stomach, either due to obstruction of any kind at or near the pylorus or to any organic change such as dilatation and ptosis or functional motor failure interfering with the propulsive power of the stomach. It usually is taken to mean spasmodic closure of the pylorus, due to excessive acidity of contents and, especially, HCl acidity. Under these conditions, some fermentation may occur in spite of high HCl acidity. Thus the indications are to neutralize, often to wash, and to employ antispasmodic measures, as already discussed.

Continuous gastric secretion, often designated by the abominable term, gastrosuccorrhea continua, is a condition in which HCl (not necessarily in excess according to physiologic standards) and ferments are found at all times when intubation is practised or the effervescence test applied. Indicating a permanent state of irritation, it is almost unanimously regarded as pathognomic of gastric ulcer but it must be admitted as conceivable that other irritant factors may be responsible.

Hypochlorhydria.—Many of these cases are symptomatic of various types of gastritis, which includes both inflammatory and degenerative changes. Either locally or on account of general depression, cancer, dilatation, ptosis, even ulcer and especially ulcer due to senile trophic changes or vascular disease at any age are likely to result in depression of secretion. Chilling, fatigue, overeating, surgical shock, fever, invalidism, senility or any other depressing cause may result in hypochlorhydria, without any definite histologic changes in the secretory membrane. Conversely, the organic conditions typically resulting in hypochlorhydria, may not thus act immediately or may even reflexly produce hyperchlorhydria temporarily. It is scarcely necessary to recognize this fact by a definite classification, as of "acid gastritis," etc.

It should also be recognized that no notable interference with digestion occurs until the diminution of free HCl reaches within a few degrees of zero, except from the frequent though not invariable occurrence of fermentative changes due to yeasts and bacteria. Many of these cases are designated "starch indigestion" and treated with amylases. As noted, a considerable excess of HCl does not absolutely inhibit conversion of cooked starch in the stomach, by ptyalin; still less does a diminution of HCl act in this way, except by favoring the destruction of carbohydrates, sugars as well as starches, by extraneous organized ferments. Restoration of normal HCl acidity, avoidance of impregnation of food with bacteria and actual antiseptics, such as menthol, salicylic compounds, etc., and the use of adsorbents, animal charcoal and kaolin, are indicated. Antiseptic drugs, do not, of course, produce absolute sterility but, properly used, they certainly do inhibit bacteria and yeasts. It should further be recognized that hypochlorhydria, even in its limiting degrees of achlorhydria and achylia, does not necessarily produce notable interference with nutrition, on account of the far greater activity of the intestine and its tributary glands. As already alluded to, gas formation in the stomach, by fermentation, is not so frequent and so massive as it is usually believed to be. More than ten per cent. of bulk of gas in unfiltered chyme after twenty-four hours' incubation at body temperature, is unusual. The belching of large amounts of gas from the stomach when the incubation test shows only a few bubbles can be explained only by the effervescence with alkaline carbonates in the intestine, escaping through the pylorus—the same phenomenon occurring when an alkaline carbonate is added to the chyme in the incubation tube. There remain, however, a relatively small proportion of actual cases in which enormous amounts of gas are produced by fermentation. Such cases cannot be promptly relieved by antiseptic measures, including HCl artificially administered, nor by sterilization of ingesta. Lavage, thorough evacuation of the alimentary canal, abstinence from food, at least of the kind of food mainly involved in the fermentation so that the stomach and intestine can regain a condition of relative sterility, are indicated.

The treatment of hypochlorhydria usually includes that of associated conditions, such as atony, dilatation, ptosis, and catarrh. From the functional standpoint, the indication is to supply HCl and stimulate its secretion. HCl should, of course, be administered at the height of digestion, after the spontaneous secretion has reached its maximum. HCl administered before meals or too soon afterward, discourages secretion. A full normal acidity is twenty-five degrees or about 1 : 1,000. As official dilute HCl is a ten per cent. solution of the gaseous acid, this means that an average meal (not a test-meal) of 500 c.c., contains the equivalent of 5 c.c. of dilute HCl. If the gastric filtrate shows, for instance, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{10}$ of the normal free HCl acidity, quite accurate dosage is easily calculated.

From the standpoint of dietetics, the indications are nearly the opposite of those for hyperchlorhydria. The food should be sapid but without going to the extreme of using spices too freely, of employing frying and other methods which make for sapidity but which also render digestion difficult. It is a safe rule that whatever makes hyperchlorhydria worse, will fail to improve hypochlorhydria—with regard to questionable foods, food adjuvants and methods of cooking. A moderate amount of rather hard particles, not too large, should be included in the diet, unless there is atony or organic obstacle to onward passage. General

hygienic measures need no discussion. Of the bitters, supposed to stimulate gastric secretion, strychnine is practically the only one necessary. The mistake should not be made of using milk, starches, gruels, and other insipid and non-stimulating foods unless fever, gastritis or some other organic condition coexists. The diet should tend toward the carnivorous, with due regard to the secretory response and capability. Salt is indicated but it should be remembered that the mere abundance of Cl fails to relieve hypochlorhydria in about the same proportion of cases, at least the majority, that the mere administration of iron fails to relieve anemia. Moreover, when the proportion of salt in the stomach reaches three per cent., direct inhibition of secretion occurs. The mistake should not be made of giving too frequent meals. What the stomach needs is rest and even a fairly long fast, by producing real hunger, may be the best treatment. Lavage may be indicated simply to relieve the stomach of retained contents. It is a safe rule never to use more than 500 c.c. of liquid in the stomach at any one time. If intubation is practised especially to stimulate secretion, the liquid should be hot, or alternately hot and cold. Needle showers may be employed within the stomach. After lavage, a spray of menthol, etc., in pure mineral oil may be employed, no special instrument beyond the ordinary stomach tube and an atomizer tip about which the stomach tube can be tightly held, being necessary. The amount of air introduced at one time should not exceed 1,000 c.c. and care should be taken that the stomach empties itself before reinflation. Thus, the atomizer bulb or the pump to which it is attached should be measured. Tank pressure is dangerous. The writer uses a bicycle pump, clamped to a table, the cylinder holding almost exactly 100 c.c.

Achylorhydria.—This term is usually employed, not in the literal sense that no HCl has been secreted but merely to indicate that none exists free after proteid combination has occurred. It is, thus, the limiting degree of hypochlorhydria. Theoretically, there should be a state in which no HCl is secreted but in which proenzymes are secreted. In clinical terms, this stage would be marked by entire absence of free or combined HCl and of qualitative tests for peptonization but with fair digestion occurring after adding HCl. Practically, it is difficult or impossible, clinically, to distinguish such a stage, short of absolute achylia, although there are cases in which a qualitative peptone test occurs, ferment action remaining weak after adding HCl, and with doubtful traces of combined HCl. Such cases may be designated hypochylia.

Achylia Gastrica.—In these cases, there is absolute lack of HCl and ferments, not even the biuret test reacting. Transient achylia may occur from chilling, great fatigue or emotional depression, shock, during a paroxysm of asthma, etc., such cases being strictly functional and literally deserving the term "acute indigestion." This term, as commonly used, applies to so many different conditions and with so little significance that it is scarcely worth while to attempt to describe what various men think they mean by it. Acute and strictly functional achylia requires no treatment directed toward the secretory failure.

In Addison's disease, cancer, whether of the stomach or other organ, anemia, nephritis, and various other constitutional diseases of severe grade, relatively permanent achylia often is noted and it is conceivable that some of these cases, at least, may be of strictly functional nature so far as the stomach itself is concerned. If, in addition achylia pancreatica develops, as indicated by fecal tests and the more obvious one of nutrition in general, death occurs.

Chronic achylia gastrica, not included in the two groups mentioned is usually considered the functional expression of anadenia, the terminal, atrophic stage of chronic gastritis. But there are many cases, either discovered accidentally or on account of rather trivial digestive disturbances, without any such history or interference with nutrition, which suggest a congenital failure of glandular development or an unexplained permanent lack of innervation. In some cases, the association of achylia with pernicious anemia suggests a causal relation, as would be expected but this association is only occasional. A surprisingly large proportion of achylia cases do not affect the blood, nutrition, elimination, etc., and maintain apparenty perfect general health. This is on account of the physiologic fact, not well enough appreciated surgically nor with regard to internal medicine, that the stomach is of relatively little importance as a digestive and nutritive organ, that nutrition depends mainly and may depend exclusively or practically so, on the small intestine, and that nutrition cannot be maintained unless the food passes through about half of the small intestine as a minimum.

Some curious facts apply to achylia. In spite of the complete lack of HCl, fermentation is not especially liable to occur, the total acidity ranging from 2 or 3 to 10 or 15 degrees, whereas in cases of hypochlorhydria, the fermentation acidity may often reach 50 degrees. Since investigating alizarin reactions, the writer has invariably found that in achylia, the end-point with this indicator, has been spontaneously reached or passed. Obviously, the range of total acidity cannot represent combined HCl, as commonly stated for this range between the alizarin and the phenolphthalein end-points.

Aside from clearly functional and transient achylia, the writer knows of no case of resumption of function although good general health may exist for years and it is entirely possible that these cases, drifting from observation and having no personal reason for further consultation, ultimately recover their gastric secretion. The various methods applicable to hypochlorhydria and achlorhydria may be employed and certainly produce, artificially, more or less temporary restoration of digestive functions. The practical outcome of the case depends upon the maintenance of intestinal function, spontaneously or by treatment. For example, a case referred on account of diarrhea, ten to twenty passages a day for nine months, with loss of weight and progressive failure of strength, was relieved in a week by attention to a small ulcer in the sigmoid. Symptomatically, the case may be considered cured after several years but it is improbable that the achylia gastrica—which may be said to have been diagnosed "intercurrently"—has changed.

A. L. Benedict.

Stomach, Surgery of the.—The surgery of the stomach is rapidly undergoing an epochal change. If there is any one thing that characterizes this modern era it is the growing tendency among progressive surgeons of the alimentary tract to regard the stomach not as a storage bag for hastily devoured food but as a vitally functionating organ intricately involved in the reception, preparation, and absorption of the food and the orderly delivery of the chyme. Its processes are essentially physicochemical. Intellectual grasp of the normal gastric physiology is wanting. It is not surprising, therefore, that conscientious surgeons often find themselves at a loss to interpret the pathological physiology of the stomach. The fault evidently lies in the heretofore disproportionate interest in gross anatomy. In this respect witness the frantic efforts being made to restore the normal or rather the mean anatomical relations of ptotic stomachs. Supplementing this morphological factor is the relative unimportance of biology or more fundamentally physics and chemistry.[1] This deficiency in elementary surgical knowledge is presently being met in two ways; by the correlation of the anatomical surgeons with the surgical research laboratories and the correlation of the research surgeons with the physicists and

the biochemists. It is this socialization of medicine, then, with the surgical group rather than the individual surgeon as the working unit that is making for the greatest efficiency and supplying the long-felt need in modern gastrointestinal surgery.

The present treatise is planned to emphasize those operations upon the stomach that have proven most serviceable clinically and most productive physiologically. Those methods which are not supported by clinical and experimental studies will either be omitted or mentioned for their historical value only.

Gastrorrhaphy.—This is the repair of a wound of the stomach. It has acquired additionally the content of gastroplication. Repair alone will here be considered and plication will be reserved for a separate study. A wound in the stomach may involve a whole or a part of the gastric wall; it may be clean cut or ragged; it may involve one or opposed walls of the viscus; it is probably always an infected wound though the amount and degree of infectiousness of the leakage products vary with the contents of the stomach; it may be associated with considerable or insignificant hemorrhage. These characteristics of the stomach wound must be met in each individual case for appropriate treatment. In cases of severe hemorrhage indicating speedy celiotomy the wounded area is approached at once and the vessels clamped and ligated. Occasionally a ligature on a needle may be made to encircle a bleeding spot most effectively. It is prudent to drain every complete perforation of the stomach, not only as a safeguard against further leakage, but as an outlet for the products of the localized perigastritis and peritonitis. The irregularities of the wound had better be left in favor of greater speed and more accurate closure. Furthermore, autolysis will destroy superfluous edges without hemorrhage where as trimming may start up troublesome bleeding. The extent of the wound demands simply the application of a part or a repetition of the technique of gastric suture.

Sutures have been devised by different operators and in most cases are known by the names of their originators. Of these sutures, the best known and most used is the Lembert. (See Fig. 4664.) The essentials of this and of the other sutures are a straight or curved round needle (an ordinary cambric needle three to four centimeters long is excellent) and a fine suture. The absorbable gut is best used for buried sutures and silk or Pagenstecher for the peripheral ones.

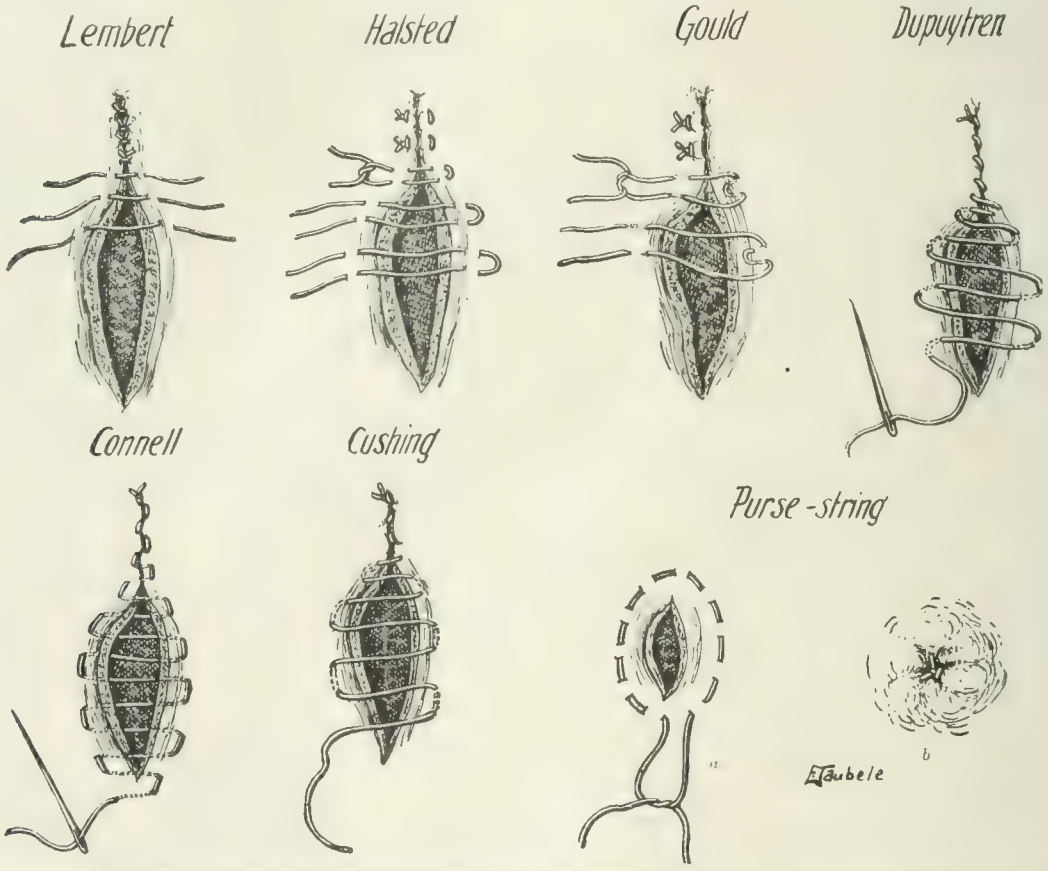


Fig. 4664.—Various Gastrointestinal Sutures. *a*, Suture inserted; *b*, suture tied. See also Fig. 4684.

This selection is amply borne out in the disclosure of gastrojejunal ulcers that have developed upon sites of buried slowly absorbable suture materials. The Lembert enters the stomach wall from without-in and from within-out, crosses the area to be inverted, and reenters the wall from without-in and from within-out. The needle penetrates the serosa and muscularis and dips into the submucosa. It does not matter if the needle enters the mucosa, but it does matter if it does not pick up a few fibers of the submucous layer, for it is the muscular layer that is vascular, friable, and yielding and the underlying submucous coat that is fibrous, resisting, and supportive. The effect of this seromusculo-submucous (usually called seromuscular) suture of Lembert is to invaginate enclosed tissue. In placing these

sutures care should be taken to dip under the vessels lying for the greater part in the submucosa. This, in effect, ties off the vessels and safeguards against occasional, but only too frequent hemorrhage. This applies to all seromuscular sutures.

Halsted's, Gould's, Dupuytren's, Cushing's, and the purse-string sutures are modifications of the old classical Lembert. Halsted's mattress is a double Lembert each half of which is inserted in opposite directions. Gould's mattress is a Lembert further modified in that the loop of the mattress is made convex to the points of entrance and departure of the suture, instead of concave. This difference advances the traction points and explains the greater invagination of the serous surfaces. Dupuytren's suture is a continuous Lembert. It is an excellent one and in common use. The Cushing stitch runs admirably and, in this respect, seems preferable to Dupuytren's. Somewhat similar and little used to-day in the Gely suture. When inserted circularly, the continuous Lembert becomes a purse-string.

Occasionally, in gastrorrhaphy, it is necessary to secure firmer union or control oozing from the edges of the wound by an intermuscular or hemostatic suture. Those in common practice are the Connell and the interlocking or chain suture. These will be found described in the article on *Intestinal Surgery* and are illustrated in the accompanying figures.

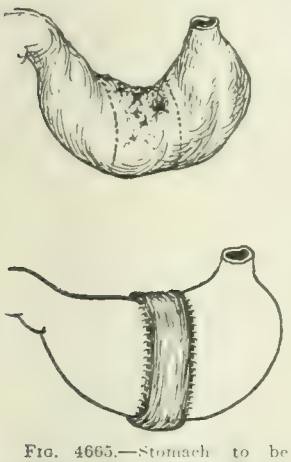


Fig. 4665.—Stomach to be Resected as Indicated (above). Stomach after resection and repair with fibromuscular cuff (below). Experimental procedure recommended for extensive loss of stomach substance.

For the small perforation an ordinary purse-string is all that is required. This may be reinforced by one or more of the same, being careful to catch the puckered furrows of each preceding in the bites of the one to follow.

For the repair of moderately extensive wounds, it is simply effective to close the mucosa by a continuous or an interrupted-continuous suture and invert the seromuscular edges by Lembert stitches (single, mattress, or continuous). When, however, inversion of the outer coats is impossible or impracticable, they may be joined as the mucous coats. It is well to cover a rough suture line with a piece of omentum to anticipate inevitable and more injurious adhesions.

For the repair of the extensive wounds of the stomach with considerable loss of substance it is often feasible to bring the seemingly redundant mucosa together by a simple over-and-over suture and to make up the deficiency in the fibromuscular layer by a tissue graft. Omentum intact or resected is advised as a filler-in. The writer has used experimentally the sheaths of the abdominal recti with good results. In this way a fibromuscular cuff three centimeters wide has been completely removed and replaced by a transplanted fibromuscular cuff. Keeping the edges separated, when such a transplant is used, undoubtedly interferes somewhat with the gastric motility more than with the edges in direct continuity. This is more than compensated for by the advantages of a strong union, an immediate closure, and safety to the patient. The only other recourse is to leave the opening patent, protect as much as possible with gauze, and close the abdomen.

For the repair of the small or moderate-sized perforation following gastric ulcer in which malignancy is suspected it is convenient and safe to circumscribe the ulcerous margin by the pentagonal strangulation stitch of Draper and MacCarthy.[2] With a long straight needle threaded with stout linen pierce all the coats of the stomach in the vertices of a pentagon continuously two times. The suture is drawn tightly and tied firmly. The result is immediate closure with autolysis of the included tissue. An alternative to sutural resection and closure of a perforated ulcer is a simple pulling together of the opening with interrupted or continuous Lembert's supplemented, if indicated, immediately or later by a subsequent gastrectomy and gastrogastrostomy or gastroenterostomy.

Gastrotomy.—This is a simple incision of the stomach and does not exist apart from the more detailed gastric operations excepting for purposes of exploration. Its purposes and technique are therefore well covered in the descriptions of gastrostomy, gastrectomy, and gastroenterostomy.

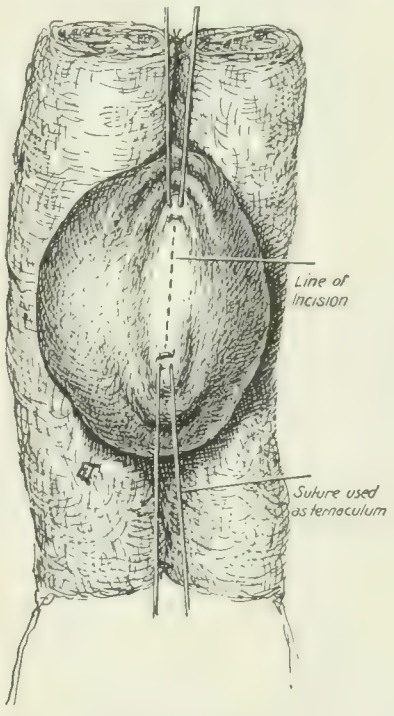


Fig. 4666.—Stomach Walled off with Moistened Pads and ready for Incision.

It is indicated in suspected disease of the stomach, in cases of neoplasms and foreign bodies, in hematemesis, and in strictures or other stenoses of the esophagus, cardia, and the pylorus.

The laparotomy is mesoventrad in the upper abdomen. The stomach is palpated and often, without handling the whole viscus, that part particularly involved may be brought into the wound. The stomach is gently packed off with hot moist pads to protect the peritoneal cavity from contamination. Two black linen sutures, one at each end of the proposed incision, are often serviceable as tractors. Make the incision perpendicular to the long axis of the stomach. Mop up excessive fluid. The purposes of the gastrotomy may now be accomplished. To facilitate examination the mirror or an appropriate endoscope may be inserted into the stomach, or a palpating finger. If these means are not sufficient it may be helpful to palpate the posterior wall through an opening in the posterior mesocolon. For closure of

the gastric wound see the section on Gastrorrhaphy. If the operator keeps in mind two sutures, namely, the Connell (hemostatic or intermuscular) and the Cushing-Lembert (seromuscular), he can readily close a gastrotomy wound and will have mastered the fundamentals of gastrointestinal suture.

Gastrolysis.—This is the operation of freeing the stomach from adhesions. The technique in itself is simple in the majority of instances. The adhesions are usually acquired and consist essentially of fibrous tissue scantily supplied with blood-vessels. Merely dividing the adhesions is therefore usually ample; in a few extraordinary cases the band may be ligated at the ends before division.

Very rarely congenital bands persist about the stomach. They should be regarded probably as anatomical varieties rather than as congenital adhesions unless their presence interferes with the normal physiology of the stomach. The writer has seen one such band corresponding to the mesogastrium anterius with an unusual attachment to the stomach. Fluoroscopically the stomach emptied within six hours but showed an irregularity on the greater curvature with unaccustomed anchorage to the midventral region of the abdominal parietes. Upon operation an omental band eight to ten centimeters in width extended from the mid-point upon the greater curvature to the anterior abdominal wall. This was regarded as an anatomical (congenital) variety with an acquired dorsad fixation upon the stomach. As it did not interfere with gastric emptying it was not considered pathological and was left intact. This problem of estimating the pathological potential (or the ability to interfere with the normal function) of presumably congenital perigastric remains enters into the subject of perigastric adhesions and such bands must be carefully studied before they are disturbed. Otherwise new and harmful adhesions will develop upon the sites of old and harmless ones.

As a rule, the pathological basis of the adhesions deserves the most attention. This may be syphilis, tuberculosis, ulcer, or neoplasm of the stomach or neighboring organic disease, commonly of the gall-bladder. These conditions must be treated first and the accompanying adhesions secondarily.

The adhesions following intraabdominal operations are of especial interest to the surgeon, who sees his cases a second time. Their most effective treatment is prophylaxis. To prevent them one must know the factors that give rise to adhesions.

Laboratory work has helped some. Fifteen dogs were eviscerated under as sterile conditions as could be devised. In five, dry gauze was brought into contact with the serous surfaces, in five moistened gauze, and in five rubber dam. The only laboratory variable in these series was traumatization of the serous membranes. This was undoubtedly greatest in dry-gauze dogs and it was in them that the adhesions were most pronounced. In other animals, stomach and intestinal operations were performed but in these as in human cases many variables entered at once; namely, the leakage into the peritoneal cavity of blood, secretions, products of digestion, and exogenous toxins and infections. Adhesions followed, but it was impossible to draw any conclusions as to the cause. All the above foreign substances produced adhesions, especially sublethal doses of infectious material from the lower tract. Therefore, irritation, whether traumatic or biochemical, assuredly gives rise to adhesions. Their prevention demands careful and accurate handling of the peritoneum. The oils, varnishes, and other substances purposely left in the abdomen to prevent them have not helped any. Hypertonic solutions of sodium citrate and sodium chloride have been recently advocated and may prove of benefit.[3] There are some individuals who seem more prone to develop adhesions than others; they have been called "adhesion-formers." These patients represent the personal equation in productive tissue formation and suggest relatively increased fibrogenesis or relatively decreased fibrolysis. This explanation brings out a biochemical mechanism originating from within or of endogenous origin. The whole subject is an important if a difficult one.

Gastroplication.—This operation is performed in order to obtain a diminution in the size of the stomach by infolding. It has been performed for atonic dilatation.

In Moynihan's method after exploring the stomach a series of exaggerated Lembert sutures is introduced into its anterior wall and tied. The result is a series of invaginations of the stomach wall and resultant decrease in size.

The value of plication is questionable. It is difficult to see how invagination of a part of the toneless gastric wall can possibly improve the lack of tone of the whole wall. Furthermore the sutures, themselves, do not hold the stomach permanently but allow the

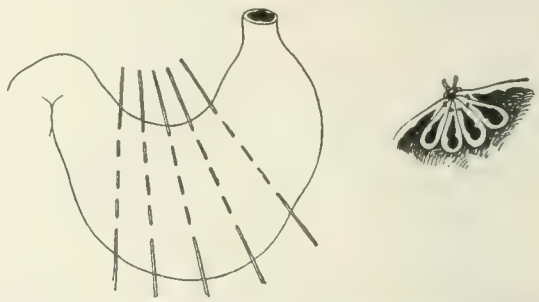


Fig. 4667.—Moynihan's Method of Gastroplication, showing sutures inserted and sutures tied.

walls to recede to their former proportions. The procedure, therefore, is temporary as well as unscientific.

Gastropexy.—This is the operation of suturing the stomach to overcome displacement. The indication, if there be any at all, is uncompensated gastroptosis. Briefly gastroptosis is congenital or acquired. Congenital gastroptosis occurs exclusively in thin, narrow-chested individuals often with defective nervous systems. Under good hygienic conditions most of these inherited cases weather the adolescent period with only occasional attacks of "dyspepsia" or of "biliousness." In the thirties instead of the exception the attack becomes the rule. On the other hand, the acquired types are the victims of bad habits, poor hygiene, and diet: many are multipara. In either event, whether born down or whether it gravitates, the stomach takes a position in the lower abdomen (below the intercristal line in the dorsal prone or below four centimeters of that line in the upright positions). This displacement raises the gastric load both by lengthening the pyloric arm and by kinking the pyloric outlet. At the same time the prostaltic power of the gastric wall is to some degree impaired by the stagnant contents. Hence dilatation succeeds ptosis and characterizes the stage of uncompensation. Whether under these circumstances a gastropexy is justifiable is a debatable problem.

Beyea, Rovsing, and Coffey have energetically advised operation. Dudley Tait and George Stewart consider Dietl's crisis the only indication for surgical correction of a splanchnoptosis. One case of congenital prolapse in the late compensated stage was suspended with the hope of preserving the gastric musculature from eventual degeneration; one year later she reported herself seventy-five per cent. improved or seventy-five per cent. free from her dyspeptic attacks. An advanced uncompensated congenital ptosis after prolonged medical treatment

had a Coffey "suspension" performed without improvement during the following year and was decidedly helped by gastroenterostomy. The operation of gastropexy at its best simply restores the mean (or normal) anatomical relations without due regard for function. Furthermore, other splanchnoptoses generally complicate gastric ptosis and involve still more the question gastroptosis.

Before attempting a gastropexy carefully exclude pyloric stenosis, duodenal and gastric ulcers, and any other localized disease of the stomach; and explore gently the remaining abdomen. The choice of method lies within the following:

1. *Duret's Operation.*—The stomach is exposed by a midline incision leaving the peritoneum intact in

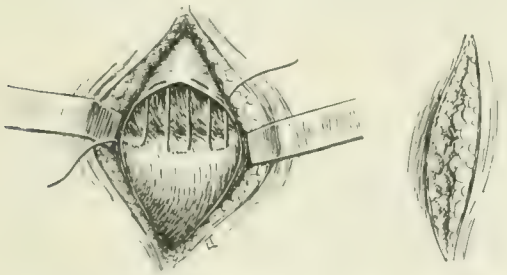


Fig. 4668.—Duret's Operation.

the upper angle of the wound. The pylorus and lesser curvature are sutured to the undivided peritoneum by a continuous suture. A needle is attached to each end of the suture and run through the muscles and fascia of each side of the wound and the ends tied. This procedure creates what is constantly striven against; namely, adhesions interfering with gastric motility.

2. *Rovsing's Operation.*—The stomach is delivered by a similar incision. Insert horizontally from left to right continuous Lemberts of stout silk or linen into the anterior stomach wall. Three or more may be introduced. The serous surfaces of the stomach and of the abdominal wall are scarified and brought into

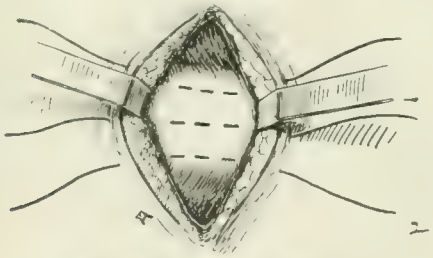


Fig. 4669.—Rovsing's Operation.

contact by tying the above sutures after each is run through the wall out on to the skin. It is recommended tying them over a sterile glass plate protected with gauze and of a trifle greater width than the corresponding area on the stomach. These sutures are left in place three weeks. Rovsing reports sixty per cent. cured and twenty improved by this method. One cannot see how it escapes the criticism of the Duret method of establishing harmful adhesions.

Beyea's Operation.—The stomach is exposed in the same way through the upper midline. The liver border is elevated to bring into view the gastrohepatic omentum. Three series of interrupted silk sutures are run through the lesser omentum from above downward (cephalocaudad). Three corresponding transverse folds are created. Bier and Eve propose suturing the pyloric end of the stomach to the capsule of the liver and both have reported cases treated in this manner. The Beyea method offers the advantage of elevating the stomach without apparent mechanical interference with its motility.

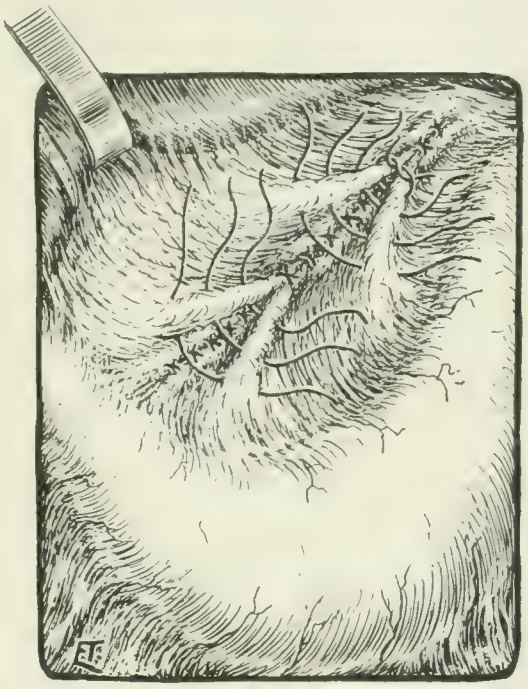


Fig. 4670.—Beyea's Operation showing three layers of transverse sutures in the gastrohepatic omentum.

Coffey's Operation.—The stomach and transverse colon are exposed through a midventral incision. Both are fixed in the upper abdomen by stout linen

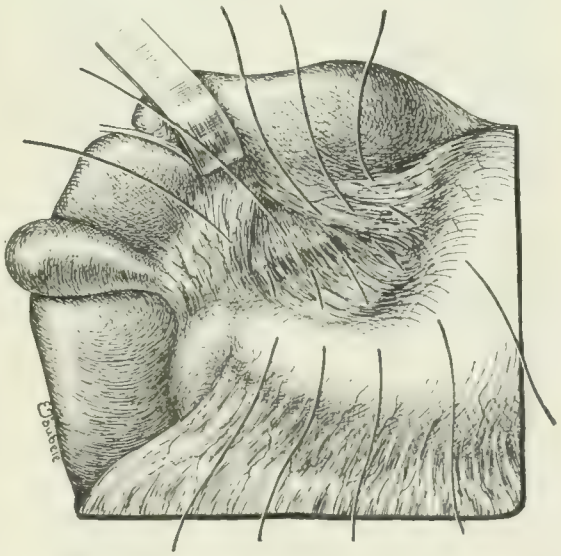


Fig. 4671.—Method Proposed by Bier and Eve.

sutures threaded on curved round needles. The lateral margins of the wound and borders of the ribs are retracted widely. For this purpose the hands are found superior to retractors. Three sutures are

taken in the peritoneum and fascia of the upper left side, a finger's breadth apart, and each in order is made to catch bites in the gastrocolic omentum (the first well back) at the greater curvature of the stomach and at the lower border of the transverse colon, respectively. Two sutures are run on the right side between the corresponding points of the same structures and the third is made to join the two midpoints of the great omentum, above and below the transverse colon to the parietal peritoneum and fascia of the midabdomen in closing. As in the preceding operation it is well to scarify, or better still, to incise the parietal peritoneum and expose the transversalis fascia before approximating the omental tissues. This so-called hammock operation has been performed three times. In one reoperated upon nine months later, the adhesions had stretched out into glistening fascial bands two finger's breadth in length. The other two, nineteen months and nine months, respectively, postoperative, report themselves improved. Of the older cases studied, all present evidence of recurrence (to some degree) of the displacement. On the whole the operation seems unsatisfactory. Coffey[5] in attacking congenital splanchnoptosis, recently reported the fixation of the ascending and descending colons and of the kidneys through separate posterior openings and stitching the omenta to the anterior parietal peritoneum through an anterior incision. This undertaking well serves to represent the gravity of the problem.

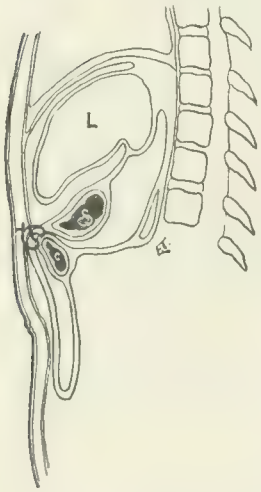


Fig. 4672.—Schematic Representation of Fixation of the Stomach and Transverse Colon to the Abdominal Parietes in the Coffey Operation.

Gastropexy is a very hazardous field for surgery. It should not be attempted until after exhaustive medical efforts at improvement (not cure) and, then, the Beyea or Coffey may be tried, reserving for the failures, carefully planned gastroenterostomies.

Gastrostomy.—This is the creation of an artificial gastric fistula. It was first suggested by Egeberg in 1837 and first performed by Sedillot in 1849.

The indications are esophageal stenosis, simple, benign, or malignant, causing dysphagia; pharyngeal carcinoma obstructing the esophagus; and gastric carcinoma occluding the esophagus. To get the best results it should be performed before the patient becomes emaciated or before the swallowing of solid food is impossible. The objections to early operation have been leakage, discharge, irritation of the skin, and the annoyance of wearing the tube. To combat these, methods have been devised by Franck, Witzel, Kader, Senn, Janeway, DePage, and others.

Simple fixation of the stomach to the abdominal wall with one common opening is unwise because of leakage.

Franck's[6] *Operation.*—A five-centimeter incision, 2.5 centimeters below and parallel to the tenth costal cartilage is made on to the stomach. The rectus fibers should be separated bluntly. A second incision is made parallel to this and superficial to the costal cartilage. The skin is undermined between the two and, under it, a stomach cone is drawn from the first into the second wound. The two openings are closed about the cone. The stomach is opened when desired. Mayo-Robson fits the stomach protrusion more snugly into a smaller second (one to two centimeters) incision, temporarily suspends it on two pins placed crosswise to the wound, immediately inserts a catheter which he recommends leaving for a few days, and uses no sutures.

Witzel's[7] *Operation.*—The abdomen is opened by a five-centimeter incision through the upper right rectus. The stomach in the vicinity of the incisura and

A *B*

Fig. 4673.—Franck's Operation representing the stomach cone delivered through the lower incision (*A*) and carried under the cutaneous bridge into the upper incision (*B*).

the greater curvature is drawn into the wound and opened sufficiently to admit the end of a 25 F. catheter. This tube is anchored to the margins of the stomach wound by one or two catgut sutures and buried in the serous coat for 4.5 centimeter by interrupted or continuous sutures. The outer end of this canal is fastened to the parietal peritoneum and the abdominal wound is closed about the tube. This tube

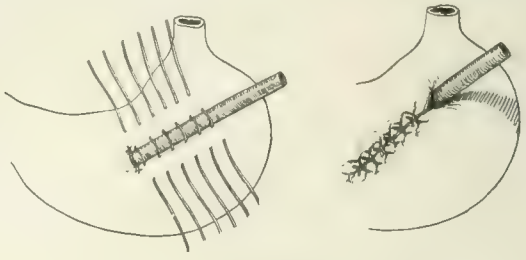


Fig. 4674.—Witzel's Operation.

may be protected by a larger one passed over it down to the margins of the wound.

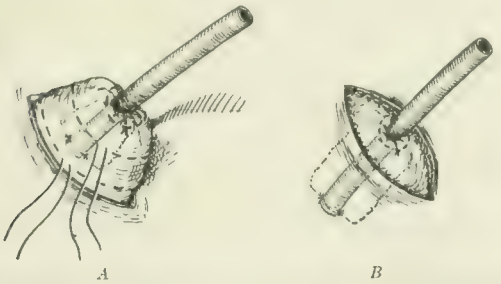
Kader's[8] *Operation.*—The stomach is opened as in the Witzel technique and a tube is sunken perpendicularly into the gastric wall by two series of invaginating silk sutures. A circular valve is thus created. Binnie suggests inserting two purse-strings about a (Jacob's) self-retaining catheter which produces the

Fig. 4675.—Kader's Operation showing two series of sutures for invagination of stomach about tube.

same result. The catheter is necessary to keep the openings patent. The wound is closed as in the above about the tube.

Senn's[9] *Operation.*—The cardiac end of the stomach is drawn into the wound, opened, and the end of a No. 20 F. catheter anchored to it. A purse-string suture is run about the tube one to two centimeters distant and two successive ones introduced. These inversion sutures should be Lembert's of silk. Senn

advised tying two "puckering strings of heavy chromicized gut two and one-half inches below apex of cone." The stomach is sutured to the parieties above and below the tube and the wound closed. The result is much the same as in the Kader method; the stomach pouch is more columnar in the Senn operation.



A B

Fig. 4676.—Senn's Operation. Sutures placed (*A*) and tied (*B*).

Janeway's[10] *Operation.*—Through a three-centimeter incision in the upper right rectus anterior gastric wall to the right is drawn into it and opened by one incision three to four centimeters long and two one-centimeter incisions perpendicular to it and toward the greater curvature. This rectangular flap is drawn out and sutured (above) so as to form a fistula

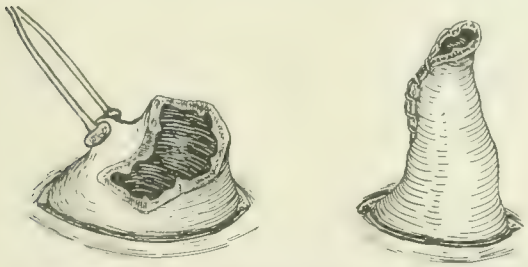


Fig. 4677.—Janeway's Gastrostomy. Note flap being drawn up into a cone; note, also, closure of the cone with sutures along the upper border.

and at the same time so as not to constrict the stomach in its short diameter. The base may be invaginated or fixed to the parietal peritoneum. The wound is closed about the fistula and the mucosa apposed with the skin.

DePage's[11] *Operation.*—This is an ingenious method represented in sketch. A tube is buried partly within the stomach and partly within a tongue of gastric wall.

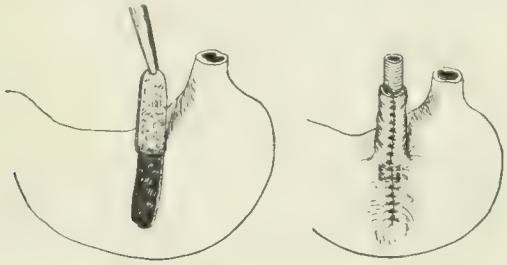


Fig. 4678.—DePage's Operation.

Of all these, the Senn operation is probably most favored. E. J. Senn reports ninety-three operations with leakage in only two.

Pyloroplasty is an operation upon the pylorus to enlarge its diameter. It is not as much used to-day as formerly. The best plastics are not plastics at all but more properly gastroduodenostomies (*q.v.*). The indications are spasms, hypertrophies, cicatrices, and congenital stenoses of the pylorus.

The *Rammstedt*[12] *operation* calls for an incision through the pyloric tissue to, but not through, the mucosa. No sutures are used within the abdomen. Two cases are reported recovered from stenosis by the author.

Nicoll's Operation.—The pylorus is incised transversely in a Λ-shaped manner and closed in the likeness of a λ. The mucosa may or may not be divided.

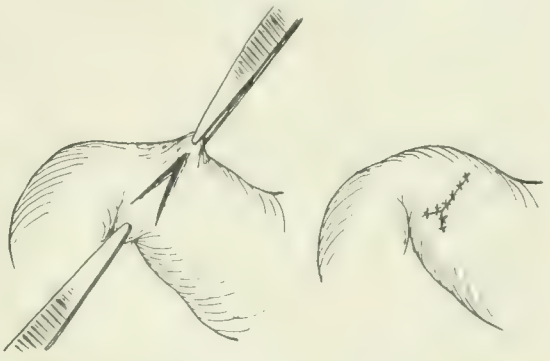


Fig. 4679.—Nicoll's Pyloroplasty.

Gastrectomy.—This is the excision of a part or whole of the stomach. It involves gastrotomy, gastrorrhaphy, possibly gastrolysis, as well as gastrogastrostomy or gastroenterostomy. Gastric resection may be classified as follows:

A. Partial: (1) Triangular, (2) segmental, (3) transgastric.

B. Complete (resection of the cardia).

Partial Gastrectomy.—The indications are localized disease of the stomach, such as well-circumscribed new growths and ulcerations.

The resection of a triangular piece from the pyloric end of the lesser curvatures is most common. The

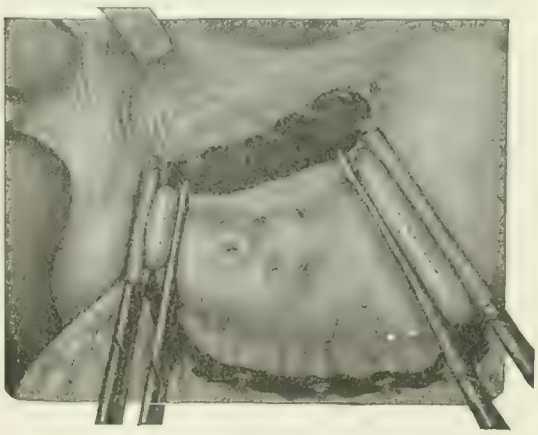


Fig. 4680.—Partial Gastrectomy, illustrating ligation of vessels, application of clamps, and planes of division (dotted lines).

stomach is exposed by the usual upper midabdominal route. The portion effected is selected. Black linen ligatures, threaded on needles, are passed around the coronary and pyloric vessels and tied while the ends are left long as tractors. The vessels of the lesser omentum corresponding to the stomach area to be removed can be doubly ligated and the mesentery divided between the ligatures. The diseased segment may now be clamped by one or two intestinal clamps and the intervening tissue grasped firmly in an ordinary clamp to facilitate handling. A good method of

utilizing the clamps is to apply the intestinal clamps on the ends that are wished to be preserved and in between these, or on the segment to be removed, two pairs of crushing clamps are applied. Each pair is fixed to the extremity, the first clamp immediately adjoining the protected clamp and the second immediately adjoining this one. Then the intervening ones of each side are taken off and their places will be found to have been "milked dry" for the lines of the incisions. Removal ought now to be accomplished without any difficulty. The divided edges are approximated by a continuous or interrupted continuous mucous suture of chromicized gut, and by a similar intermuscular suture or, instead of these two, one through-and-through (Connell) suture and in either case by a continuous (Cushing) Lembert of silk or Pagenstecher. Interrupted Lembert's may be applied wherever necessary. Whether the "three clamp" method is used or not, allowance should be made for the devitalized edges by running the sutures not within one-fourth inch of their margins. Of course, this closure should be transverse to the long axis of the stomach. This, in general, may be taken as a working basis for the removal of circumscribed tissues from other parts of the organ.

Recently, however, William Mayo and others have advised the removal of a complete segment or cuff from the stomach for ulcer. It is thought gastric motility is less interfered with. To determine this point, experiments are being undertaken. Triangles and cuffs of the neuromusculature and of all the coats of the stomach have been removed. The resultant motility is being checked up by *x*-ray, and by direct

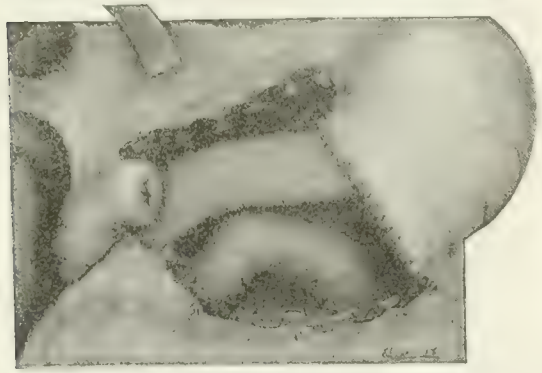


Fig. 4681.—Partial Gastrectomy. First stage, that of removal of portion of stomach completed. Note closures of stomach and of duodenum, preparatory for gastroenterostomy (see Fig. 4685).

observation and changes in tonus are recorded in rhythmical tracings. Segmental resection is similar to the removal of a triangle. The main trunk vessels at both curvatures and the corresponding mesenteric vessels are ligated. The segment is removed in the same way. The same suturing is employed in closing the wound. (See Figs. 4680 and 4681.)

Transgastric gastrectomy is recommended by W. J. Mayo as a means of removing an ulcer from the posterior wall. Such as ulcer may be approached through the gastrohepatic omentum or transverse mesocolon. In the former method the anterior wall is opened to explore the interior and dissect out a posterior ulcer. The wounds are closed as already described.

Complete Gastrectomy.—This was first performed by Connor in 1883 and later by Slatter. It is indicated in malignancy of the whole or presumably the entire stomach when not contraindicated by metastases of the neighboring organs. An incision in the midventral region is made from zyphoid to umbilicus. Doubly ligate and divide the omenta between ligatures. By traction on the stomach the esophagus is drawn down and clamped (with protected clamp). The cardiac end of the stomach is also clamped (with a crushing clamp) and the tissue between the two instruments divided. Similarly clamp and divide the pyloric extremity. At this stage if the terminal anastomosis of the duodenum with the esophagus appears impossible the duodenal end is closed by a continuous through-and-through suture and inverted (as in Fig. 4681). Whenever direct union is possible without tension perform it. A most accessible loop of the jejunum is selected and laterally joined to the cut end of the esophagus by the usual intermuscular and Lembert sutures. The semi-occluded duodenal loop* is a possible source of danger and it is well to anticipate retention by avoiding unnecessary angulations as well as to leave the stump accessible. To this end, it may be wise to perform an entero-enterostomy. The problem of the removal of the stomach is tedious and complicated for the operator and dangerous for the patient.

The resection of the cardia is a most difficult procedure, carried on in stages, and besides gastric resection, requiring thoracotomy and neck dissection.

The mortality of incomplete gastric removal lies between fourteen and sixteen per cent.; that of complete gastrectomy is thirty-six per cent.[13]

Pylorectomy.—By this term is meant removal of the pylorus, an operation justifiable only in benign pyloric disease. For malignancy gastrectomy is indicated.

Two problems are involved, namely, the removal of the diseased focus and the reunion of the divided ends

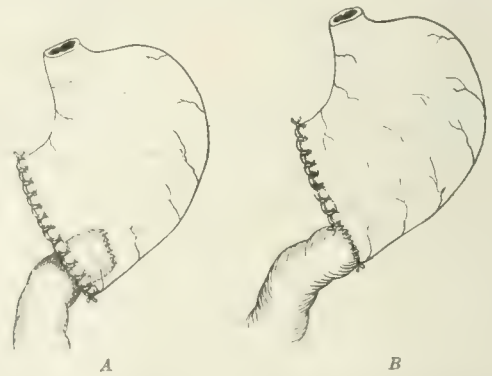


Fig. 4682.—Other Methods of Completing Second Stage, That of Anastomosis of Divided Ends; *A*, termino-lateral, *B*, terminal.

of the alimentary tract. The removal of the growth necessitates keeping in mind the regional vessels and lymphatics. The exposure is accomplished as in the above operations and the planes of division determined upon. The vessels of the gastrohepatic omentum are ligated and the omentum is divided distal to the regional nodes. The coronary vessels are ligated at the point where they enter and leave the lesser omentum; the pyloric artery and vein in the hepatoduodenal ligament; and the gastroepiploics posterior to the duodenum on the right and at the plane of gastric section on the left. The great omentum is ligated and divided, carefully avoiding the midcolic artery. Two clamps are applied to the duodenum and two to the stomach side of the growth (the intermediate ones should be crushing clamps). The specimen is now ready for removal by division between each pair of clamps, preferably one centimeter distant on

* We understand little about semi-occluded loops. Laboratory studies a long time ago showed the danger of complete or incomplete occlusion of the intestine, especially near the duodenum. Whipple, in continuing these studies, presents evidence for believing the poison which the early investigators held originated from the intestinal lining epithelial cells, to be a heteroproteose.

the left and 2.5 centimeters on the right. Any involved glands in the vicinity should be removed.

The anastomosis of the divided ends may be undertaken in one of three ways: the terminal (Billroth), the terminolateral (Kocher), and the lateral (Billroth). *Terminal.* Close the stomach wound by a chain or Connell and an invaginating (Cushing-Lembert) suture leaving an opening at the greater curvature corresponding in size to the duodenum. The duodenum is now united with this opening in the usual way. *Terminolateral.* The gastric end is closed completely and the duodenal is joined directly to its anterior or posterior face near the lower right corner. *Lateral.* Both duodenal and stomach ends are closed and a gastroenterostomy performed. The terminal method presents increased dangers of leakage. The terminolateral anastomosis is reported most successful. The lateral method offers the incomparable advantage of a two-stage operation; it being possible, when it is indicated, to perform the gastroenterostomy and postpone the radical operation until a later date.

From the physiological standpoint, the terminal method is the most satisfactory because the union is in the direction of the normal prostaltic drive and because the new outlet of the operatively contracted stomach corresponds most perfectly with the physiological point of outlet of the original normal stomach. The lateral method is faulty because it intercepts the

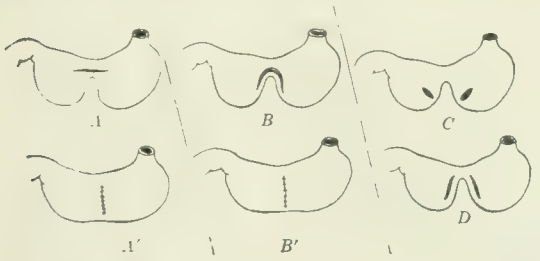


Fig. 4683.—Diagrams Representing Different Methods of Performing Gastrogastrostomy. Note that in each case the circular fibers of stomach are divided excepting in *C*. Note, also, that the ulcerous cicatrix, if present, is left in the stomach in all, a procedure objectionable in the light of the present conception of most surgeons.

alimentary current perpendicularly, impairs the circular musculature of the jejunum, and if not properly constructed, of the stomach as well, at their respective sites of union and leaves a semi-occluded duodenal loop. The terminolateral compromises the advantages and disadvantages of both the preceding, receiving, if not intercepting, the chyme in its long axis and leaving no blind intestinal loop. On the whole, therefore, it seems wise where the two-stage operation is not necessary, to perform the Kocher pylorectomy.

The mortality given by the Rochester Clinic is 12.4 per cent. for 266 partial gastrectomies, 224 of which were pylorectomies.

Gastrogastrostomy is the reunion of the two portions of the stomach after stricture or resection. For the hour-glass deformity following stricture, the longitudinal incision on the anterior surface or the horseshoe incision, similar to that in the Finney pyloroplasty, is often made. This divides the strictured area longitudinally that the edges may be united transversely. (Fig. 4683, *A*,*A′*; *B*,*B′*.) As the stricture of the hour-glass stomach commonly arises from ulcer and as ulcer of the stomach, in the majority of cases, is believed to develop into cancer, it is for the best interests of the patient to remove the strictured area. It is simpler, as it is sometimes done, to join the two pouches about a common stoma as in performing a gastroenterostomy. (Fig. 4683, *C* and *D*.) Recently gastric ulcer is removed with a cuff-resection and the ends sutured together as described under gastrectomy (see the section on Segmental Resection).

In any case it is well to reflect upon the gastric tonus and motility produced in each procedure. At the present writing, laboratory studies seem to show that in segmental resection there is an immediate blocking of the gastric tone and an impairment of the motility of the pyloric portion of the stomach, without immediate disturbance of either tonus or motility in the proximal part. Dogs, under mild ether narcosis with gastric segments removed, with gastrogastrostomy performed, show peristaltic waves at ten- to twenty-second intervals at the rate of 1.8 centimeters per second, with two and, occasionally, three waves on the stomach at the same time in the proximal portions while the distal ends remain atonic (relaxed) and non-motile (free from peristaltic contraction).* Just what interval is required for the neuromuscular complex to be restored is unknown at the present time. One of our (Stewart's) human cases throws a gastric shadow corresponding to an atonic and dilated stomach three months after a segmental resection. We are led to believe and to hope that regeneration of the Auerbach system eventually succeeds by the report of the Mayo Clinic[14] that the "sleeve resection . . . . gives an excellent permanent result." At the same time the remaining methods, above described, involve such extensive divisions and separations of the cut ends of the circular musculature of the stomach that even proximally normal motility is impossible. They are, therefore, probably destined to be replaced by the (cuff) terminal method of gastrostomy. Mayo's report or implication that the motility remains good following segmental resection certainly applies at the present time at least to the cephalad portion of the stomach, and probably to the caudad portion as well.[15] (See case report in the article on *Stomach, Tumors of the.*)

Gastroenterostomy, or the union of the stomach with the small intestine through an artificial stoma is, of all operations upon the stomach, the most difficult to plan and among the easiest to execute. Since first performed by Wölfer in 1881 the technique has undergone several modifications. Furthermore, it has been applied to remedy many pathological states of the stomach and of the duodenum. So far as possible only those methods and their respective indications that have been tried out physiologically in the surgical laboratory shall be considered. The remaining techniques shall be tabulated not for imitation but for the sake of completeness.

At the present writing even the late textbooks contain descriptions of procedures based solely upon pathological anatomical findings, however insignificant, without a word of attention to the disturbances in function or the pathological physiology. Note, for instance, the intricate pains to discover an ulcer in the duodenum and the apparent disregard for the dynamic balance of the rest of the alimentary tract. The motility of the stomach is not considered although it exists at all times in constant intimate correlation with the duodenum, the iliocolic and possibly the appendicocolic sphincter as well as the large intestine. The ulcer, the gastroptosis, the gastrectasia, and the pylorospasm are coming to be regarded as physiological equivalents of normal dynamic factors reflexly thrown into abnormal correlation. Although the cause of this reflex pathology is usually unknown, to relieve the symptom-bearing overworked gastric musculature is more etiological than to relieve one of the signs of its eventual disintegration; namely, the ulcer.† Both the tissue and the functional pathologies should be considered in planning a gastroenterostomy.

It is common, too, in autopsying dogs with dilated stomachs and with stomachs with residues including

* This statement is based upon the author's work in course of preparation at the N. Y. Univ. Surgical Laboratory.

† Compare Rosenow's views of the specificity of cocci and ulcer.

fragments of bone and other foreign bodies, to find ulceration. The author, formerly, saved the first two such stomachs but has since passed them by and has come to look upon the stomach ulcer, somewhat as the stercoral ulcer, as the product of the two old forces; namely, persistent irritation from a foreign body or residue and infection which is probably always possible from the stagnant stomach contents.

Gastroduodenostomy is the union of the stomach and the duodenum. The Finney operation is the one of choice. It is more commonly known as the Finney pyloroplasty. The indication is a compensated stomach with pyloric stenosis of benign character.

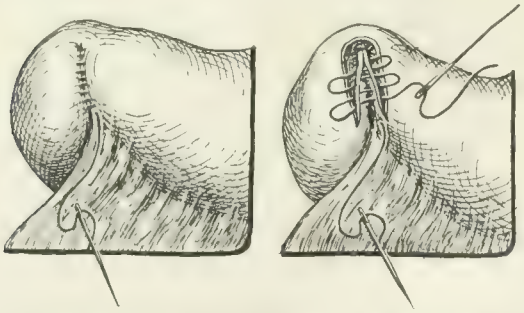


FIG. 4684.—Finney's Gastroduodenostomy as Performed by the Author. Note horseshoe-shaped incision and Lembert and Connell sutures.

The stomach and duodenum are exposed through an upper right rectus incision. The two opposing surfaces are brought together and sutured by a continuous or interrupted Lembert. The incision is made one-fourth inch anterior to and within one-fourth inch of the extremities of this suture but not beyond the ampulla of Vater (Mayo). The cut edges are united by a continuous through-and-through (Connell) or interlocking suture posterially and (Connell) anterially. An anterior Lembert or the posterior continued anterially completes the anastomosis. Could this operation be performed without division of the strong circular musculature or could the divided ends be sufficiently mobilized to pull against each other affectually this plan would be ideal for most gastroenterostomies. The new outlet coincides with and widens the physiologic outlet and does decrease the resistance of an otherwise heightened and stenosed pylorus.

The Heineke-Mikulicz operation with the incision properly placed in the opposing surface of the pyloric stomach and duodenum is essentially the same as the above. The incision through the pylorus for 2.5 centimeters into the stomach and into the anterior surface of the duodenum is shorter than in the Finney operation. It is directed to grasp the upper and lower lips of the incision at the midpoints and to pull them apart before suturing. This procedure serves but to illustrate more clearly the transverse closure of the longitudinal wound as described under pyloroplasty. This operation shares the difficulties of the true plastics upon the pylorus for the shorter incision, by readjustment, becomes, essentially, the old pylorus before operation which, in addition, remains anchored in the upper abdomen by a normal or short hepatoduodenal ligament or by postoperative adhesions. In either event, the pyloric resistance to gastric emptying that existed before operation remains or increases. This was the experience in what appeared to be a properly chosen case for the Mikulicz operation, a case in which the stomach sagged far into the pelvis before a heightened pylorus of no discoverably increased diameter and upon whom gastrojejunostomy had to be performed.

Jaboulay (1894) and later Kummel and Kocher anastomosed the duodenum to the pyloric end of the stomach well below and not immediately subjacent to the gastroduodenal flexure as represented in the above methods. Kocher[16,17] made his anastomosis terminolateral.

Gastrojejunostomy implies the union of the stomach with the small intestine aboral of the duodenojejunal flexure. The indications for gastrojejunostomy are stenosis of the pylorus, non-malignant, malignant (when this operation is combined with gastrectomy), and hopelessly malignant; ulcer at the pylorus; and gastric insufficiency that has not responded to non-operative treatment. Much has been learned regarding the connection of ulcer with cancer. The clinical studies of Joseph Bloodgood and William Mayo have shown the probability of ulcer located on the gastric side of the pyloric veins undergoing carcinomatous change and the likelihood of ulcer on the duodenal side remaining benign. It is important to remember that every cancer probably has a precancerous beginning and that, probably, many gastric ulcers are destined to undergo malignancy. The tendency for this change to begin at the borders of the ulcers, should be kept in mind; the fact that carcinomatous formation exists for some time microscopically before it is recognizable clinically is important. Of such a nature is this histological picture that little dependence can be put upon the frozen section. One should, as Bloodgood advises, familiarize himself with the surgical pathology of possible precancerous lesions and treat each case at operation largely upon its own merits with due consideration for the incidence of carcinoma at the site of the operation. With these points in mind, it will be thought wise to treat many if not most of the gastric ulcerations as real carcinomata.

The method of choice is the posterior (V. Hacker's) operation. The stomach is exposed by the usual midventral or right rectus route and made more accessible, if necessary, by division of the rectus fibers. The stomach, pylorus, and duodenum are examined. The size and position of the stomach are noted and the tone of its walls estimated. The most favorable site of anastomosis is selected. There should be an abundance of hot moist pads at hand to protect exposed viscera. The transverse colon is elevated. With a hand placed upon that part of the stomach previously chosen for anastomosis, pressure is exerted against the posterior mesocolon. A bloodless area is selected and

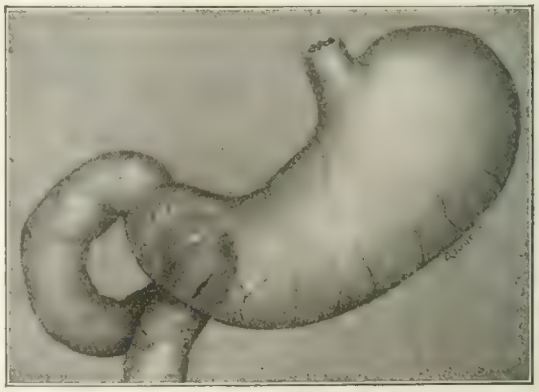


FIG. 4685.—Posterior Gastrojejunostomy. Note particularly: 1, position of jejunal stoma; 2, position of gastric stoma; 3, direction of gastric stoma, 4, and jejunum naturally taking a position downward and to right in direction of prostaltic drive of stomach.

opened. The posterior gastric wall is evaginated through this opening and (with a protected intestinal clamp) clamped off for seven to eight centimeters perpendicular to the tangent of the greater curvature. (This line will be seen to correspond to the interval of the greater vessels and to be directed upward and toward the cardia.) The duodenojejunal angle is iden-

tified beneath the transverse mesocolon and four centimeters above the level of the iliac crests and to the left of the spine. A loop of jejunum is chosen that corresponds in size, direction, and distance from the duodenojejunal angle to the already isolated oblique loop of the stomach. It is considered important that the direction of the duodenum correspond with that of the stomach or that the peristalsis of the stomach and of the duodenum be continuous or isoperistaltic. This loop of jejunum is clamped and brought alongside the stomach loop outside the abdomen. To immobilize the two clamps during the anastomosis the rubber ends of each may be fixed in other clamps or sutured. The posterior Lembert should begin along a line on the jejunum peripheral to that of the mesenteric reflection and as close to the ends of the clamped loops as possible. This suture is preferably a Cushing-Lembert (see section on Gastrorrhaphy). Incisions are made in the duodenum and stomach one-fourth inch from the suture line and from its two ends. The edges are sutured by a posterior interlocking or Connell and by an anterior Connell. The posterior Lembert is now continued anterially. Interrupted Lembert's may be inserted where it is necessary to strengthen the foregoing sutures. It is well after the conclusion of the second (posterior hemostatic) to loosen the clamps gently to determine the possibility of hemorrhage from the suture line. The whole suture line, especially the extremities, is carefully examined. The edges of the mesocolon are caught in four interrupted sutures to the stomach and duodenum and the organs are returned to the abdomen. The wound is closed in layer fashion.

Variations.—1. Many surgeons excise a piece of mucosa one to two centimeters wide from the margin of the gastric stoma.

2. The distance of the jejunal stoma from the duodenojejunal flexure is an arbitrary one. Under the "no-loop" method the Mayo's have designated a point one and one-half to three inches distant. Others have elected sites up to nine inches away.

3. Site of the Gastric Stoma.—The older surgeons still speak of gravity drainage in surgical stomachs whether compensated or not. The "lowest" point on the greater curvature is chosen as the stoma site and to this end it is advised to displace forward the attachment of the gastrocolic omentum and the gastroepiploic artery to secure some anterior wall. There can be but one site ideal for the gastric stoma or one site physiological for the stomach with impaired prostaltic power. The surgeon must determine this site for each individual case by preoperative study supplemented by his operative findings. To determine this point, the writer came to the following conclusions from his clinical and experimental studies.[18]

"The position of the stoma is vitally important and depends upon the following: (*a*) For normal or hypertrophied stomachs the pylorus is the most efficient outlet. (*b*) for normal or hypertrophied stomachs the nearer the artificial stoma coincides with the physiological point of outlet the greater is the efficiency. (*c*) For 'moderately' atonic stomachs or stomachs with fifty per cent. impaired prostaltic power, the efficiency of the stoma is probably greatest in the pyloric antrum, while (*d*) for the markedly atonic stomachs, the pendant stoma seems to date most efficient."

4. Should the cephalocaudad axis of the jejunal loop coincide with that of the gastric loop? Experimentally in dogs the writer has obstructed the duodenum and anastomosed the remaining small intestine at a distal jejunal site with a pyloric stoma so that the prostaltic gastric wave intercepted that of the oral end of the small gut. In each instance the terminal ileum was obstructed. In the few animals (with normal stomachs) so treated the greater accumulation occurred in the proximal limb of the anastomosed small intestine. The clinical and experimental conditions are not identical inasmuch as the small intestine had been tied off at two points and was thereby deprived of normal peristaltic stimuli. Nevertheless the tendency of the stomach to drive its contents in a longitudinal direction is depicted and seems to suggest freer gastric emptying for the isoperistaltic union.

5. The direction of the gastric stoma is quite generally accepted to be most advantageously placed at right angles to the greater curvature and not parallel to it. A parallel stoma divides both the vessels and the circular muscle.

6. The question of whether the union of the stomach and of the small intestine should be isoperistaltic or heteroperistaltic deserves consideration. The former respects the direction of the stomach drive and throws the receiving loop of intestine into line with it.

The anterior (Wölfler's) method of gastrojejunostomy is an operation of choice and an alternative for the posterior. It resembles the posterior one generally but differs from it particularly in that the anterior surface of the stomach is anastomosed with an accessible portion of the jejunum. The small intestine is carried around and in front of the transverse colon to meet the stomach. In other words, the "loop" is longer, the anastomosis is anterior to the attachment of gastrocolic omentum, and the techniques are identical.

Other operations are the Maury String Method, the Mikulicz-Czerny Operation, and Roux's Operation. These are obsolete or not in common practice and not advised. WILLIAM HOWARD BARBER.

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Stomach, Tumors of the.—The tumors of the stomach may, for purposes of description, be classified as follows:

I. Neoplasms: A. Benign: (1) Polypi, (2) Adenomata, (3) Lymphadenomata, (4) Myomata, (5) Fibromata, (6) Lipomata, (7) Myxomata, (8) Osteomata, (9) Angiomata.

B. Malignant: (1) Sarcomata: (*a*) round-celled, (*b*) spindle-celled, (*c*) myosarcomata, (*d*) angiosarcomata. (2) Carcinomata: (*a*) carcinoma medullare, (*b*) carcinoma fibrosum, (*c*) carcinoma gelatinosum, (*d*) ulcus carcinomatosum.

II. Cysts: (1) Dermoid, (2) Serous, (3) Hydatid, (4) Blood, (5) Chylous, (6) Cysts from new growths.

III. Infective Tumors: (1) Syphilomata, (2) Tuberculomata, (3) Plastic linitis.

IV. Aneurysms.

V. Foreign Bodies.

The benign growths differ in the frequency of their occurrence, in color, shape, size, and position according to their respective composition and natures. The etiology is, of course, unknown.

Benign Neoplasms.—*Polypi.*—Several of the tumors (adenomata, fibromata, lipomata, myomata, and papillomata) may take upon themselves polypoid proportions and become known as polypi. Polypus refers, therefore, to the physical dimensions, rather than to the microscopical character of the tumor. Epstein found fourteen stomach polypi in 600 autopsies and Versé collected four out of fifty-five gastrointestinal polypoid growths. They may be single (in forty-one per cent.) or multiple (in fifty-nine per cent.). The color is grayish-brown to red. Menetrier recognizes two forms of polypi according to the distribution of the fibrous tissue; the lobular and cystic, due to fibroid obstruction of the excretory ducts, and the uniformly smooth variety with fibrosis of the depths of the glands. The size varies from 0.5 to 2 centimeters for the multiple growths and as great as ten centimeters for the single polypus. The solitary is often located at the pylorus; the multiple appear scattered over the body of the stomach. Myer points out that polyadenoma en nappe, originally described by Menetrier, and denoting a circumscribed hypertrophy and hyperplasia of the mucosa to two to five times its normal thickness is exceedingly rare and that only three cases have been described, one by Andral and the others by Menetrier.

Adenomata.—These tumors involve the glands with their supporting tissue framework and blood-vessels. They are pedunculated or sessile; single or multiple. They form the majority of the polypoid growths described above. The adenomata are markedly prone to become malignant; indeed, it is often impossible to decide upon the benignancy of these growths even under the microscope.

Lymphadenomata.—The lymphatic tumors arise from an overgrowth of the lymphoid tissue of the mucous layer of the stomach or from the mesenteric glands. Located at the cardia and seldom, if ever, about the pylorus, they appear as smooth, creamy white, sessile or pedunculated masses. These tumors are rare. Those arising from the mesenteric nodes are found chiefly in childhood and are prone to develop into lymphosarcomata. It is important to remember that with these lymphoid growths there may be similar enlargements of other lymph glands, and of the spleen, tonsils, and follicles of the tongue and pharynx.

Myomata.—Tilger found the occurrence of the muscle tumors in the Russian hospitals to be 0.007 to 0.04 per cent.; forty instances have been recorded since Morgagni's case in 1762. They are composed of non-striated muscle covered by thinned-out mucous membrane. They are pedunculated or sessile and usually occur singly. The shape is round or oval, the surface smooth, the color brown to white, and the size varies from one to twenty centimeters. The site is pyloric, less frequently cardiac. Of these tumors, the submucous may become cystic and the subserous, sarcomatous.

Fibromata.—Primary (intramural) fibromata of the stomach are of doubtful occurrence. It is believed that most of the reported cases have arisen from ulcerous cicatrices, keloids, or impaired mucous membrane, or are actually scirrhus carcinomata or fibrosarcomata. The more common pedunculated tumors are single or multiple, smooth or lobulated, two to ten centimeters in length, and generally in the pyloric region. Cheyne reports an interesting instance of a 4-ounce fibromyoma projecting from the lesser curvature into the abdomen.

Lipomata.—The lipomata or fatty tumors, though very rare, arise from the submucous or subserous tissues. These pale yellow tumors may occur alone or in groups, and may be pedunculated or diffuse. Fenwick's case measured five by six centimeters. They may undergo cystic or malignant degeneration.

Myxomata.—These gelatinous, semitransparent growths, probably sarcomatous, have been reported three times. They were found encapsulated within the wall of the stomach.

Osteomata.—Webster, in 1827, reported a pedunculated, cartilaginous tumor containing spicules of bone and corresponding in size to "a quart-bottle cork," protruding from the antrum into the pylorus. This class represents tumors, like the fibromata and the sarcomata, that have undergone partial ossification.

Angiomata.—Cavernous and lymph agiomata of the stomach occasionally occur.

The *symptoms* may be absent altogether or severe, depending upon the size, location, and the nature of the tumor. Large growths, wherever located and of whatever texture, give rise to sensations of weight and to evidences of pressure upon the surrounding organs. Pyloric tumors may cause obstruction of an intermittent or of a progressive nature. The symptoms of gradually increasing pyloric closure resemble those of occlusion from other causes, as from ulcer. There may be anorexia, eructation of gas and of sour fluid, vomiting, and epigastric pain, all of which increase

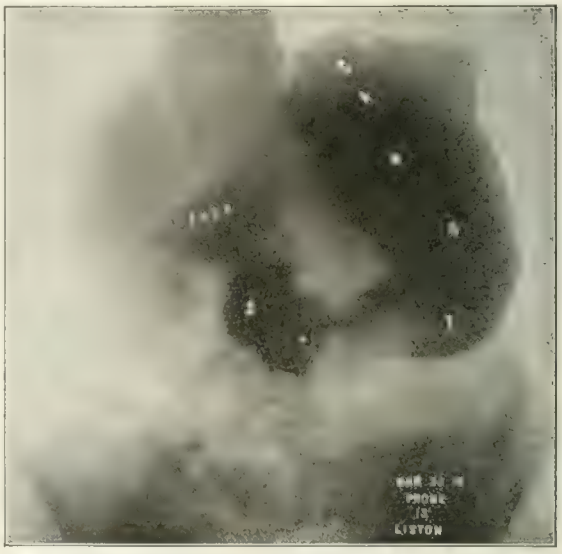

Fig. 4686.—New Growth (Adenocarcinoma) of the Stomach.

with the obstruction. If the pyloric blocking is complete and sudden, of course, the picture, as in Webster's classical case, that "died about twenty-two hours from the commencement of the attack" (or complete pyloric occlusion), is more fulminating and severe. In the ulcerative or vascular growths, blood may appear either in the vomitus or stomach washings, or fæces. Loss of weight and cachexia similarly depend upon the size and disposition of the tumor. The signs of mass are elicited only from the larger tumors but unfortunately, "all palpable tumors occurring after middle life with progressive symptoms are really malignant"; this gives one no justification for awaiting the signs of a tumor to make a diagnosis of a gastric growth. In two cases, diagnoses of stomach polypi were made beforehand by recovering fragments of the tumors from the gastric washings. Of the greatest value in all these conditions, is the information obtained from the radiographs (see Fig. 4686).

The treatment may be omitted in those instances that give no symptoms and that present no evidence of malignancy. The innocent growths with symp-

toms may be treated accordingly. The logical therapeusis of the so-called benign neoplasms of the stomach, bearing in mind the sarcomatous and the carcinomatous tendencies, is obviously operative. The choice of operation (compare Eiselsberg's report) depends upon the individual case. (See article *Stomach, Surgery of the.*)

Malignant Neoplasms.—The malignant tumors are sarcomata and carcinomata. The *sarcomata* comprising five to eight per cent. of the primary neoplasms of the stomach, are of four varieties, namely; the round-celled (in sixty-two per cent. of cases), the spindle-celled or fibrosarcomata, (in twenty-two per cent. of cases), the myosarcomata (five cases reported), and the angiosarcomata (two cases reported). Any of these types may metastasize, but most commonly (seventy per cent.) it is the round-celled and next frequently, (thirty-seven per cent.), the spindle-celled. It is, furthermore, to be observed that of all the secondary malignant growths, the round-celled sarcoma is, probably, the most common.

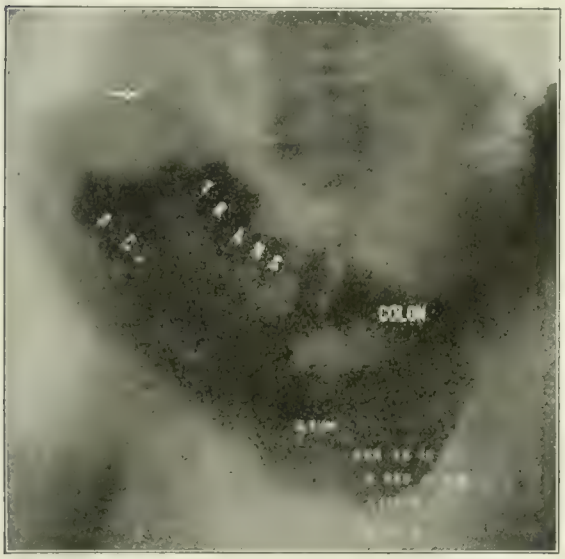

Fig. 4687.—Adenocarcinoma of the Stomach; Viscus empty.

The sarcomata are circumscribed, smooth or irregular, but firm and indurated, and often grow to enormous size, even to the filling of the greater part of the abdominal cavity. As in the benign growths, nothing is known of the causation of sarcomatous tumors, but it is well to associate the two possible etiological factors, traumatism and the mean age of thirty-four years.

The symptoms, as in benign growths, include thirst, vomiting which is intermittent and increases with the dilatation, and epigastric pain. Hemorrhage is seldom to be found either in the stomach or in the bowel contents owing to the fact that the sarcomata infrequently ulcerate. There are loss of strength, anemia, an occasional slight leucocytosis, and a temperature ranging from 99 to 102 degrees. The physical signs are those of a pyloric tumor or of a mass involving a large portion of the stomach and, in addition, the signs of dilatation of the stomach. The skin metastases are very characteristic. There may be a few skin nodules about the umbilicus or they may be widely scattered in the skin of the chest and back. Splenomegaly and tonsillar hypertrophy are often associated. Albuminuria, when present, indicates kidney involvement.

The treatment is operative. Symptomatic care may be given to those who are hopelessly involved. Specific therapy may be tried in certain cases but should not be permitted, under any conditions, to delay operation, when operation is indicated.

The *carcinomata* are the most frequent of all the gastric tumors. From the standpoint of the organ affected, the stomach is second only to the female uterus as the site of election for cancer to develop. This fact is well shown in Welch's summary of 30,000 cases. In respect to the distribution of the malignant foci within the stomach, itself, the same author, on the basis of 1,300 cases, draws the following conclusions: "in the pyloric region, 791; lesser curvature, 148; cardia, 104; posterior wall, 68; involving a greater part of the stomach, 61; greater curvature, 34; anterior wall, 30; fundus, 19; multiple tumors in 45 cases."

These tumors may be of various shapes and sizes. They may be large or small, soft or hard, flat, rounded, or lobulated. The varieties, commonly described, are, (1) carcinoma medullare or adenocarcinoma, (2) carcinoma fibrosum, (3) carcinoma gelatinosum or colloid cancer, and (4) ulcus carcinomatosum. Of these, the first is the most frequent pathologically, the last, clinically. The fibrous occurs next often.

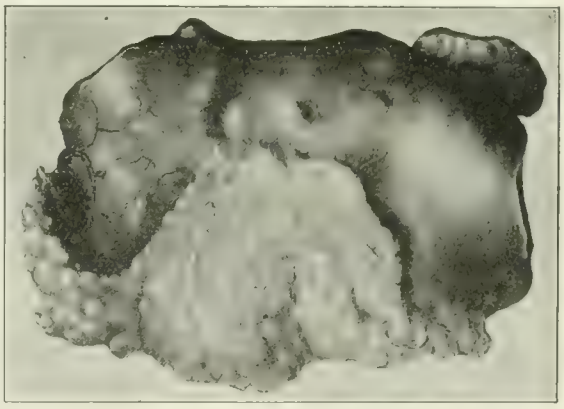

Fig. 4688.—Adenocarcinoma of Body of Stomach, Removed by Operation

The colloid form thrives naturally in the gastro-intestinal tract. The gelatinous material, found in and eventually displacing the alveolar cells and displacing the alveolar spaces, gives it the name of alveolar carcinoma. The pathogenesis of gastric cancer is little understood, except as it concerns the correlation of malignancy with the old calloused ulcer. It is only fair to say that at the present time, two opposing schools have arisen, one represented by Bloodgood and Mayo who hold that most ulcers develop into cancer (Mayo puts it at seventy-one per cent.), the other by Patterson of London who believes that comparatively few ulcers degenerate into carcinoma.

The following etiological factors may be mentioned: age, most frequently fifty to sixty; sex, 3.04 males to one female; social status, married or widowed, 87.5 per cent.; occupation, 32.4 per cent. among farmers; (this factor probably varies with the localities studied); prosperity; race, possibly the colored (in America); and, finally, traumatism.

The symptoms of a gastric cancer may be entirely absent. The evidences of onset may be (in the order of frequency) pain, "dyspepsia," vomiting, loss in weight, dysphagia, and tumor. Later, there may be anorexia, nausea, vomiting, hemorrhage, and epigastric pain, and also loss in weight, in strength, and anemia. There may or may not be the physical signs of a gastric tumor. The laboratory informa-

tion in a case of carcinoma of the stomach, as in sarcoma, or in any tumor is what should be expected from an organ with impaired secretion and motility. There may be decreased or absent hydrochloric acid, increased lactic acid, blood remnants, tumor fragments, the Boas-Oppler bacilli, yeast, sarcinæ and other organisms. Of the specific tests, the Abderhalden reaction, as performed by our associates, has corresponded most unfailingly with the pathological findings.

The treatment is unreservedly operative in all early cases with the hope of removing the disease and palliative in the advanced ones.

The following is interesting and instructive from the standpoints of diagnosis, treatment, and post-operative result:

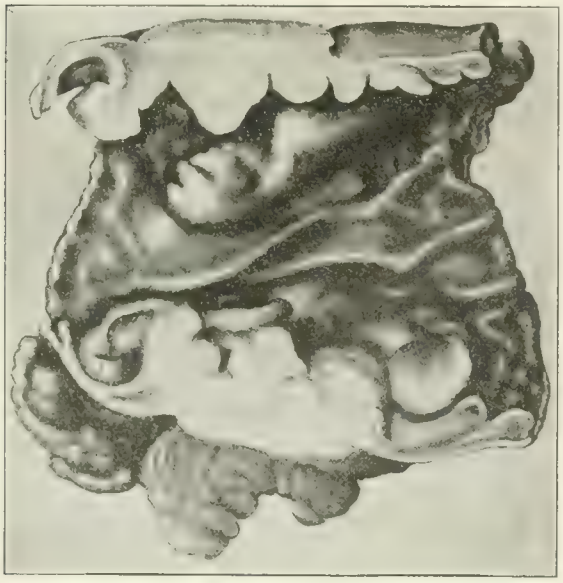

Fig. 4689.—Adenocarcinoma of the Stomach. Organ open, showing the extent of the growth.

A. L., first seen 3-20-16, is 66 years of age and was born in U. S. A. Was referred to me by Dr. M. G. Herzfeld of New York City. Family history irrelevant. Past history irrelevant. It may be noted that for some unknown reason she has had a longing for "walnuts" which she has devoured with much pleasure at the rate of a ½ pound a day for the past 6 months. Present history. For the past 2 years, her only gastric complaint has been nausea after meals. She has always had a good appetite, always enjoyed eating, and has never vomited. Her weight a year ago was 128; at the present time it is 108½. Loss in strength forced her to seek relief. She was very feeble, pale, and with dry skin. The signs were those of a mass in the left hypochondrium, movable with respiration, and tender upon deep pressure. The test meal showed hypochlorhydria and no blood. There was no blood found in the stool. Urine examination was negative. The roentgenograms confirm the above findings and illustrate the essential importance of the *x*-rays in gastric diagnosis. They were taken by Dr. Le Wald. Note, especially, in Fig. 4686 the obliterating mass and the well compensated (3 cycle) stomach; in Fig. 4687 the emptying of the bismuth meal in less than 4 hr. and 45 min.; in Fig. 4688 the greater part of stomach with tumor removed showing the old ulcer site and the probable starting-point of the tumor; in Fig. 4689 the same opened up (microscopical report, Dr. Jeffries, adenocarcinoma); in Fig. 4690 the residual stomach after segmental resection; in Fig. 4691 the preservation of the gastric motility as evidenced by complete emptying in 5 hr., 30 min. (another plate gives clearance within 4 hr).

The patient was up and about in 8 days and eating solid food. She never vomited or became nauseated. She was discharged on the thirteenth day.

Cysts.—The cysts of the stomach are extremely rare but have been recorded. A dermoid, containing hair, is reported by Ruysch in 1732. Serous cysts may occur between the muscular and serous coats of the stomach. Two hydatids have been reported, one a primary and the other involving the stomach secondarily. Blood cysts with pus and mucus are mentioned by the statistical writers. Engel Reimers describes a chylous cyst which appeared upon the

Fig. 4690.—Skiagram Two Weeks after Resection of the Stomach for Carcinoma.

posterior surface of a gastric ulcer of the lesser curvature at the pylorus. It contained milky fluid and was covered by peritoneum. Besides these, the neoplasms, above described, may undergo cystic degeneration.

The symptoms that may present themselves in cysts of the stomach are paroxysmal pain in the epi-

Fig. 4691.—Stomach Empty, showing preservation of gastric motility in the part left after extensive resection for adenocarcinoma.

gastrium or hypochondria, vomiting, losses in weight and in strength, evidences of pressure giving rise to dilatation of the stomach, and jaundice or ascites or both (by portal canal obstruction). These gastric cysts must, of course, be differentiated from cysts of the neighboring organs (liver, spleen, kidney, and pancreas) and from abscesses of the stomach (by

absence of fever and by slow growth). Under no conditions should the cysts of the stomach be aspirated through the abdominal wall, a procedure which, to anyone, must appear more dangerous than laparotomy.

The treatment is symptomatic and operative.

Infective tumors of the stomach include the tuberculomata and the syphilomata, both of which are comparatively rare, though more instances of the latter are being recognized at the present time than formerly.

Tuberculosis of the stomach, when primary, may simulate cancer as illustrated in Ruge's case. The tuberculous nodules ought not to be missed. They appear as pouting masses from beneath the mucous membrane and often ulcerate. The incidence of this type is probably not more than one per cent. of tuberculous individuals.

Gummata of the stomach have been mistaken for malignant disease. The differentiation of gastric syphilis from gastric cancer is important from the standpoint of treatment for if a suspected lesion is definitely luetic, it should be subjected to specific medical therapy and if cancerous, operative surgery ought not to be delayed. These tertiary lesions appear as multiple, round or flattened, yellow masses and project from the submucosa of the pyloric region. Chiari observed three cases in 243 necropsies.

Plastic linitis is ascribed to a chronic indurative thickening of the walls of the stomach and is extremely rare.

Aneurysms of the coronary or of the splenic arteries have been recorded. The size is one to three centimeters in diameter. They are prone to develop at the sites of gastric ulcers.

Foreign Bodies.—From the earliest times, instances have been recorded of the swallowing and of the harboring of foreign bodies in the human stomach. In many instances, these foreign bodies are said to be living animals. In the narratives that describe the ingestion of living things, such an air of credulity prevails that it is difficult, if not impossible, to refute them on circumstantial grounds alone.

Lezard relates that a girl swallowed a salamander, that she felt it move in her stomach, and then passed it by the rectum after which it remained alive for one-half hour.

Vetillard, a physician in Mans, wrote Buffon in 1771 of an individual having swallowed a caterpillar and of regaining the animal alive.

Bernstein reported that a common gray lizard gave symptoms for many years but was eventually passed from the rectum.

Gaspard and McCoy enumerated other live animals that were swallowed and detained within the stomach for an indefinite time.

Dalton alludes to two cases of garden slugs having been swallowed and passed alive by the rectum and then proceeds to test the feasibility of the reports experimentally. He found, for instance, that garden slugs and water lizards perish in a short time in the stomach because of the deprivation of air and of the destruction by the gastric juice. Slugs are digested in a few minutes. It appears from this that many of the old narratives have gained in proportions through repetition and in credence through the impressiveness of the association of living animals in the human stomach and of thier remaining alive throughout the alimentary tract.

In this connection, it may be said that the hydrochloric acid of the gastric juice is beginning to be looked upon more as a germicide than as an essential part of gastric physiology. Stomachs with no hydrochloric acid often empty within the normal limits of time. On the other hand, it is known that the contents of the normal stomach (one not dilated and with HCl present) are relatively sterile, whereas that of the pathologic stomach is infectious. The duodenum, though separated only by the pyloric sphincter, contains or at least secretes no hydrochloric acid and is, compared with the stomach, alive with microorganisms. This is a fact that we have demonstrated to our satisfaction repeatedly in class teaching. It appears, therefore, as Dalton surmised, that the germicidal property of the normal stomach lies in the hydrochloric acid and that this element in the gastric juice very largely renders the stomach uninhabitable by the larger animal forms mentioned above.

Similarly, Schaefer observed that the amount of acid found in the stomach coincided with that required experimentally to stop the growth of pathogenic bacteria. Troschel, referring to the Dolium galea, noted that the animal squirted from its mouth a liquid clear as water, the secretion was produced from two large gland-like organs lying near the stomach, and that the secretion contained 0.4 to 0.6 per cent. hydrochloric acid. Schulz studied the *Pleurobranchia mecklii* and found its external surface covered with a slimy secretion of acid reaction when squeezed. Troschel believed this acid was a means of protection against enemies and, with this in mind, pointed out the drawing in of the suckers of the Echinoderms when exposed to it and the extreme sensitiveness of many sea-animals to it. These reports further emphasize the improbability of the normal human stomach remaining, for any considerable length of time, a harbinger of other forms of animal life.

A foreign body of the stomach may be defined as something that has no economy for the stomach or for any other part of the body. Foods and therapeutic agents have a purpose to fulfill and obviously belong in the stomach. The great medley of objects, inert and harmful, unconsciously swallowed in childhood or imprudently or accidentally passed into the stomach in adult life, are foreign bodies in the stomach.

Foreign substances include gases, liquids, and solids. The gas most frequently swallowed is air, and the individuals are known as air-swallowers. They are a constant concern to all diagnosticians and have to be differentiated from cases of true gastric malfunction. The corrosive and toxic liquids will not be considered. Mercury is a classical example of liquids given for therapeutic effect and has been given in doses of one-half to three pounds. The solids command the most attention.

The formed bodies may be rounded as coins, fruit-stones and buttons; fragmented as bone and artificial teeth; sharp-pointed as pins, needles, pieces of wood, forks, etc.; or cutting as knives. They may be short or long and motile or amotile. Human hair does not well fit in this category but is often found in the stomach, at times as hair tumors almost filling the lumen and resembling new growth.

The mechanism of swallowing foreign bodies is briefly, forced extension of the head with the mouth widely opened to obliterate the oropharyngeal and the pharyngoesophageal angles. The swallowing of a semisolid as soup probably by removing inhibitory peristalsis as well as by the "washing-down" effect helps to carry the body to the stomach.

The lesions caused by objects in the stomach differ in degree from slight redness to perforation, with various degrees of inflammation between. Incidents are on record of foreign bodies giving rise to abscesses and of rupturing through to the outside of the body.

The *symptoms*, depending in part upon the nature of the irritating body, are (1) esophageal and (2) gastric. During the passage through, or the arrest of a foreign body in the esophagus, anguish and pain may be experienced. There may be expectoration of blood. Convulsions or vomiting may be present. When it has reached the stomach, there is wellbeing with or without anorexia, thirst, or vomiting. The gastric pain is localized in the epigastrium, is often

intermittent and sharp, is increased by sudden bodily movements, and is relieved by favorable positions of the body and by the taking of food. The signs are those of the physical proportions of the object, itself, as detectible through the abdominal wall by palpation, percussion, or by means of the *x*-ray and, in addition, the signs of the sequellæ of the injury caused by the foreign body, as gastritis, perigastritis, and peritonitis.

The *diagnosis* depends upon the above symptoms and signs coupled with the history. Further information may sometimes be obtained by the use of metallic pointed sounds and by gastroscopy.

The *prognosis* is generally favorable. Mignon collected 163 cases with a mortality of only 7.36 per cent.

Treatment.—Many objects can be recovered before they reach the stomach. Others need be forced on into the stomach. Within the stomach, gentle manipulation may be exerted upon the foreign object to facilitate its passage through the pylorus. In many instances, the safest procedure is gastrotomy. (See article on *Stomach, Surgery of the.*)

William Howard Barber.

Stomatitis.—This word, which from its derivation signifies inflammation of the mouth, is held to include inflammatory affections of the cavity of the mouth as far back as the soft palate. Any abnormal condition of an inflammatory character which involves the gums, the tongue, or the inner surface of the cheeks, is included, therefore, under the designation of stomatitis. Experience shows that there is little tendency toward limitation to any one of these structures—usually the entire cavity of the mouth partakes of the diseased condition.

The affections included under this name are, in great part, limited to the age of childhood. Adults are never the subjects of certain forms of the disease, and seldom suffer from any variety of it, save as part of some other morbid condition. Not infrequently, however, stomatitis is nothing more than a part of such general condition. Diphtheria sometimes involves the mouth as well as the tonsils, pharynx, and palate; inflammation, with pustulation in the mouth, may occur in smallpox, varioloid, and varicella; facial erysipelas often presents an inflamed condition of the mouth; measles, rötheln, and syphilis are accompanied by characteristic mouth affections; and many drugs, such as mercury and iodine, in addition to the mineral and other stronger acids, produce an abnormal condition.

It must be remembered that in children there is a tendency to put anything and everything—all germ-laden—into the mouth; hence one reason why stomatitis is so much more common at that age. The troubles incident to the period of dentition have also a causal relation to stomatitis.

As remedies for stomatitis in general, the following have been used. As mouth washes, in the form of solutions: Potassium permanganate, gr. ij. to ℥i.; potassium chlorate, gr. x.–xx. to ℥i.; boric acid, saturated solution; phenol, one-per-cent. solution; hydrogen dioxide, fifteen volumes per cent.; silver nitrate, gr. x.–xx. to ℥i. Also the solid stick of silver nitrate may be employed; and potassium chlorate may be given internally in doses of gr. v.–viij. q. 4 h.; in the case of children, however, the latter remedy must be used with care. Tonics of iron, quinine, nux vomica, and cod-liver oil are required. The diet must be liquid, either warm or cold, and must be generous and sufficient; chipped ice and iced water are acceptable to the patient. The mouth must be regularly washed or, if that is not possible, sprayed. If the gums are spongy, they should be painted with tincture of myrrh.

Catarrhal Stomatitis.—(*Synonyms:* Acute stomatitis, Erythematous stomatitis, Pultaceous stomatitis, Simple stomatitis, Superficial stomatitis.)

Etiology.—It most commonly occurs in infants and children, but it is also found in adults. The most common cause is an irritant either chemical or mechanical, such as overheated or too highly spiced food, acids, alkalies, very hot beverages, broken or carious teeth, and the excessive use of tobacco or alcoholic drinks. In the case of infants irritation caused by a coral, by difficult dentition, by a poorly developed or unclean nipple, or by a feeding bottle which has not been properly cleansed, may produce stomatitis. An excess of sugar or starchy food and also exposure to cold are causative factors in some cases.,

Symptoms.—These are the classical symptoms of inflammation: redness, first in patches, later more general; swelling, chiefly of lips, cheeks, gums, and tongue, the latter often showing the impression of the teeth; disordered secretion—in the adult the mouth is at first dry, later there is an increased flow of saliva with secretion of considerable mucus; at the same time the breath is fetid, and in children there is dribbling accompanied with considerable tenderness, so that the infant refuses to nurse or to allow the mouth to be cleansed. In adults the pain is as a rule slight, though it may be considerable, and, in conjunction with the dryness of the mouth seen in the early stages, renders mastication difficult. The disorder usually lasts about a week. In this form of stomatitis there is no ulceration.

Prognosis is good in acute cases, but infants are liable to suffer from inanition owing to the pain experienced in taking food. In chronic cases, generally due to alcohol or tobacco, the offending substance must be withdrawn.

Treatment is chiefly hygienic; whenever possible the causes must be removed and strict cleanliness insisted upon. In mild cases mouth washes of borax, of potassium chlorate, or of sodium bicarbonate may be useful; in the severer forms silver nitrate in one-per-cent. solution should be applied. At the same time general treatment in the shape of tonics and salines must not be overlooked. In infants the feeding apparatus must be kept scrupulously clean.

Croupous or membranous stomatitis is an inflammation of the mouth with the formation of a false membrane of a yellowish-white or grayish-white color. The disease may be diphtheritic or it may be due to gonorrhea or syphilis; it is also caused by extremes of temperature (as frost-bite) and by chemical irritants. This form of stomatitis is much the same as diphtheria, but without the Klebs-Loeffler bacillus. The pseudomembrane is apt to ulcerate and become detached from the subjacent tissue which then shows marks of erosion.

Treatment.—If the inflammation is due to diphtheria, give antitoxin; in most other cases the treatment is the same as in other forms of stomatitis, and consists of good food, proper hygiene, antiseptic and astringent mouth washes, tonics, and stimulants.

Ulcerative Stomatitis.—(*Synonyms:* Fetid stomatitis, Phlegmonous stomatitis, Stomacace, Putrid sore mouth, Phagedenic gingivitis.)

This form of stomatitis is a serious condition in which there is a superficial necrosis of the mucous membrane of the mouth, with subsequent ulceration.

Etiology.—The disease is probably caused by a microorganism, though none has as yet been isolated. It is generally found in children between the ages of four and fourteen; it may be epidemic, and is apt to accompany or follow improper feeding, infectious diseases, also poisoning by mercury, arsenic, lead, or phosphorus. Unhygienic surroundings and any local irritations are potent factors in this as in the other forms of stomatitis.

Symptoms.—The gums, of the lower jaw chiefly, are spongy, painful, swollen, and bleed readily; later on, the cheeks and lips become affected. The gums also recede from the teeth, which become loosened and may

fall out; ulcers may also occur round the sockets of the teeth, and a purulent fluid forms between the gums and the teeth, as well as between the teeth. There are profuse salivation, very fetid breath, and swelling of the neighboring lymph glands. In chronic cases the periosteum of the lower jaw becomes involved, and areas of necrosis ensue. There is great debility, and nausea and diarrhea, caused by swallowing the profuse fetid saliva, are also apt to be present.

Treatment is on the same lines as in other forms of stomatitis. On account of the disagreeable odor of the breath the patient should be isolated. Mouth washes are required, but in case potassium chlorate is used care must be taken that no untoward results occur, particularly in children. Hydrogen peroxide or dioxide makes an admirable mouth wash.

Bednar's Aphthæ, also called *Plaques pterygoidiennes*, or *aphthæ of the palate*, is a variety of ulcerative stomatitis. It is sometimes of traumatic origin, being due to pressure. It occurs generally in bottle-fed children who have unhygienic surroundings and are badly cared for, and is caused by the pressure on the hard palate of an artificial nipple or of the nurse's finger, or of a swab used in cleaning the child's mouth. But in breast-fed children it may also be found; it is then caused by the pressure of the infant's tongue on the thin mucous membrane, during the act of nursing. As a rule the affection is of a mild character, and is found on the hard palate near the alveolar process, but in badly neglected cases the ulceration may be both deep and extensive. In mild cases no special treatment is required beyond the removal of the cause; while in more severe cases a five-per-cent. solution of silver nitrate should be applied.

Aphthous Stomatitis.—(*Synonyms:* Follicular stomatitis, Vesicular stomatitis, Herpetic stomatitis, Aphthæ, Canker.)

In this form of stomatitis, which is more common than the catarrhal variety, the mucous membrane of the mouth is hyperemic and is characterized by grayish or yellowish vesicles which are liable to ulcerate, and are chiefly found on the margin and frenum of the tongue, and on the cheeks; also on the inner surface of the lower lips, near the junction with the gums.

Etiology.—It is probably due to some specific germ, but none has yet been isolated. It is found most commonly in children, and, if not idiopathic, is due to improper food, indigestion, one of the fevers, lack of hygiene and general uncleanliness of the mouth.

Symptoms.—The child is fretful on account of the pain; dull and feverish; the mouth is hot; the saliva flows freely and may irritate or excoriate the chin and neck. The ulcers described above are surrounded by red areolæ and bleed readily if any attempt is made to remove the grayish-white base. The process lasts about a week.

Prognosis is good. The sores may be treated with silver nitrate; local washes of potassium chlorate or potassium permanganate should be used; food, tonics, and stimulants are required.

Parasitic Stomatitis.—(*Synonyms:* Mycotic stomatitis, Stomatomycosis, Thrush, Muguet, Soor.)

Thrush is one form of parasitic stomatitis, but it is the most important variety. The disease is due to a vegetable parasite, and consists of white flake-like patches on the mucous membrane of the mouth and tongue. These patches consist of epithelium, leucocytes, and the spores and filaments of a fungus. The fungus or mould has been described as oïdium albicans, saccharomyces albicans, oïdium lactis, mycoderma vini, and monilia candida. The fungus displays remarkable polymorphism, having a great tendency to spore formation in a solid medium, and to filament formation in a liquid medium. The fungus tends to grow rapidly, particularly upon an unclean surface. The spores lodge between the epithelial cells; then separating the different layers and destroying the superficial layer they penetrate down into the connective tissue. The disorder is apt to become epidemic in institutions where there are many children, being transmitted by unclean feeding apparatus. The spots or patches look like curdled milk, but are covered with epithelium and are readily removed without bleeding, being thus differentiated from aphthous or follicular stomatitis.

Etiology.—The disorder is found generally in childhood, and occurs in the debilitated or uncleanly, more particularly in bottle-fed infants. It is apt to follow catarrhal stomatitis; and the growth of the fungus is favored by mouth breathing and by the restricted movements of the tongue which are necessitated by many forms of stomatitis.

Symptoms.—The symptoms are as a rule slight and much like those of catarrhal stomatitis. The saliva is acid and decreased in quantity; and the mouth is apt to be dry.

Treatment, as in other forms of stomatitis, consists in absolute cleanliness, the employment of mouth washes of an antiseptic character, the observance of a proper hygiene, and the administration of good food, tonics, and stimulants.

Gangrenous Stomatitis.—(*Synonyms:* Noma, Cancrum oris, Water cancer.)

This is an uncommon but very formidable complaint, and is almost invariably found in young children. It is favored by poor hygienic conditions, lack of food, and general enfeebling diseases. It may follow an ordinary ulcerative stomatitis, but the two conditions are very different. Probably some microorganism is the cause of the disease, but so far it has not been isolated. Cancrum oris must not be interpreted as an ordinary gangrene of a local character, for the blood supply of the face is far too good to allow of such a supposition. Characteristics of this disease are: (1) that it begins on the inside of the cheek; (2) that it is almost always unilateral, though cases have been reported in which both cheeks were attacked; (3) that it perforates the whole thickness of the cheek; and (4) that it is rapidly fatal. At first there will be observed a small red swelling on the inside of the cheek, often opposite the opening of Stenson's duct. This small swelling gives place to a large, rapidly growing ulceration and is followed by gangrene. The destructive process begins from within and works outward. The whole thickness of the cheek is soon involved; it becomes brawny, and the outside is red and glazed; perforation soon occurs. The breath is fetid, the teeth fall out, the jaw becomes necrosed, and the whole process is marked by the extraordinary rapidity with which it advances, a rapidity so great that in from one to two weeks the patient dies either from exhaustion or from pyemia. "The intelligence remains generally undisturbed, and the little patients do not seem to be greatly alarmed, but rather apathetic. The temperature and respiration become influenced principally because of, and in proportion to, the inflammation of the lungs, which is frequently a precedent and concomitant condition. This associated pulmonary inflammation is, however, never of the sthenic type of simple acute lobar pneumonia. Diagnosis in the later stage is rendered unmistakable by the ulcer, nodule, slough, and perforation. The early stage is to be distinguished from malignant pustule (anthrax). The latter begins as a pustule upon the outside of the cheek, often at the site of an abrasion; it is far more common in adults, and the anthrax bacillus is discoverable in the pustule and blood. There is very little pain, but much prostration, and generally there are nausea and diarrhea.

The *prognosis* is bad; different writers place the death rate at between eighty and ninety-five per cent.

Treatment to be of any use must be vigorous and early. Free extirpation or the application of the cautery should be early resorted to; there should be

frequent applications of hydrogen dioxide, and tonics and nourishing food should be administered every two or three hours.

Mercurial Stomatitis.—(*Synonym:* Mercurial ptyalism.)

This is an inflammation of the mucous membrane of the mouth and gums, due to the use of mercury; it is rarely found in syphilities.

Symptoms.—The patient complains of a metallic taste, tenderness of the gums which are also unusually red, and increased flow of saliva; the tongue becomes swollen and there is difficulty in both mastication and deglutition. The salivation is apt to be extreme; and the odor of the breath is most offensive.

Treatment.—Those working in mercury should cleanse both mouth and teeth frequently; and those taking the drug should at once discontinue its use. The best remedies are salines, alkaline drinks, and atropine to arrest the flow of saliva. During convalescence tonics will be required.

Burns and Scalds.—These are generally caused by accident, and are due to hot liquids introduced into the mouth, to chemicals (acids and alkalies), or to inhalation of hot air or steam. They are most commonly met with in children, owing to their greater liability to drink out of the spout of a kettle or teapot. Adults are more likely to suffer in explosions, under which circumstances they may inhale steam or ignited gas. The inside of the mouth and pharynx are involved, and edema of the glottis is a probable complication. The symptoms are intense burning pain, dyspnea, suffocating cough; the lips and mucous membrane of the mouth are either white, sodden, puffy, and blistered, or the mouth may escape and show little or nothing of the hurt. In this latter event the glottis may be scalded, when the edges of the epiglottis will be scorched and the larynx also involved.

Treatment is the same as that for burns in other parts of the body: (1) *constitutional*, to combat shock and to keep up the patient's strength; and (2) *local*, in the form of mild antiseptic mouth washes and cool mucilaginous drinks. For edema of the glottis tracheotomy may be required. There may be cicatricial contractions resulting in great deformity, and, for the relief of this deformity, extensive plastic operations are often performed. R. J. E. Scott.

Stomoxys.—A genus of flies which includes about fifteen species. *S. calcitrans*, the stable-fly (*q.v.*) or biting house fly, is found all over the world, and is suspected of carrying diseases. See *Insects, Parasitic.* A. S. P.

Stone, Richard French.—Born near Sharpsburgh, Bath County, Kentucky, April 1, 1844. In 1863 he followed one course of lectures at the Rush Medical College in Chicago. He completed his medical education at the University of Pennsylvania, and received the degree of Doctor of Medicine from that institution in 1865. During the closing years of the Civil War he performed with great credit the duties of an army medical officer, and then settled in Indianapolis, Indiana. It was during his life in the latter city that Dr. Stone wrote and published his great work entitled: "Biography of Eminent American Physicians and Surgeons," Indianapolis, 1894—a work which is a veritable treasure house of facts relating to all those physicians who have contributed, in various degrees, to the building up of American medicine and to the making of American medical history. In the assembling and editing of all these biographies Dr. Stone showed excellent judgment, a spirit of fairness, and untiring energy; and for the faithful manner in which he performed the difficult task which he set before himself he certainly deserves the praise and thanks of the American medical profession. Many of the brief biographical sketches of American physicians which are now for the first time printed in this third edition of the Handbook, consist either of compilations or of extracts from those furnished in Stone's work. Dr. Stone died at Indianapolis in 1913. A. H. B.

Stone, Warren.—Born at St. Albans, Vermont, Feb. 3, 1808. He received the degree of Doctor of Medicine from the Medical School at Pittsfield, Massachusetts, in 1831. In the autumn of the following year he took passage to New Orleans in the brig Amelia; but the breaking out of cholera among the passengers and crew compelled the officers to beach the vessel on Folly Island, near Charleston, South Carolina. Dr. Stone himself suffered from the disease. As soon as the necessary arrangements could be made, another vessel was chartered to take the passengers to New Orleans, and thus Dr. Stone arrived at his destination early in December, sick, poor, and without sufficient clothing to protect him against the cold weather of that season. He soon found employment, however, in a very subordinate capacity, in the Charity Hospital. Later, after he had given ample evidence of his ability and industry, he was appointed Assistant House-surgeon; and he retained this position up to the year 1836, when he was unanimously elected Resident Surgeon. In the following year he was elected Professor of Anatomy in the Medical Department of the University of Louisiana; and in 1838 he became Professor of Surgery in the same department—a position which he held up to the time of his resignation, early in 1872. During the Civil War Dr. Stone was appointed Surgeon General of the State. He died Dec. 6, 1872.

Of Stone's published writings the following deserve to receive special mention: "Dislocation and Fracture of Spine;" "Amputation of the Mammæ;" "Ligature of the Femoral Artery;" "Observations on the Treatment of Wounded Arteries," 1845; "Ligature of the Posterior Tibial Artery;" "Operation and Removal of one-half of the Inferior Maxilla;" "Lateral Operation for Stone in the Bladder;" "Case of Epilepsy Trephined three times with Relief," 1858; "Comminuted Fracture of the Thigh, Amputation, and Recovery;" "Ligature of the Common Iliac Artery;" and "Tracheotomy." A. H. B.

Storax.—See *Styrax.*

END OF VOLUME VII.

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